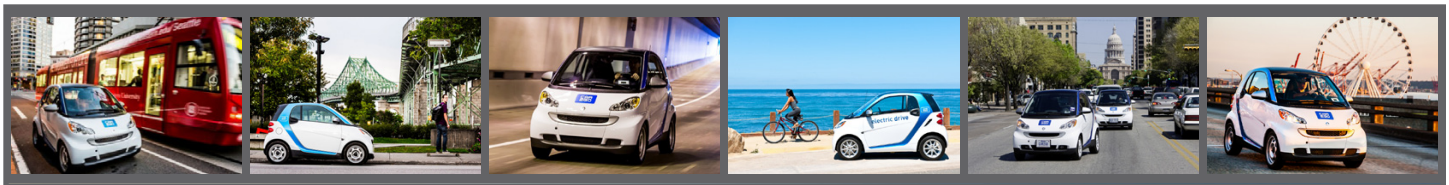

IMPACTS OF CAR2GO ON VEHICLE OWNERSHIP, MODAL SHIFT, VEHICLE MILES TRAVELED, AND GREENHOUSE GAS EMISSIONS:

AN ANALYSIS OF FIVE NORTH AMERICAN CITIES

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Contents

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Innovative mobility strategies, through both technological advances and shifting people's travel patterns and behaviors, are important tools for reducing energy consumption and to create a more sustainable transportation future.

IMR is based at the Transportation Sustainability Research Center (TSRC) at UC Berkeley. IMR's current research areas include: mobility and the sharing economy, alternative fuel vehicles, intelligent transportation systems (ITS), public transit connections, mobility for special populations, and alternative transport futures including automated vehicles. IMR designs research projects and conducts evaluations throughout the State of California, the U.S., and internationally.

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Executive Summary

Carsharing is the shared use of a vehicle fleet by members for tripmaking on a per trip basis. There are four forms of carsharing in North America today: 1) roundtrip, 2) one-way, 3) peer-to-peer, and 4) fractional. In roundtrip carsharing, members begin and end a trip at the same vehicle location and typically pay for use by the hour, mile, or both. One-way carsharing enables members, who pay by the minute, to begin and end a trip at different locations—either throughout a free floating zone or station-based model with designated parking locations. Peer-to-peer carsharing functions much like roundtrip carsharing; however, the vehicle fleet is typically owned/leased by private individuals and facilitated by a third-party operator. Finally, the fractional ownership model enables users to co-own a vehicle and share its costs and use. Roundtrip carsharing has been operating in North America for over 20 years. In July 2015, there were 39 roundtrip carsharing operators in North America with a total membership of 1,005,893 and a collective fleet of 18,582 vehicles. In 2010, one-way carsharing launched in North America in Austin, Texas with the car2go service. As of July 2015, there were three one-way operators in North America, serving 511,000 members with a collective fleet of 6,870 vehicles (Shaheen and Cohen, 2016, forthcoming).

Car2go is currently the largest carsharing operator in the world, with a presence in nine countries and nearly 30 cities. It operates as a one-way instant access carsharing system within a pre-defined urban zone. Members can find an unoccupied parked vehicle, access it immediately, and use it to meet their local travel needs. As long as the vehicle is parked within the operating zone, users only pay for the time that they drive. As a one-way system, car2go provides flexibility to the user. There are questions as to whether one-way carsharing increases overall vehicle miles traveled (VMT), by facilitating easier one-way travel (and automotive commuting) within urban environments. The results of this study suggest that access to ubiquitous shared automobiles allows some residents to get rid of a car or avoid acquiring one altogether. These actions taken by a minority of members have VMT-reducing effects that are estimated to exceed the additional driving that does take place within car2go vehicles. This study surveyed car2go members in five cities to determine the impacts on vehicle ownership, modal shift, VMT, and greenhouse gas (GHG) emissions. The cities surveyed were Calgary, San Diego, Seattle, Vancouver, and Washington, D.C. We asked questions that required respondents to attribute specific changes in their life as caused by the presence of and access to car2go. We also used vehicle activity data to evaluate the total driving that car2go vehicles travel in a city during a year, as well as a profile of the frequency of use by the broader car2go population.

Not surprisingly, we found that car2go has a diverse range of impacts on the member population. Most of the car2go population appears to use it for a small number of trips a year to satisfy incidental mobility needs. This activity generally adds to driving that is additional or would have otherwise occurred with another automobile. The analysis also found that a minority of the population uses car2go as a substitution for personal automobiles as they either sold personal vehicles owned or suppressed the acquisition of a private auto. The impacts of these changes are large relative to the overall increase in driving that is caused by car2go activity. Thus, the results of this analysis suggest that car2go is on net reducing vehicles that would be owned by households, reducing driving, and thus lowering GHG emissions.

There are diverse impacts on travel behavior; the magnitude of these impacts varies across the five cities; and the results are subject to some measurement uncertainty. The study asked modal shift

questions that show the relative shares of respondents that changed their use of other modes in response to car2go. car2go was found to both substitute and complement public transportation, as well as other active transportation modes, such as walking and to a lesser degree bicycling. In most cities, a majority of members exhibit no change in public transit use due to car2go. But among those that do change their behavior, the count of car2go members reducing their public transit use outnumbers the count of those increasing their use. There are exceptions in the cases of both bus and rail, and there are users that make more complementary use of these modes with car2go. In all cities except Washington, D.C., a greater number of members reported walking more due to car2go than walking less. At the same time, car2go had mixed effects on bicycling with smaller magnitudes of change. car2go was found to compete directly with taxis, as most respondents used taxis less as a result. The reported impact of car2go on personal driving also showed mixed effects. In San Diego, more people reported decreasing their driving than increasing it due to car2go, whereas in the other study cities, more people reported increasing their driving than decreasing it. Between 29% and 38% of respondents in four of the cities reported that there was another person with them when they used car2go at least half the time. This question was not asked in San Diego, but it was added as part of the Seattle revisions.

The measurement of mode shift by count of people may differ from the overall cumulative impacts. That is, those driving more due to car2go appear to be doing so in small amounts for incidental uses. While those decreasing driving by selling personal vehicles and avoiding a vehicle purchase are a smaller group. However, this group has a more sizeable impact, which generally overwhelms the additional miles driven on car2go vehicles. This result appears to hold even under some rather conservative assumptions regarding driving displaced from suppressed vehicles. Our analysis also includes consideration of miles driven by staff to redistribute the car2go vehicles. For four of the five cities, staff miles were found to range between 3% and 7.5% of all car2go miles driven. For San Diego, which operated a fully electric fleet of vehicles at the time, staff miles comprised 17% of all miles driven, in part due to the need to shuttle vehicles to depots for recharging.

car2go also causes substantive change on the vehicle holdings of a minority of members. In this study, we measure the change in the raw sample; however, when we scale the impacts to the broader population, we re-weight the effects to consider the distribution of usage frequency in the activity data. This was done to balance the responses in consideration of the fact that more active users are more likely to respond to the survey and are more likely to report substantive impacts relative to the general population. When considering the re-weighted impacts of active car2go drivers (i.e., those using it more than once a month), the results suggest that between 2% to 5% of the car2go population sold a vehicle due to car2go across the study cities. The average age of vehicles sold ranged between 12 and 15.7 years across the five cities, and the entire sample of sold vehicles had an average age of 14.4 years across all of the cities. Another 7% to 10% of respondents (aggregate results) did not acquire a vehicle due to car2go. While these percentages are nominally a small share of the re-weighted sample, at the population level they translate to vehicle reduction impacts that exceed the number of car2go vehicles operating on the streets of the cities studied. We found that members sold between 1 to 3 personal vehicles for each car2go vehicle, and between 4 to 9 vehicle acquisitions per car2go vehicles were suppressed across the cities studied. Overall, car2go removed between 7 to 11 vehicles from the road per vehicle (on average) across the study cities. In aggregate, this estimate translates to about 28,000 vehicles removed from the roads across the five study cities due to car2go operations. In Table 1 below, we provide an overview of key vehicle and GHG impacts in each of the five cities.

Table 1 Vehicle and GHG Impacts from Free-Floating One-Way Carsharing

City	Vehicles Sold	Vehicles Suppressed (foregone purchases)	Total Vehicles Removed per Carsharing Vehicle	Range of Vehicles Removed per Carsharing Vehicle	Estimated % Reduction in VMT per car2go household	Estimated % Reduction in GHG per car2go household
Calgary, AB (n=1,498)	2	9	11	2 to 11	-6%	-4%
San Diego, CA (n=824)	1	6	7	1 to 7	-7%	-6%
Seattle, WA (n=2,887)	3	7	10	3 to 10	-10%	-10%
Vancouver, BC (n=1,010)	2	7	9	2 to 9	-16%	-15%
Washington, D.C. (n=1,127)	3	5	8	3 to 8	-16%	-18%

The average vehicle that was sold among respondents was driven between 5,800 to 7,800 miles per year across the five cities. Based on the driving reported by survey respondents, we generate an upper estimate of the miles that would be have been driven on suppressed vehicles by taking 80% of the average VMT driven on all vehicles reported in respondent households. This estimate ranged from 5,100 to 7,400 miles per year across the five cities. These mileage estimates permitted a broader estimation of the miles that are reduced through the personal vehicles suppressed due to car2go. The average VMT driven on car2go vehicles per customer per year was found to range from 75 to 142 miles across the five cities, which illustrates the fact that car2go vehicles are not, on average, driven long distances by the broader member base (although some members use it quite a bit more). We also computed the estimated VMT impact that would result, if only 20% of the average VMT driven were avoided from suppressed vehicles. This amounts to the assumption that only 1,300 to 1,900 miles per year would be driven on vehicles not acquired by car2go members who reported a vehicle suppression. Taking the estimated miles removed due to vehicles sold and suppressed, against the additional driving done on car2go vehicles, we calculate--using the upper suppressed mileage factor--between 20 million to 37.5 million miles (aggregate) are eliminated or not driven due to car2go across the five cities. The estimated VMT impact under the more conservative assumption is markedly lower, but it still reflects a net reduction, ranging from 6 million to 12 million miles a year across the five cities. Although we estimate that only 2% to 5% of the population sells a private vehicle and another 7% to 10% of the population forgoes a vehicle purchase, the cumulative avoided driving on just those vehicles is large enough relative to the VMT driven on car2go vehicles overall, that a VMT decline occurs under some rather conservative assumptions. Overall, this translates into a reduction in GHG emissions, which for the upper (80%) suppressed mileage VMT estimate, we computed to range between 5,300 to 10,000 metric tons per year across the five cities or 10 to 14 metric tons per year per car2go vehicle (on average) across the five

cities. If the lower, more conservative 20% assumption is applied to suppressed mileage, then the range of GHG impacts amounts to 2,200 to 4,200 metric tons per year or 4 to 7 metric tons per car2go vehicle (when averaged over all vehicles). The percentage reduction on VMT and GHGs is computed in aggregate across all households using the 80% suppressed mileage assumption. This computation considers the total estimated net VMT reduction as a percent of the total estimated VMT of car2go households. Since households both increase and decrease their VMT as a result of car2go (and by different magnitudes), the percentage change only applies in aggregate. Nonetheless, estimated impacts of VMT suggest that on balance car2go changes VMT by -6% to -16%, per car2go household and GHG emissions change by -4% to -18% per car2go household. Overall, the results of this study suggest that car2go one-way carsharing is substantively impacting travel behavior, miles driven, GHG emissions, and the number of vehicles on urban roads within operating regions.

Introduction

Carsharing is the shared use of a vehicle fleet by members for tripmaking on a per trip basis. There are four forms of carsharing in North America today: 1) roundtrip, 2) one-way, 3) peer-to-peer, and 4) fractional. In roundtrip carsharing, members begin and end a trip at the same vehicle location and typically pay for use by the hour, mile, or both. One-way carsharing enables members, who pay by the minute, to begin and end a trip at different locations—either throughout a free floating zone or station-based model with designated parking locations. Peer-to-peer carsharing functions much like roundtrip carsharing; however, the vehicle fleet is typically owned/leased by private individuals and facilitated by a third-party operator. Finally, the fractional ownership model enables users to co-own a vehicle and share its costs and use. Roundtrip carsharing has been operating in North America for over 20 years. In July 2015, there were 39 roundtrip carsharing operators in North America with a total membership of 1,005,893 and a collective fleet of 18,582 vehicles. In 2010, one-way carsharing launched in North America in Austin, Texas, with the car2go service. As of July 2015, there were three one-way operators in North America, serving 511,000 members with a collective fleet of 6,870 vehicles (Shaheen and Cohen, 2016, forthcoming).

We designed the study to better understand how car2go is used; how it changes travel behavior; and its impacts on vehicle ownership, driving, and greenhouse gas (GHG) emissions. Car2go is a one-way carsharing service provider with a free-floating operational model, primarily. Between 2014 and 2015, we distributed an online survey to car2go members in the cities of San Diego, Seattle, Vancouver, Calgary, and Washington, D.C. Across all cities, the survey was completed by 9,497 car2go members. The survey was first administered in San Diego in September 2014. We received input on the survey instrument from our research partners at the Federal Highway Administration (FHWA) of the U.S. Department of Transportation; the San Diego Association of Governments (SANDAG), the regional metropolitan planning organization; and car2go. Next, it was modified based on feedback received from the City of Seattle and released in Seattle, Vancouver, Calgary, and Washington, D.C. in January, March, July, and September 2015, respectively. Based on an analysis of the survey and car2go activity data, we estimate the impacts that car2go has had on vehicles sold and suppressed by car2go members, modal shift, vehicle miles traveled (VMT), and GHG emissions within the five cities during the year the surveys were deployed.

This working paper has six sections including: 1) methodological overview, 2) impact of car2go on vehicle holdings, 3) car2go impacts on modal shift, 4) car2go and estimated changes in VMT, 5) GHG emission impacts, and 6) key takeaways.

Methodological Overview

The survey was sent to all car2go members within the five cities: Calgary, San Diego, Seattle, Vancouver, and Washington, D.C. Respondents in each city were entered into a drawing for one of ten, $50 Amazon gift cards. We asked questions about modal shift, changes in vehicle holdings, and annual VMT. Respondents were asked questions assessing whether they got rid of a vehicle due to the presence of car2go, as well as whether or not they would purchase a vehicle if car2go, specifically disappeared. In both cases, respondents had to indicate that car2go was a cause of getting rid of a vehicle or of not acquiring one. Responses to these questions were tabulated within the sample to generate an estimate of vehicles sold and suppressed. These impacts were stratified by the self-reported frequency of car2go use. The stratified impacts calculated from the survey data were then weighted according to the

distribution of usage frequency by members as observed within activity data provided by car2go in each city. Researchers then classified active members within the re-weighted data, as people that use car2go more than once a month. The factors for private vehicles sold and suppressed from the weighted impact profile of active members was applied to the average overall car2go user population for the year within each city to calculate an estimate of the number of private vehicles sold and suppressed. This total was then divided by the average number of car2go vehicles, over the course of the year within each city, to estimate the "vehicles sold per car2go vehicle" and the "vehicles suppressed per car2go vehicle" on average. This produced a low and high range of impact for each city, as well as a total impact range across the cities.

We designed the survey questions to assess car2go impacts, such as private vehicles sold or suppressed and modal shift. Respondents could also indicate that they sold a vehicle or changed their behavior but not because of car2go. These actions were excluded from the impact profile. Some respondents in each survey were filtered out of the analysis due to missed responses, misanswered questions, or other confounding factors. This reduced the total sample size to 7,346 responses. We also extracted respondents that relocated when their move (home or work) impacted VMT more than the presence or use of car2go. This resulted in a final sample of 6,167 for computing vehicle, VMT, and GHG impacts. The complete sample of 9,497 was used for assessing modal shift in this analysis because the question structure was a relatively simple ordinal scale question asking whether mode shift had occurred as a result of car2go. Since respondents were reporting a change in relative usage frequency on a basic ordinal scale, it presented less opportunity for confounded answers.

Some limitations exist in these findings. Primarily, the impacts of car2go on respondents are self-reported. On some level, this is unavoidable, since the respondent is the most knowledgeable as to whether or not car2go was a causal reason for a change in vehicle ownership, VMT, or some other change in travel behavior. Also, the measurement of annual personal driving is self-estimated. Where possible, confirmation of impacts was embedded in the methodology. For example, respondents were filtered out if their responses were implausible or outlier measurements. Furthermore, respondents were asked to list their vehicles during the year before joining car2go and at the time of the survey. If they indicated that they sold a private vehicle specifically due to car2go (required of respondents to be considered an impact), but there was no change in the vehicles reported, then the impact was not considered in the calculations. Vehicle suppression was restricted to one vehicle per household in this analysis to be conservative, even though some households reported car2go suppressing more. Despite these verification steps, limitations remain regarding the self-reporting of impacts and the causal relationship of those impacts to car2go. We were unable to include a control group of the general population due to budget limitations. Overall, the majority of respondents indicated that car2go had not caused them to sell or suppress a private vehicle purchase, and in most cases had not caused a change in other travel behavior. These results reflect car2go operations in environments that are generally urban in nature. Furthermore, members opt in to using carsharing systems, like car2go. This is a part of the process of using carsharing and other shared mobility services. People that cannot use car2go, do not sign up for the service and consequently do not experience a direct impact from it. Thus, the results reflect the estimated impacts on individuals who have chosen to use car2go because the service provides some mobility or economic benefit. Specific methodological points related to vehicle ownership, modal shifts, VMT, and GHG impacts are included in each discussion below.

The Impact of Car2go on Vehicle Holdings

The results suggest that the availability of car2go has reduced the net number of vehicles on the road in the five cities studied within North America. Across all of the cities surveyed, the suppression effect of car2go (i.e., the effect car2go has on removing the need for members to purchase a personal vehicle) is larger than the shedding effect of car2go (i.e., the effect that car2go has on allowing members to sell or get rid of a personal vehicle). Across the five cities, we estimated that between 2% to 5% of members sold a vehicle due to car2go, which reflected the weighted sample of active members as projected onto the car2go population. Another 7% to 10% suppressed (or avoided) a vehicle purchase due to car2go (also reflecting the weighted sample of active members only). As noted above, we considered active members in this analysis to be those that use car2go more than once per month.

We applied the impact percentages to the average membership base for the year 2014 to estimate the number of vehicles sold and suppressed by car2go members. We used the year of 2014 for the computation of these rates because we had activity data during this year to derive the usage frequency profile for the population. The estimates were then divided by the average size of the vehicle fleet for that year. This yielded an estimate for the total number of private vehicles sold and suppressed per car2go vehicle. These estimates describe how the presence of car2go impacts vehicle holdings based on the fleet size within that city. These impacts are subject to fleet management practices and existing member-vehicle ratios. For example, if car2go quickly adds 100 new vehicles to a fleet to serve an expanded area, personal vehicle holdings resulting from this fleet growth may not be immediately impacted at the rates presented here. The effects of car2go on personal vehicle decisions made by households proceed at a slower, more gradual pace as a new region acquires active members who adapt to and feel comfortable with its presence. Areas with different land uses and public transit access also respond differently. This study evaluates cities with a range of population densities and public transit networks. At the low end are Calgary and San Diego, with population densities of 3,400 and 4,000 people per sq. mile, respectively. Vancouver has the highest population density with about 13,000 people per square mile, followed by Washington, D.C. (~9,800) and Seattle (~6,700).

The analysis shows a range of vehicle ownership impacts across the cities. As the effect of vehicles sold is generally the lower of the two, it is considered the lower bound of within-city vehicle impacts. The upper bound of within-city impacts includes the estimated number of vehicles suppressed and sold per car2go vehicle. These effects are independent of each other in that they avoid double counting among respondents. Double counting can occur when a respondent indicates that they both sell and suppress a vehicle purchase. In such a case, a respondent who sells a private vehicle due to car2go would be re-acquiring the vehicle in the absence of car2go. When such a conflict arises, we count the vehicle as sold and not a vehicle suppressed. Because the impacts of a private vehicle sold and suppressed are independent, they can be added to produce an estimated impact of total vehicles removed due to car2go. Across the five study cities, it is estimated (based on the minimum and maximum of ranges across cities) that:

- Car2go members sold between 1 to 3 vehicles per car2go vehicle (on average).
- Car2go members suppressed the need for between 4 to 9 vehicles per car2go vehicle (on average).
- Overall, when considering both effects together, each car2go vehicle removed between 7 to 11 vehicles from the road of the five cities studied (on average).

Table 2, below, shows a summary of these effects as derived from the weighted survey responses, consideration of active member totals, and the translation of those impacts to the car2go population.

Table 2 Summary of Car2go Vehicle Impacts

City	Weighted Sample-based Vehicle Sold Percent of Active Members	Weighted Sample-based Vehicle Suppression Percent of Active Members	Final Sample Size For Vehicle Impact Analysis	Vehicles Sold per car2go vehicle	Vehicles Suppressed per car2go vehicle	Total Vehicles Estimated Removed per car2go Vehicle	Within-City Range of Vehicles Removed per car2go Vehicle
Calgary	2%	9%	1246	2	9	11	2 to 11
San Diego	2%	10%	643	1	6	7	1 to 7
Seattle	3%	9%	2463	3	7	10	3 to 10
Vancouver	2%	10%	863	2	7	9	2 to 9
Washington, D.C.	5%	7%	952	3	4	7	3 to 7

The vehicle impacts vary by city, with Calgary having the largest overall impact on a per vehicle basis, driven by its large suppression effect, while San Diego had the lowest. It is worth noting that car2go implemented an experiment in San Diego through the deployment of a 100% electric smartfortwo fleet. This fleet operated for years with limited charging infrastructure and extensive staff support to keep the fleet charged and vehicles distributed. Despite these challenges, the electric smartfortwo fleet maintained a growing member base. Furthermore, the emissions of the smartfortwo fleet were approximately one-third of the conventional smartfortwo fleet. Because of the higher operating costs of the electric vehicle (EV) and limited charging infrastructure, car2go decided to convert the fleet to gasoline-powered vehicles. The experiment conducted by car2go provided lessons regarding the operation of a one-way electric carsharing vehicle fleet, as well as understanding regarding the challenges of deploying supporting EV infrastructure in an experimental environment.

The aggregate impacts reported by each city are a function of the active population using the system, the fleet size, and how users answered travel behavior-related questions in the survey. In 2015, car2go fleets and the membership base grew rather proportionally, keeping member-vehicle ratios close to the same in most cities. Applying these vehicle factors to the average car2go fleet size of 2015 within each city yields an estimate of the number of vehicles sold, suppressed, and removed overall as a result of car2go. These estimates, which represent a projection based on the vehicle rates of the average car2go fleet size in 2015, are provided in Table 3 below.

Table 3 Estimated Total Vehicles Sold, Suppressed, and Removed Due to Car2go in 2015 Based on Vehicle Fleet Size by City

City	Estimated Total Vehicles Sold	Estimated Total Vehicles Suppressed	Estimated Total Vehicles Removed due to Car2go
Calgary	982	5,076	6,058
San Diego	445	2,486	2,931
Seattle	1,619	4,696	6,315
Vancouver	1,571	6,672	8,243
Washington, D.C.	1,832	2,776	4,608
Total	6,449	21,707	28,155

Table 3 shows that the largest aggregate impacts among the five cities are estimated to be in Vancouver, which had among the larger member populations and fleets, followed by Seattle, Calgary, Washington. D.C., and San Diego. It is important to note that these estimates are not rates of removal (i.e., annual number of vehicles removed per year), but rather they are an estimate of the number of automobiles removed due to the presence of car2go operating in that city in 2015. It is an estimate of what car2go is replacing in terms of personal vehicles. In total, the estimated city-level impacts on vehicles removed are a function of a number factors including: 1) total membership size; 2) total fleet size; 3) rates of private vehicles sold and suppressed, as reported by the survey respondents; 4) the percentage of active members in each city; and 5) the frequency distribution of their activity. High-density cities, such as Vancouver and Washington, D.C., have the highest percentage of active users. Lower-density cities exhibit a lower percentage of active users relative to their respective membership base. San Diego shows the lowest aggregate vehicle impacts. This is primarily driven by a smaller fleet size and membership base, as well as a lower relative share of active users in contrast to the other study cities. City attributes, such as population density, public transit access, and vehicles per household also likely play a contributing role as to how each population responds to the presence of car2go. For example, the fact that cities with high population densities also have higher rates of active users suggests that urban form and the provision of public transit both impact how car2go is used. At the same time, high-density urban environments often have fewer vehicles to sell due to higher living costs and parking constraints. The “push and pull” among the broader relationships between urban form and carsharing impacts should be explored in future research.

Car2go Impacts on Modal Shift

We also asked survey questions that probed how car2go changes travel behavior with respect to other modes. Not surprisingly, the results indicate that car2go has a diverse impact on how people travel. We asked survey questions pertaining to how people travel using public transportation, including the specific modes of bus, urban rail, and intercity rail. We also asked similarly structured questions with respect to walking and bicycling, as well as automotive modes. As with the vehicle impact questions, the

modal shift questions asked respondents to indicate whether car2go was a *cause* of change in their use of other transportation modes. Using the example of walking, respondents were asked "As a result of car2go, I walk…". They were given an ordinal scale of responses, ranging from "Much less often" to "Much more often," to which survey respondents could indicate whether car2go had caused an increase, a decrease, or otherwise did not change their travel with each mode. Table 4, below, provides a summary of these results for four of the modes asked across all five cities, including the main public transit and non-motorized modes. Table 5, which follows Table 4, provides a summary of the results for four more modes, including intercity rail and modes using the private automobile. As discussed in the methodology, these distributions are reflective of the unweighted sample, in that they show the broader responses of completed surveys and not just the population considered to be active members.

Table 4 Modal Shift Attributed to Car2go for Public Transit and Non-Motorized Modes

City	Urban Rail				Bus			
	N	Increased Frequency	Decreased Frequency	No Change	N	Increased Frequency	Decreased Frequency	No Change
Calgary	1845	6%	24%	70%	1845	4%	30%	66%
San Diego	816	11%	20%	69%	819	8%	26%	66%
Seattle	3330	6%	3%	91%	3333	8%	28%	64%
Vancouver	1386	6%	19%	74%	1385	5%	48%	47%
Washington, D.C.	1318	3%	24%	72%	1300	3%	21%	76%
City	**Walk**				**Bicycle**			
	N	**Increased Frequency**	**Decreased Frequency**	**No Change**	**N**	**Increased Frequency**	**Decreased Frequency**	**No Change**
Calgary	2102	22%	12%	66%	2098	5%	3%	92%
San Diego	1074	34%	9%	57%	1077	7%	6%	87%
Seattle	3484	20%	9%	71%	3481	3%	6%	92%
Vancouver	1419	20%	11%	69%	1427	5%	8%	87%
Washington, D.C.	1325	10%	12%	78%	1321	3%	3%	94%

Public Transit Use

Many respondents reported that car2go substituted for the use of other public transit modes. But in almost every city and almost every mode, a majority of respondents reported that car2go had not substantively changed their use of specific modes. However, there were some exceptions. Overall, the results show that in every city there are people that both increase and decrease their public transit use,

such as urban rail (e.g., light rail or heavy rail) and bus. However, in most cases more people decrease rather than increase their public transit use as a result of car2go. One exception is in Seattle, where a small percentage of respondents (6%) increase their use of urban rail due to car2go, exceeding the smaller percentage (3%) of respondents decreasing their rail use. Across the other four cities, more people report a decrease in their frequency of urban rail and bus use than an increase.

Walking and Cycling Use

For walking, the results are a bit different across the cities. A majority of respondents reported no meaningful change in walking due to car2go, but in four of five cities, at least 20% reported walking more frequently over the roughly 10% that reported walking less frequently due to car2go. The exception is Washington D.C., where slightly more respondents report a decline in walking. For bicycling, the results are less pronounced. In San Diego and Calgary, the two least dense cities, slightly more respondents were reported to bicycle more frequently than less frequently, whereas in Vancouver and Seattle, slightly more respondents decrease bicycling than increase it. In all cities, the percentage of respondents shifting bicycling in one direction or the other is below ten percentage points. Table 5 below shows the results of similar questions for intercity rail and automotive modes.

Table 5 Modal Shift Attributed to Car2go for Automotive Modes and Intercity Rail

City	Drive Overall				Taxi			
	N	Increased Distance	Decreased Distance	No Change	N	Increased Frequency	Decreased Frequency	No Change
Calgary	2110	20%	10%	70%	2096	2%	64%	35%
San Diego	1081	11%	27%	63%	1078	2%	59%	38%
Seattle	3482	28%	15%	57%	3486	2%	42%	56%
Vancouver	1425	47%	15%	38%	1421	3%	65%	33%
Washington, D.C.	1327	44%	11%	45%	1323	1%	57%	42%
City	**Intercity Rail**				**TNCs (e.g., Uber/Lyft)**			
	N	**Increased Frequency**	**Decreased Frequency**	**No Change**	**N**	**Increased Frequency**	**Decreased Frequency**	**No Change**
Calgary	NA	NA	NA	NA	NA	NA	NA	NA
San Diego	816	6%	5%	89%	1078	22%	16%	62%
Seattle	3333	1%	1%	98%	3484	7%	27%	66%
Vancouver	1382	0%	1%	99%	NA	NA	NA	NA
Washington, D.C.	1311	1%	1%	98%	1325	6%	37%	58%

Driving and Taxi Use

Changes in overall driving and taxi use reflect different dynamics. In the case of taxi use, the results indicate that car2go is substituting for taxis among the majority of respondents in most cities. For driving, the results are more nuanced. In San Diego, 27% of respondents report driving less due to car2go versus 11% driving more. The remainder of the cities reports more people increasing their driving than decreasing it. In all five cities, the percentage of respondents that reported a decrease in driving is at least 10%. However, in the densest cities of Vancouver and Washington, D.C., the percentage increasing their driving is the highest at 47% and 44%, respectively. There are several points to note about this result. Similar to the example of walking provided above, the modal shift question asks the respondent to consider the ordinal change in driving, relative to their previous use. But unlike the walking example, respondents were asked in the context of distance. In the table above, a person increasing their driving by a little is equally weighted to a person decreasing their driving by a lot. Not surprisingly, the average magnitude of driving change is different across the respondents. As discussed in the next section, the average distance driven on car2go vehicles per customer, and per trip, is relatively small, whereas the personal miles driven on private vehicles sold and avoided is relatively large. These differences are discussed in more detail in the section evaluating VMT change.

Intercity Rail Use

Respondents were also asked whether car2go influenced their use of intercity rail in cities where these modes were operational. The results showed that in most cities, the change in intercity rail due to car2go was very small. In San Diego, a few more people increased their use of this mode than decreased it, but the overall change was still small.

Ridesourcing/Transportation Network Company (TNC) Use

For ridesourcing/TNC use (also known as ride-hailing), the impact was more varied. In San Diego, ridesourcing and car2go appeared to exhibit a more complementary relationship, whereas in Seattle and Washington D.C., ridesourcing and car2go act as substitutes. The reason for this difference is unclear, but it may be due to urban density, as San Diego is the second least dense city in this study. Trip purpose may also play a role in that some individuals may use car2go for travel to social and recreational activities but prefer ridesourcing for return trips. Ridesourcing services were not operating in the surveyed Canadian cities at the time of the car2go survey.

Car2go and Estimated Changes in Vehicle Miles Traveled

The estimation of VMT change suggests there is a net reduction in VMT that results from the presence of car2go. This analysis considers two primary components of VMT reduction and a component of VMT increase. The components of the VMT decrease are: 1) the miles eliminated by private vehicles sold by the car2go population, as detailed in the vehicle impacts section, and 2) the vehicles not acquired as a result of car2go by the car2go population. Naturally, there is a degree of uncertainty related to the estimation of miles driven on vehicles that are never acquired and thus never actually driven. While this effect from car2go is real, quantifying it with precision and certainty is probably impossible with present day measurement tools. We can never know with certainty how far a vehicle that is not acquired would have been driven. But it is self-evident that vehicles that are suppressed by the presence of car2go would have been driven some distance, even though this distance is somewhat unknown since it is

never manifested. While the distance is not directly measureable, it can be estimated in a number of different ways. In this analysis, we use information about how much the car2go survey population drives on the private vehicles it owned at the time of the survey (e.g., their current vehicles). The VMT reductions from personal vehicles sold and suppressed by car2go users are contrasted to the total amount of driving that occurs on car2go vehicles. The net difference generates an estimate of the VMT change associated with car2go activity.

There are some other behavioral components that are not directly considered in this analysis. For example, in this survey there are some households in every city that report a measurable drop in personal driving due to car2go, but they do not sell or suppress vehicles. This might happen if a household shifts to greater public transit use for commuting, uses car2go for local trips downtown, and avoids the need for automobile commuting. They reduce personal driving by amounts larger than car2go driving but still retain their private vehicles. This behavioral dynamic, however, was not found to be widespread across the survey population and is not considered in our calculations.

We also observe modal shift that result from the substitution of taxis and ridesourcing vehicles with car2go. Not surprisingly, some of the miles driven in car2go vehicles would have been taken in taxis and ridesourcing vehicles, yielding a minimal net change in driving overall from that shift. We did not consider this substitution in the analysis, although on balance it might favor larger consequential VMT reductions due to car2go, since some car2go driving would have happened anyway in other vehicles. Finally, all of the miles driven on car2go vehicles by customers and staff for maintenance and vehicle redistribution are counted in these estimates. These are miles that would not have occurred in car2go's absence. A summary of the underlying factors applied in our VMT analysis are shown in Table 6, below.

Table 6 Factors in VMT Analysis

VMT Analysis Factor	Calgary	San Diego	Seattle	Vancouver	Washington, D.C.
Average Miles Driven by Sold Vehicles	6,947	7,821	6,739	7,213	5,835
Average Mileage of Suppressed Vehicles [Upper Estimate (80%)]	6,177	7,467	6,282	5,288	5,161
Average Mileage of Suppressed Vehicles [Lower Estimate (20%)]	1,544	1,867	1,571	1,322	1,290
VMT on car2go Vehicles per car2go Customer per Year	76	78	113	142	98

Table 6 shows the average miles that were driven by the vehicles that were reported as sold by survey respondents due to car2go. Also shown is the estimated miles driven on vehicles not acquired by

members as a result of car2go. Both are estimates subject to some uncertainty. As discussed, the miles driven on suppressed vehicles are the more uncertain estimate, since these miles are never actually traveled. To better understand the implications of this assumption, we evaluate a range of mileage driven on vehicles suppressed by car2go. As an upper estimate, we estimate that the annual mileage not driven on suppressed vehicles is 80% of the average annual miles driven on all personal vehicles held by survey respondents at the time of the survey. As a lower estimate, we consider the hypothetical impacts, if mileage not driven on suppressed vehicles of the population was just 20% of the average of all current personal vehicle miles reported in the survey. Application of these two factors provides an upper- and a lower more conservative-mileage estimate. The point of the lower estimate demonstrates impacts under conservative assumptions, given the uncertainty of suppressed vehicle mileage. It is unlikely that most people acquiring a vehicle would only drive it less than 2,000 miles a year, once the fixed costs of vehicle ownership are already paid. Finally, activity data of car2go vehicles were used to calculate the total miles traveled by car2go in each city. This included miles driven by customers, and importantly, the miles driven by staff members redistributing the vehicles. This total was then divided by the average number of customers in 2014 to yield an average of car2go miles per customer, which is applied to other years given knowledge of the customer base. This factor is shown in the fourth row of Table 6.

These averages range from 76 miles per year per customer in Calgary to 142 miles per customer in Vancouver. Car2go trips are short on average. The distance of a customer trip across the five cities ranged from 3.4 miles (Washington DC) to 4.1 miles (San Diego). Across the five cities, car2go operations averaged about 5 customer trips per vehicle per day (not including staff trips this time). The range among cities was wide, bounded by San Diego averaging about 2.5 and Seattle averaging about 6 customer trips per vehicle per day.

The miles driven for redistribution purposes (e.g., staff trips) vary by city. This ranged from 3.4% of all miles (in Vancouver) to 17% of all miles (in San Diego). This upper percentage in San Diego was inevitably due to the EV fleet operating in that city, where vehicles required frequent shuttling back and forth to a limited number of charging stations. San Diego in this case was an outlier, for the other cities, the percentage of staff miles driven was 7.5% of total miles or less. Some car2go customers, of course, drive far more than the average, and they comprise the more active members. Overall, these averages suggest that on a per customer basis, car2go members do not drive large distances annually on car2go vehicles. With these factors and the estimate of vehicles sold and suppressed, along with the membership base information provided by car2go, we generate a range of estimates for VMT change resulting from car2go use. These estimates are summarized in Table 7, below, using data derived from these factors and the 2015 membership and vehicle populations.

Table 7 shows the estimates (rounded to the thousand, where appropriate) that were derived from the vehicle impacts summarized earlier for the population in each of the five cities and based on vehicle impact factors. The average miles driven on vehicles sold and avoided are applied to this population to generate a range of estimates of the total VMT reduced from vehicles sold and suppressed. The measure of average customers within the city for 2015 is presented, followed by an estimate of miles driven on the car2go vehicles using the factor for miles driven per customer per year, as defined in Table 6.

The net difference in the miles removed from sold and suppressed vehicles and the total miles driven on car2go vehicles comprises the estimated VMT impacts. Across all five cities, these total net impacts range from 21 to 37 million miles per year using the 80% suppressed mileage assumption and from 6 to 12 million under the more conservative 20% suppressed mileage assumption. Key factors governing this range are the car2go population, average driving on vehicles removed, the amount of driving on car2go vehicles system wide, and the impact car2go has had on personal vehicles. The results suggest that car2go likely reduced net VMT by hundreds of miles per customer on average, ranging from 480 to nearly 770 miles per customer on average, under the 80% suppressed mileage assumption and 140 to 290 under the 20% suppressed mileage assumption. On a per vehicle basis, the estimated range is nearly 34,000 to 57,000 VMT per vehicle on average, under the 80% suppressed mileage assumption and from 12,000 to 19,000 VMT per vehicle on average, under the 20% suppressed mileage assumption. These results suggest that car2go is reducing VMT, particularly when considering vehicles not acquired, and those reductions appear to hold under conservative assumptions. The percentage change in VMT is based on net impacts and the estimate of total household driving across the car2go population. For this estimate, we show the percentage change based on the 80% (upper) suppressed mileage assumption and find that across all five cities the percent VMT reduction would range from 6% to 16% of car2go household VMT. Note that this is within the universe of car2go households and not the broader urban environment in which the system is operating. This number only applies to aggregate assessments and is an average. Not surprisingly, individual households change VMT in ways that are highly varied that constitute both increases and decreases. The percent of VMT reduction ranges from -6% (Calgary) to -16% per household (Vancouver and Washington, D.C.), with an average across the five cities of about -11%.

Table 7 Vehicle Miles Traveled Impact Estimates

2015 Estimate	Calgary	San Diego	Seattle	Vancouver	Washington, D.C.
Number of Vehicles Shed by Active Members	982	445	1,619	1,571	1,832
Number of Vehicles Avoided by Active Members	5,076	2,486	4,696	6,672	2,776
Annual VMT Reduced by Vehicles Shed (mi/yr)	6,822,000	3,481,000	10,911,000	11,332,000	10,689,000
Annual VMT Reduced by Vehicles Suppressed (mi/yr) [Upper Estimate]	31,353,000	18,563,000	29,502,000	35,281,000	14,327,000
Annual VMT Reduced by Vehicles Suppressed (mi/yr) [Lower Estimate]	7,838,000	4,641,000	7,376,000	8,820,000	3,582,000
Total Estimated VMT Eliminated by car2go (mi/yr) [Upper Estimate]	38,175,000	22,044,000	40,413,000	46,613,000	25,016,000
Total Estimated VMT Eliminated by car2go (mi/yr) [Lower Estimate]	14,661,000	8,121,000	18,286,000	20,152,000	14,271,000
Average Number of car2go Customers	68,000	26,000	54,000	64,000	37,000
Estimated car2go VMT (2015)	5,221,000	2,032,000	6,126,000	9,108,000	3,624,000
Estimated Total Net VMT Change (2015) [Upper Estimate]	-32,955,000	-20,012,000	-34,287,000	-37,505,000	-21,392,000
Estimated Total Net VMT Change (2015) [Lower Estimate]	-9,440,000	-6,089,000	-12,160,000	-11,044,000	-10,647,000
Estimated Reduction in VMT per Customer [Upper Estimate]	-482	-771	-631	-585	-581
Estimated Reduction in VMT per Customer [Lower Estimate]	-138	-235	-224	-172	-289
Estimated VMT Reduction per car2go Vehicle (mi/veh/yr) [Upper Estimate]	-57,000	-49,000	-53,000	-41,000	-34,000
Estimated VMT Reduction per car2go Vehicle (mi/veh/yr) [Lower Estimate]	-16,000	-15,000	-19,000	-12,000	-17,000
Percent Reduction in VMT per car2go household [Based on Upper Estimate]	-6%	-7%	-10%	-16%	-16%

Car2go and Estimated Greenhouse Gas Emission Impacts

The estimated impacts of car2go on VMT can be translated into estimates of GHG emission impacts. As detailed in the VMT analysis, driving is directly reduced by car2go through the elimination of vehicles sold by respondents due to car2go. Driving is further reduced or avoided as a result of vehicles not acquired due to the availability of car2go. The estimation of GHG impacts resulting from these changes is produced through the application of fuel efficiency factors to these VMT estimates, which yields an estimate of fuel not consumed due to car2go under the scenarios detailed above. With estimates of fuel not consumed, emission factors are applied based on the mix or type of fuel that would have been consumed by vehicles sold and suppressed, as well as the car2go vehicles.

To translate fuel consumption into emissions, this analysis applies the methodology described by the U.S. EPA (2014) for the combustion of a gallon of gasoline.[1] It assumes that 95% of all GHG emissions are derived from carbon dioxide (CO_2), while the remaining 5% are derived from methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFC). All fuel displaced as a result of car2go was assumed to be gasoline (in reality some would be diesel).

Respondents reported their vehicles before and after car2go. For those respondents who reported selling a vehicle due to car2go, the make, model, and year of the sold vehicle is identified. We linked these vehicles to their base models in the fuel economy database published by the U.S. EPA, and we identified the combined fuel economy factor. We then averaged the fuel economy factors of the private vehicles sold to obtain an estimate of the average fuel economy of the population of sold vehicles within each city. We applied these average fuel economy factors to the total miles reduced from vehicles sold to yield an estimate of the annual fuel not consumed from these vehicles. Next, we applied the gasoline GHG emission factor, as defined above, to estimate the avoided emissions from the fuel not combusted. We consider the avoided gasoline combustion as the emission reduction from the privately sold vehicles due to car2go.

For vehicles suppressed by car2go, there is more limited empirical information on the mix of vehicles that would have been acquired. Hence, we apply a relatively conservative fuel economy factor of 42 miles per gallon to estimate the fuel that would have been consumed on these vehicles, while the emission factor for gasoline combustion remains the same. Finally, the emissions from car2go vehicles are derived from the mix of vehicles derived from the activity data and the mix of driving on those vehicles. We used the EPA combined fuel economy factors for the combustion engine and electric Smartfortwo vehicles to estimate the emissions derived on a trip-by-trip basis. This included emissions for both staff and customer trips. For San Diego, the fleet was all electric at the time of the survey. The EPA rates the electric Smartfortwo as having a combined MPGe of 107 mpg-e and reports energy consumption of 32 kWh per 100 miles. The precise emission factor for this vehicle and any other EV is a function of charging time of day and the local grid mix of electricity generation. It is a value that changes with the season and will change over the years. San Diego, as part of the California grid, has on balance some of the cleaner electrical energy sources in the nation due to high natural gas usage and a growing portfolio of renewables. While there are a number of factors that determine the precise emissions associated with electricity generation and emissions (as is the case with gasoline), the U.S. EPA factor in this case serves as a reasonable proxy that is comparable to those applied to other vehicles. The other

[1] U.S. EPA (2014) Greenhouse Gas Emissions from a Typical Passenger Vehicle. EPA-420-F-14-040a

car2go fleets were primarily combustion engine vehicles. Vancouver had some EVs in the fleet, which were indeed driven; however, they constituted 0.2% of total miles driven in the Vancouver fleet. Thus, we only applied the combustion engine (36 mpg) factor to estimate emissions from the estimated miles driven. The aggregate annual emission impact of car2go is the net difference in the annual emissions avoided from car2go vehicles sold and suppressed minus the increase in emissions from car2go driving. Table 8, below, shows the net impacts of car2go on emissions. This result is a natural extension of the net change in VMT reported in Table 7 (above).

Table 8 Car2go Greenhouse Gas Emission Impact Estimates

2015 Estimate	Calgary	San Diego	Seattle	Vancouver	Washington, D.C.
Average Fuel Economy of Shed Vehicles	25.4	23.0	24.9	23.4	23.5
Fuel Not Consumed by Shed Vehicles (gallons of gasoline)	268,313	151,121	438,408	484,792	455,706
Annual GHG Emissions Prevented by Shed Vehicles (t/yr)	2,510	1,414	4,101	4,535	4,263
Fuel Not Consumed by Suppressed Vehicles (gallons of gasoline / yr) [Upper Estimate]	746,500	441,976	702,429	840,024	341,119
Fuel Not Consumed by Suppressed Vehicles (gallons of gasoline / yr) [Lower Estimate]	186,619	110,500	175,619	210,000	85,286
Annual GHG Emissions Prevented by Suppressed Vehicles (t/yr) [Upper Estimate]	6,983	4,135	6,571	7,858	3,191
Annual GHG Emissions Prevented by Suppressed Vehicles (t/yr) [Lower Estimate]	1,746	1,034	1,643	1,964	798
Estimated car2go Emissions (t/yr)	1,357	178	1,592	2,367	942
Net Annual Emissions Change due to car2go (t/yr) [Upper Estimate]	-8,137	-5,371	-9,080	-10,027	-6,512
Net Annual Emissions Change due to car2go (t/yr) [Lower Estimate]	-2,899	-2,270	-4,152	-4,133	-4,119
Estimated Emissions Reduced per car2go Vehicle (t/veh/yr) [Upper Estimate]	-14	-13	-14	-11	-10
Estimated Emissions Reduced per car2go Vehicle (t/veh/yr) [Lower Estimate]	-5	-6	-6	-4	-7
Percent Reduction in GHG per car2go household [Based on Upper Estimate]	-4%	-6%	-10%	-15%	-18%

The average fuel economy of private vehicles sold ranges from 23 to 25.4 miles per gallon across the five cities. The GHG emissions are reported in units of metric tons. A single metric ton is 1,000 kg or about 2,200 lbs. To put this measure in the context of travel, a vehicle driving 10,000 miles a year at an average of 30 mpg will produce a little more than 3 metric tons per year from driving.

The estimated emissions from car2go fleets range from 178 (using 2015 VMT estimates) to 2,367 t per year. The lower end of this range is due to the lower emissions of the Smart EV fleet that was widely operated in San Diego. In aggregate, car2go was estimated to reduce GHG emissions by amounts ranging from 5,370 to 10,028 t GHG in 2015, using the upper estimate. The lower estimate, based on the 20% suppressed mileage assumption suggests a reduction between 2,200 to 4,100 t GHG calculated for the year of 2015. This is an impact that is estimated to recur annually as it is derived from avoided annual driving from vehicles sold and suppressed. But this will naturally fluctuate with the size of the vehicle fleet and the customer base it serves. On a per vehicle basis, it is estimated that each car2go vehicle displaces between 10 to 14 metric tons of GHG per year on average, when considering the upper estimate and between 4 to 7 when considering the lower estimate. The percentage reduction in GHGs is generally in line with those of VMT. Calgary's notably declines relative to VMT. This is because the vehicles sold in Calgary were unusually efficient relative to the general population of vehicles; household driving in Calgary was reported to be relatively high; and the car2go population is relatively large. In general, changes in GHGs will move closely with changes in VMT. Based on the 80% suppressed mileage assumption, the percent of GHG reduction ranges from -4% (Calgary) to -18% (Washington, D.C.) per household, with an average across the five cities of -10%. Broadly, when considering both vehicles sold and vehicles suppressed due to car2go, the estimates suggest that car2go is having an impact reducing GHG emissions within all five cities.

Key Takeaways

We found that car2go has a diverse impact on the travel behavior of urban residents within the five cities we studied. A majority of members use public transit less frequently; walk more frequently; use taxis less frequently; and have a range of impacts on other modes.

Data analysis from the survey suggests that car2go is having an impact on vehicles owned by members, as well as on overall driving. The assumptions and weighting applied to the vehicle ownership and VMT impacts reported from the survey are generally conservative, taking into account the balance of customer usage, and only the impacts of active members. Nevertheless, these results show that vehicle ownership impacts are multiples of the number of car2go vehicles deployed.

The vast majority of respondents indicated that car2go did not result in a vehicle sale or a postponed purchase. Overall, car2go has a net vehicle reduction despite the fact that only a minority of the sample indicated a causal effect on vehicle holdings. The balance of these impacts is tilted considerably toward vehicle suppression.

One possible reason for this is the timing of this study relative to the shared mobility industry today (i.e., there are many shared modes now available, such as bikesharing, ridesourcing, etc.). At present, carsharing is a known option in many cities that people can opt into. Hence, it is likely that the suppression effect (in contrast to vehicles sold) will increasingly dominate the impacts found within large-scale studies on the impacts of carsharing and other shared modes in core urban areas.

The conclusions with respect to VMT are similar. The minority of people who sell and avoid a private vehicle purchase are causing the car2go VMT reduction, while the broader population does not appear to drive car2go for large distances. Even if assumptions regarding the amount of VMT displaced were further reduced, estimated net reductions in VMT appear to hold. This suggests that one-way carsharing is almost certainly reducing VMT overall, even though the magnitude of the reduction may not be precisely determinable. This is evident by the relatively low average mileage per customer driven on car2go vehicles, which is bounded between 75 and 150 miles per customer per year (on average) across the five cities studied. In Table 9 below, we provide a synopsis of the aggregate and city-by-city impact metrics from the study.

Table 9 Overview of car2go Results

Category	Calgary	San Diego	Seattle	Vancouver	Washington, D.C.	Five City Average or Aggregate
Percentage of car2go Population Selling a Vehicle	2%	2%	3%	2%	5%	2.70%
Percentage of car2go Population Suppressing a Vehicle	9%	10%	9%	10%	7%	9.35%
Estimated Vehicles Sold per car2go Vehicle	2	1	3	2	3	2
Vehicles Suppressed per car2go Vehicle	9	6	7	7	4	7
Estimated Vehicles Sold	982	445	1,619	1,571	1,832	6,449
Estimated Vehicles Suppressed	5,076	2,486	4,696	6,672	2,776	21,706
Estimated Vehicles Removed	6,058	2,931	6,315	8,243	4,608	28,155
Estimated car2go VMT / yr	5,221,000	2,032,000	6,126,000	9,108,000	3,624,000	26,111,000
Estimated Annual Net Change in VMT [Upper Estimate]	-32,955,000	-20,012,000	-34,287,000	-37,505,000	-21,392,000	-146,151,000
Estimated Annual Net Change in VMT [Lower Estimate]	-9,440,000	-6,089,000	-12,160,000	-11,044,000	-10,647,000	-49,380,000
Estimated Annual Net Change in GHG Emissions (t/yr) [Upper Estimate]	-8137	-5371	-9080	-10027	-6512	-39,127
Estimated Annual Net Change in GHG Emissions (t/yr) [Lower Estimate]	-2899	-2270	-4152	-4133	-4119	-17573
Estimated Annual Net Change in GHG Emissions per car2go vehicle (t/yr/veh) [Upper Estimate]	-14	-13	-14	-11	-10	-12.7
Estimated Annual Net Change in GHG Emissions per car2go vehicle (t/yr/veh) [Lower Estimate]	-5	-6	-6	-4	-7	-5.5
Percent Reduction in VMT per car2go household [based on Upper Estimate]	-6%	-7%	-10%	-16%	-16%	-11%
Percent Reduction in GHG per car2go household [based on Lower Estimate]	-4%	-6%	-10%	-15%	-18%	-10%

While car2go one-way carsharing operations within the five cities studied were estimated to add between 2 and 9 million miles of driving to urban roads, that mileage is a fraction of the personal mileage estimated to have been removed by vehicles sold and suppressed. There is a degree of uncertainly to this estimate, particularly with respect to the mileage eliminated due to vehicle suppression. Nevertheless, even if very conservative estimates of annual VMT on suppressed vehicles are applied, the net impact of car2go's one-way carsharing would still be a reduction in VMT overall. The analysis here finds that car2go would have a net zero impact on VMT if all personal vehicles estimated to be sold and suppressed by active members were driven a little less than just 1000 miles per year. This is far below the reported annual VMT of average sold vehicles and far below the average annual driving of personal vehicles. These impacts also translate to a reduction in the GHG emissions associated with gasoline not combusted as a result of reduced driving. When considering reductions as represented by the 80% suppressed mileage estimate, VMT of car2go households is estimated to fall by -6% to -16%, and for GHG emissions, by -4% to -18%. Overall, the results of this study suggest that car2go one-way carsharing is having a notable impact on travel behavior, miles driven, GHG emissions, and the number of vehicles on the road within operating regions.