Evaluating the Effect of Car-Sharing: Exploring the Gap Between What We Know vs. What We Need to know and Its Effect on Optimism Bias

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Word count: 5997, with 2 Tables and 4 Figures

Abstract

Carsharing in the United States has been a focus of study and research for more then a decade. Its proponents argue that carshare adoption will reduce VMT in cities and can serve as a travel demand management policy. However, no comprehensive forecasting of carsharing impact has been done and most of the evidence is based on evaluation studies of new carshare projects. This paper focuses on the gap between the available data and knowledge and the required data and knowledge. The study demonstrates how the data and knowledge gap contributes to optimism bias about the expected impact of carsharing as a TDM policy.

1. Background and motivation

Travel demand management policies, or TDM, have been an important tool in the effort to reduce vehicles-miles traveled (VMT) for more than three decades. Forecasting the effect of travel demand management policies is a challenge as old as the policies themselves. The term “Travel Demand Management” was coined in the 1970s. It is used to describe a wide variety of policies that focus on changing travel behavior and reducing car use on the existing transportation network (Meyer, 1999). Early attempts to forecast the effects of TDM policies were generally too optimistic, and policies failed to deliver the promised behavioral change (Giuliano, 1992; Bae, 1993).

This paper will focus on carsharing, a short term car rental service. Carsharing is a relatively new TDM practice first introduced into North America in the 1990s.

Although it is perhaps too early to tell if carsharing will live up to expectations, enough forecasts have been published to warrant an examination. In this paper I will review the evaluating and forecasting efforts conducted to assess the impact of carsharing. I will examine the changes in studying carsharing impact over time and analyze the potential biases in forecasting its impact as a TDM policy.

Studies of the impact of carsharing include evaluation studies of existing carsharing programs that focus on actual current performance and forecasting studies that focus on prospective performance. By applying the evaluation results as a hint to future performance, the forecasts can be qualitative and general; conversely, by using pure theoretical models or data from evaluation studies, such studies can be quantitative.

The research hypothesis explored in this paper argues that the forecasting (both quantitative and qualitative forecasts f the policy impact) of new TDM policies are likely to be biased in the direction of being overly optimistic as a result of incomplete data. Possible drawbacks of policies are initially ignored or evaluated qualitatively, while their potential is forecast quantitatively. I also argue that the forecasting process is evolutionary as new forecasts are based on data and knowledge accumulated to that point in time. The method used in this study involved the review of carsharing impact works and a meta-analysis of their components and predictions.

2. Carsharing as a TDM policy

Carsharing is a short-term car rental service in which service members can rent a car and pay per hour or mile of use. Carsharing has been used in Europe for many years and is marketed by its promoters as a sustainable TDM policy based on three arguments (Shaheen,1998). First, carsharing is promoted as the missing link between public transportation and private vehicles (Cooper et al., 2000). Secondly, carsharing is represented as a way to change goods (the vehicle), into services, i.e. mobility.

(Manzini and Vezzoli, 2002). Thirdly, carsharing is a way to move from fixed costs to variable costs (Steininger, et al, 1996). The suggested positive effects of carsharing are based on the assumption that it will substitute for the use of private cars, but it is also possible that carsharing may increase the use of private vehicles by improving their accessibility. Additionally, carsharing's positive effect of substituting for private vehicles might be counter-balanced by substituting for public transportation and non- motorized trips.

Forecasting the effect of carsharing as a TDM policy is valuable to public policy for two main reasons. First, as part of a future transportation planning process carsharing can reduce VMT, emissions, and energy consumption. Second, according to Shaheen et al (2004), who studied carsharing programs in the US, most of the carsharing operations received public support, both as direct funding from local or federal sources and as parking or other subsidies. This support has been justified based on the positive effects attributed to carsharing.

2.1 Evaluating the effect of a TDM policy

There is more than one way to measure the effect of carsharing as a TDM policy. Possible measures include car ownership changes, the number of private vehicles replaced by a single carshare vehicle, and the numbers of carshare members and vehicles. However, for many policy purposes VMT change is the most relevant measure, while vehicle numbers are only a proxy for it. VMT is probably the most challenging to evaluate and forecast. The evaluation and forecasting of the total VMT change is required, both in order to integrate carsharing into the transportation planning process as a TDM or as a travel control measure (TCM), required as a part of the air quality planning process as a strategy for reducing regional emissions by reducing VMT. Forecasting the VMT change generated by carsharing is also a crucial step in a cost benefit analysis required to justify public investment. VMT reduction is a simple measure that allows assessment and comparison of different policies with different major effects on travel behavior (Ferguson, 2000).

2.2 Forecasting VMT Impact of Carsharing: An ad-hoc Gold Standard

What do we need to know in order to evaluate the VMT reduction effect of carsharing? There is no gold standard for evaluating the impact of carsharing as a TDM policy. According to Singelton and Straits (2005), establishing causality in social science that is not based on experiments is usually based on three requirements: association, direction of influence, and nonspuriousness. Theoretically, all three requirements can be studied simultaneously, but for technical as well as practical reasons, and as a result of knowledge gaps, establishing association almost always precedes the other two criteria. Moreover, establishing nonspuriousness may be an almost impossible task of ruling all out possible external effects. The process of establishing causality generally reduces the quantitative estimations of a policy's benefits, as each inquiry into the time order or spuriousness questions tends to reduce the originally demonstrated association as presented in Tal (2008).

In order to create an *ad hoc* standard for assessing the quality of the evaluations. I will use three types of authority: legal, scientific, and expert knowledge. The legal source is the regulation and guidelines for estimating travel activity effects of TCMs. The scientific source is the commonly used social science research methods as found in social science research methods text books. Expert knowledge, the third authority source, is simply a review of what the experts in this field see as needed data.

The methodologies used in evaluating TCM measures are mostly focused on estimating the aggregate change in travel and do not focus on methods of estimating the travel behavior change. In contrast, the number of users or the elasticities are estimated

externally predominantly based on observed behavior.[1] The basic structure by which both TCM methods and experts engage the question is:

Total VMT reduction= ƒ(#people, VMT/person)

Based on questions raised by Steininger et al, (1996), The first set of questions involves the level of attraction to carsharing, as well future market for carsharing. The second set of questions involves how a given level of carsharing will affect travel behavior, primarily by mode split, car ownership, and VMT. A forecast of carsharing's effects as a TDM policy is a function of the combination of these sets of questions for a specific time and location. A specific forecast that targets a year and location addresses the two parts simultaneously. In a specific forecast, the travel behavior changes are estimated simultaneously with the market based on the same population. A general forecast may use an *ad hoc* estimation for one part of the equation in which a different population is used for each part.

The gold standard for evaluating actual VMT change per person is an experiment that can provide evidence of causation between the carshare use and VMT change. A full experimental design includes a random assignment of the population to a treatment and control group, a pretest and at least one post-test (Singleton and Straits, 2005). In the case of carsharing, an experiment of this type would need to include recruitment of a representative sample, measurement of the sample's vehicle use, random assignment of one group to a carsharing program, and measurement again of both groups after some time has passed.

[1] See for example **The Use and Evaluation of TCMs**. Texas Transportation Institute, Research Report 1279-6. September 1994; **TCM: Methodology Matrix**. U.S. Environmental Protection Agency, 1998.

A third part to the gold standard of evaluating carsharing is the ability to generalize and forecast the VMT reduction based on the two components presented above. A forecast requires a simultaneous analysis of both components in which the same population will be analyzed.

The research hypotheses in the next section will focus on the process of evaluating carsharing as a new policy. It will also discuss how the process of getting to the ideal forecast using the suggested gold standard may lead to estimates that are being overly optimistic biased.

3. Research Hypothesis

Research over the last three decades suggests that forecasts for new policies aimed at changing travel behavior are usually optimistic. However, there is limited direct evidence of such overestimation bias, as most of the research in the field is focused on the performance of the policies rather than on the quality of the forecasts. The accuracy of travel demand forecasts is rarely the subject of rigorous study, nor is it usually considered as the primary motivation for model improvement.

According to previous work by Tal (2008) the accumulation of knowledge, data, and experience led to a decline in the forecasted effect of telecommuting. The case of telecommuting establishes a correlation between the model type used and an overestimation in policy forecasts. In telecommuting, there was a reduction in overestimation over almost three decades that can be attributed in part to both improvements in knowledge gained and improvements in methods. Based on the telecommuting example, the hypotheses for the case of carsharing suggest only partial

forecasts (those based on the potential market size), will be presented and that these will be overly optimistic.

Evaluating the impact of TDM policy is a scientific process, using social science methods, that aims to establish causality in non-experimental contexts. The study of the impacts of a TDM policy such as carsharing is a deductive process that starts from a theory about the effect of carsharing on travel behavior (Cooper et al., 2000; Manzini and Vezzoli, 2002; Steininger, et al., 1996). Hypotheses are then created and tested based on the theory, usually by measuring the actual behavior of carshare users.

Sources of overestimation are varied and can be divided into two components: tools and methods, and deliberate biases. The hypotheses presented in this paper are focused on the effect of methods and tools only. The methods I am focusing on include modeling and forecasting tools, types of data collected, types of questions asked, and the possible effects that are being modeled.

My first hypothesis is that forecasts based on early evaluation of the impact of carsharing as a TDM policy will be overly optimistic due to both the partial framing (i.e. focus on only one part of the *ad hoc* model presented as a formula above and assuming the maximum potential on the other), and due to lack of data or knowledge.

I also hypothesize that in initial forecasts, the potential is calculated based on the behavioral change (which is the policy goal), the assumption that every individual who will theoretically gain from the new policy will actually adopt it, and the belief that early adopters of the policy reflect the behavior that can be expected from later users. In forecasts based on this approach, the policy potential is modeled quantitatively while

possible limitations that will prevent adoption are described qualitatively because of a lack of data, or left out altogether because of a lack of knowledge.

In the case of telecommuting, I found that the first forecast initiated the collection of new sets of data and knowledge, as well as the creation of new modeling and forecasting processes. Both of these factors reduced the first model's overestimations by discovering behaviors that were different from what was expected. Given that carsharing evaluation is a more recent innovation than telecommuting, I expect to find early studies that demonstrate similar potential drawbacks and that can then be translated to lower forecasts.

4. Research method

The history of evaluating the effect of carsharing in the United States is only about a decade old and the number of studies devoted to these forecasts is limited. Nevertheless, research into this policy yields a significant number of papers and reports that aim to study the effect of carsharing on users and to study its market. I will focus only on neighborhood carsharing, which is not affiliated with a public transportation activity or a specific public institute, and which is the most common and studied type of carsharing. The dataset for this work includes published reports and scientific papers evaluating carsharing impact in the United States. It is also includes reports published by carsharing companies, but only if they were previously used in a scientific report or a published paper.

The dependent variables in this study are the impact evaluations and forecasts (qualitative and quantitative) of carsharing as a TDM policy. There are three categories in this group. The first is the type of variable used in the study to demonstrate the impact of

carsharing. This variable can have the value of total VMT reduction, or VMT reduction per vehicle. The second category involves the impact on the user, such as measures of travel behavior changes for users from households with or without vehicle availability.

The sources of data on the performance and impact of carsharing forecasting vary in method and in level of detail reported. The analysis data presented in this paper is limited to papers and reports that detailed their study methods and to data that, if not accompanied by a detailed report, were cited and used by another paper or study. I am also using averages from other studies that were cited and published as a result of another report or paper. The motivation to use this set of data is based on the assumption that this is relevant data that will be used by policy makers, decision makers, or planners to evaluate the effect of carsharing as a TDM policy.

The explanatory variables are focused on the tools used to create the forecasts. I used three different dimensions to create a typology categorizing the forecasting tools and the questions and assumptions made. First, I distinguished between forecasts that focused on the market only, on travel behavior only, and on correlated (i.e. used the same population for both) forecasts of both issues. The second classification is based on Salomon (1998), who classifies TDM forecasts as deriving from 10 different methods. Of these 10, I will use seven that are relevant for carsharing. Salomon's typology considers both qualitative and quantitative methods to evaluate the effect of a policy: (1) assuming the current number based on theoretical framework, (2) using empirical studies in which a theoretical framework is followed by data gathering, and (3) using a case study or demonstration project, current levels can be estimated, scenarios built, or forecasts generated. The forecasting methods include: (1) using scenario building, (2) using

projections to a maximum future point, (3) presenting the maximum potential under ideal conditions, and (4) using "what if" assumptions. Analyzing the research question, or the stated problem the study is based on, will constitute the last part of the data gathering. The classification of the research question will be based on organizing each research question by the knowledge needed to answer the question, as demonstrated by Tal (2008).

5. Studies on Carsharing in the United States (The story of forecasting carsharing)

In the past decade, carsharing in the US has been a subject open to fairly extensive research by the federal and local governments. Nevertheless, according to a 2005 TCRP report, knowledge of the effects of carsharing as a TDM policy is something more based on speculation than on fact (Millard-Ball et al, 2005). More recent work published between 2005 and 2008 does not dispute this conclusion, but focuses on the less studied area of market size for future users. In this section we will review the efforts to study the impact of carsharing in the United States, in order to explore the deficient data and knowledge based on the presented methodology and research question.

In the case of carsharing, implementation precedes systematic study of the potential impact of the program. A single project, the Short Term Auto Rental, or STAR demonstration project, was implemented and studied in San Francisco from 1983 to 1985. The STAR study (Walb et al, 1986), based on approximately 120 households, attributed a reduction of 12.3% in vehicle ownership to the carsharing project availability.

A decade after the closure of the STAR program, carsharing became popular enough in Europe to allow similar studies of carsharing operations. Europe was the main

source for estimating the effect of carsharing in the late 1990s. Steiner et al., (1996) analyzed the travel behavior of Austrian carshare members before and after they joined the service. The study also analyzed the potential market, concluding that carsharing could be used by 9% of Austrian households. According to this paper, carsharing increased the VMT of households without vehicles by 118% and reduced the VMT of households with vehicles by 62%, to create a combined reduction of 46.8%, or 2.7% of the urban VMT if full market potential was met. Shaheen et al. (1998) reviewed and summarized carsharing studies from Germany and the Netherlands, and reported a travel reduction in the Netherlands of 37% for former car owners, and a reduction of travel in Germany by 58% after carsharing was introduced.

A different approach, of aggregate analysis of the potential market size of carsharing, was conducted by Litman (1999, 2000), who estimated that, based on location and VMT traveled per year, about 6% of privately owned vehicles could shift to carsharing. The VMT reduction potential would be much lower, as potential vehicles are those which average less than 6000 miles per year.

Katzev (1999) analyzed the Portland Carsharing program in its first year. The result shows members drove more after joining the program mainly as a result of non-vehicle owners who traveled from 0.3 miles a week to 25 miles, while vehicle owners dropped from 103 to 84 VMT per week. Copper et al. (2000), analyzed the travel behavior of the same program and concluded t the total VMT reduction by the user was 7.6%, with a 25% reduction among vehicle owners and a 19% increase in VMT among non-vehicle owners.

In 2002, Cervero started a four year project evaluating the effect of San Francisco's new carshare program that includes surveys and travel diaries from both users and a control group (Cervero et al. 2002, 2003, 2004, 2005, 2006, 2007). Similarly to previous case-study carsharing research, Cervero focused on the characteristics and travel behavior of the carsharing user, which comprises a small sample for the purpose of statistical analysis. Unlike previous studies, this set of studies was the first to try to control for periodic factors and other external variables besides carshare use that might affect travel behavior The main unanswered question is still whether carshare users change their travel behavior because of the carsharing program, or if people who change their travel behavior because of external reasons choose to use carshare.

A similar study, based on a survey without a control group, was conducted in Philadelphia in 2003 (Lane, 2005). The author concludes that, in aggregate, VMT was reduced, and that each shared vehicle helped to remove 23 vehicles during the program's first year.

Based on the evaluation of early case studies, Schuster et al. (2005) developed a Monte Carlo simulation to forecast the market size of carsharing in Baltimore, Maryland. This base-case analysis was based on identical travel patterns for private car owners and carshare users. Additional analyses were based on the assumption that carshare users would reduce their VMT by 25%, according to Cervero et al (2004), or by 50%, according to European data suggested by Steiner et al. (1996). A 25% VMT reduction resulted in carsharing being cheaper than private vehicles for 6.87% of vehicles, and a 50% reduction in VMT resulted in carsharing being cheaper for 12.42% of vehicles.

A comprehensive study that includes several research methods and a survey of current knowledge, conducted by the Transit Cooperative Research Program, was published in 2005. The study assessed the impact of car-sharing on parking demand, vehicle travel, air quality and mobility for low-income households. Millard-Ball et al. (2005) argued the most important impact of carsharing, and also the best documented, is vehicle ownership reduction.

Between 2005 and 2008, more studies and reports focused on operating carsharing services and focusing on current market segments and carsharing users travel behavior. The research methods used varied from interviews and surveys of carsharing managers (Androw et al, 2006; Shaheen et al., 2006) to a case study analysis as performed in the longitudinal study by Cervero et al (2007).

The data and knowledge accumulated from different studies and reports allow an overview study that includes some kind of meta-analysis of both the data collected and the knowledge collected among carshare experts. Shaheen et al. (2007) reviewed and compared evidence on carshare use around the globe. The review included peer reviewed scientific publications alongside reports and carshare providers' press release internet brochures. The VMT reduction per user in North America was reported to be between 7.6% and 80%.

The literature reviewed in this section suggests a broad effort to assess the market and impact of carsharing in the United States in the last decade. The methods and main focus of each study are presented in Table 1, Most of the studies are focused on evaluation of the travel behavior change and less on the market size. The studies on market size use primarily "maximum potential" and "what if" methods. Some shorter

studies and reports, mainly from carsharing companies, were not reviewed in this section but were often used and cited in the reviewed works. In spite of the large number of publications found that were dedicated to study carsharing, only a limited number of quantitative forecasts presented the demand and effect of carsharing. In the next section I will analyze these forecasts and methods used.

Table 1: Forecast and Evaluation Studies of Carsharing

		Research focus		Evaluation study methods		Forecasting method			
Study year	**First Author**	**Travel behavior**	**Market size**	**integrating empirical studies**	**case study or demonstration project,**	**maximum potential**	**projections**	**"what if"**	**empirical behavioral studies**
1986	Walb	+			+				
1998	Shaheen	+	+	+					
1999	Katzev	+			+				
2000	Copper	+			+				
2000	Litman	+	+			+		+	
2003	Cervero	+			+				
2005	Schuste		+			+		+	
2005	Millard	+	+	+		+			
2005	Lane	+			+				
2006	Cervero	+			+				
2007	Cervero	+			+				
2006	Shaheen			+					
2007	Shaheen		+	+			+		
2007	Celsor		+			+			
2008	Zhou		+	+	+				+

6. Forecasts of the Market and Effect of Carshare as a TDM Policy

More than a decade after the initiation of modern carsharing services and subsequent studies researching its effect in both the United States and the entirety of North America, a considerable body of quantitative data has been published about the demand and travel effects of carsharing. In 1996, Steininger et al., argued that carsharing in Austria had the potential to reduce the urban VMT by 2.7%. None of the published studies in North America focused on forecasting carsharing impact as a TDM policy by reporting on

aggregate or regional expected VMT reductions, as presented in the European example, and only partial data implied this effect.

Only a limited number of studies used the general population as their target group, focusing on all potential carshare users. The majority of studies used carshare users, or potential users that already expressed an interest in the service, as their reference group. The forecasts of the carshare potential market from the general population used different econometric methods to conclude carsharing had the potential to replace 6% of all privately owned vehicles or 6.9% to 12.4% of Baltimore's vehicles (Litman, 2000; Lane, 2005).

The studies that focus on travel behavior changes usually report changes in vehicle ownership after joining a carshare program, as well as a change in VMT. The VMT reduction is usually reported for all users, and in some cases, for two different user groups: the group of users with vehicle accessibility and the group of users without vehicle accessibility.

Figure 1 presents the VMT change per carshare user in the United States as reported by 8 studies between the year 2000 and 2007. The studies include disaggregate case studies of users' self-reports or travel diaries before and after they joined a carshare program, and with and without a control group combined with meta-analysis of commercial or other data. All of the studies are based on revealed behavior and suggest a lower VMT reduction in early years and a higher VMT reduction over time. The first interpretation, suggested by Cervero et al. (2006), for this phenomenon suggests the novelty effect of carsharing created more driving. This phenomenon can be also explained by the possibility that higher percentages of early adopters were people with

low vehicle availability, and therefore, that the carshare program allowed them to drive more. Both explanations suggest a strong correlation between VMT reduction and vehicle availability. When a population with low car availability joins a carshare program, VMT will increase, and when a population with intentions to reduce the number of vehicles per household joins a carsharing program, total VMT will decline.

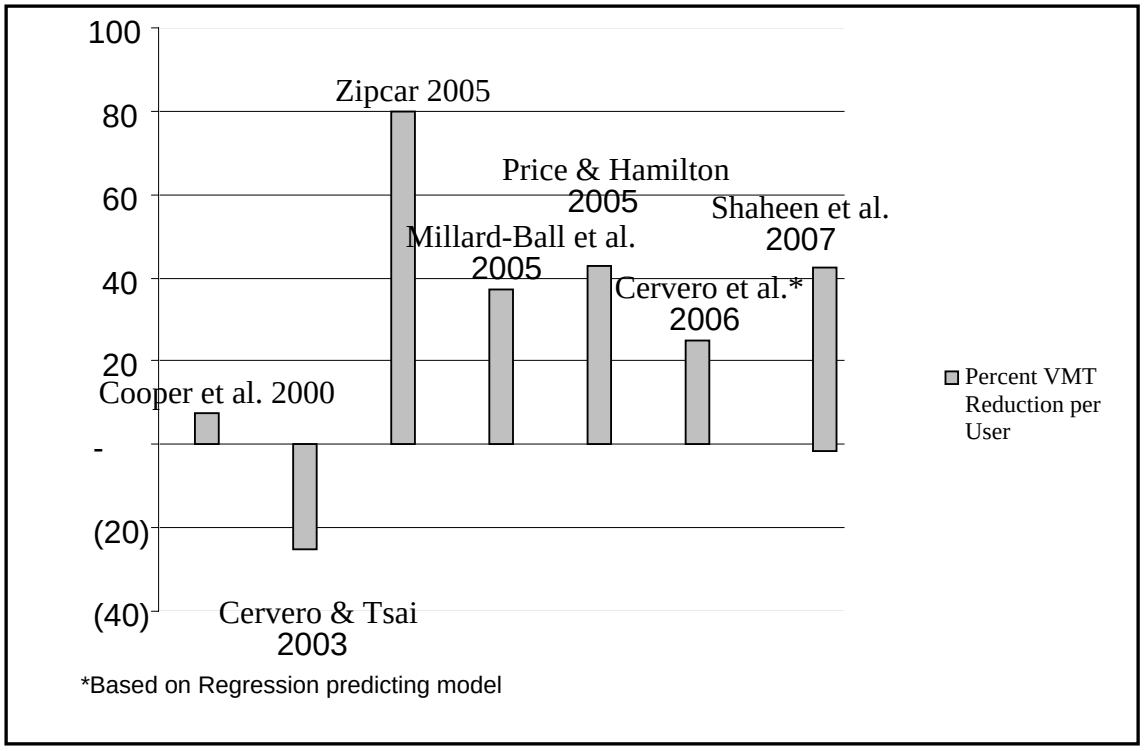

Figure 1: VMT Reduction per Carshare Member

The most commonly used indicator in studies on the effect of carsharing is the number of users who reduced their vehicle ownership level. The methods used are based on different aggregations of actual behavior shown in several single case studies, aggregations by carshare corporations and a meta- analysis of other studies. The cases reported in Figure 2 are partially based on Millard-Ball et al (2005).

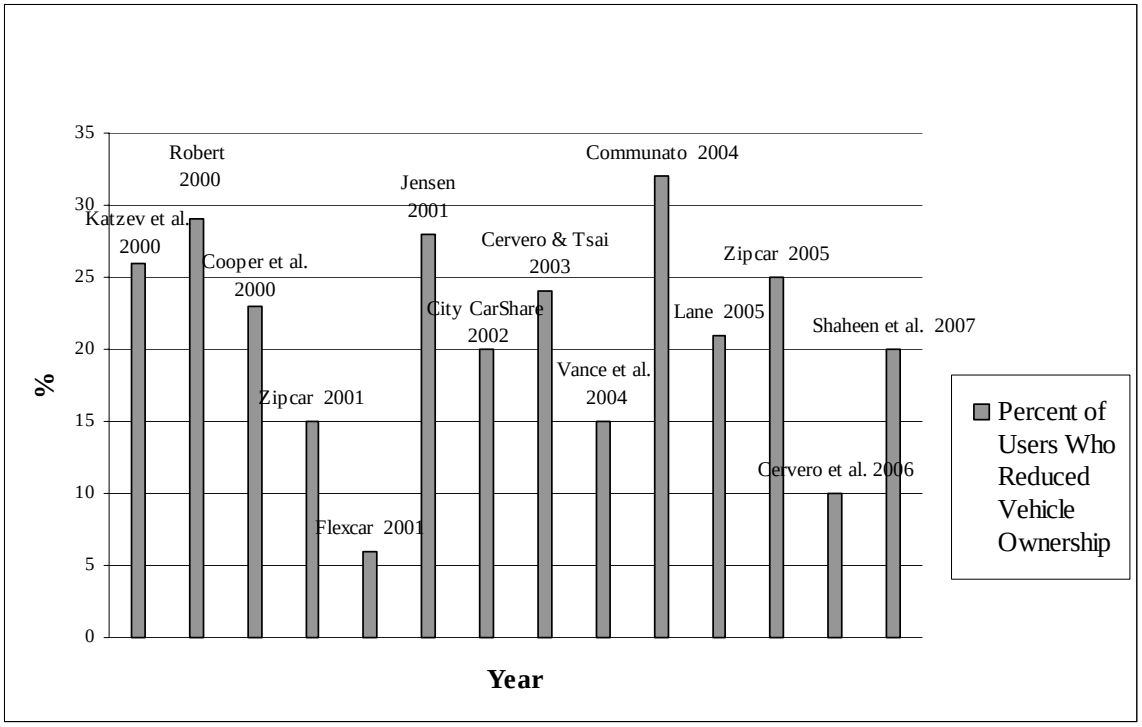

Figure 2: Carshare Members Vehicle Ownership Reduction[2]

A third commonly used way to present the effect of carsharing is by determining the number of vehicles sold per carshare vehicle. This variable divides the reduced number of vehicles owned by carshare members by the number of carshare vehicles available to this group (Figure 3). The sample sizes in these studies are small, ranging from only a few carshare vehicles to not more than a couple dozen. The aggregate sample size of all studies is unclear because of some missing data, but in most cases, the carshare user sample is from a couple of dozen to two hundred users.

[2] Partially Based on Millard-Ball et al., (2005).

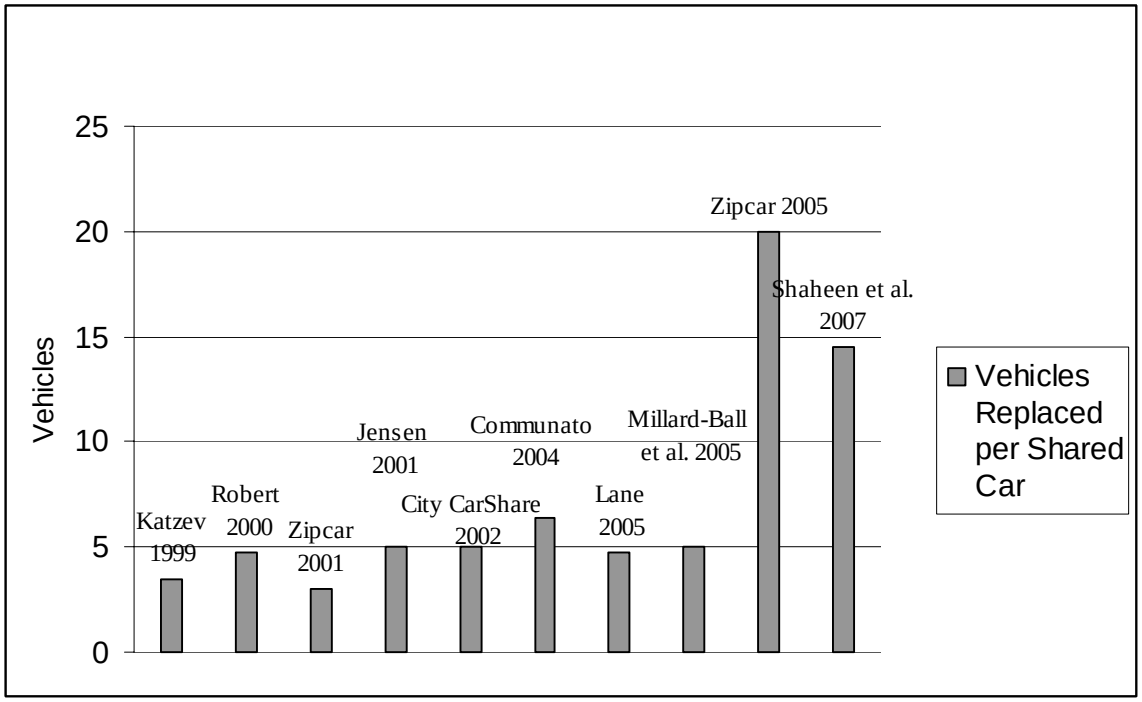

Figure 3: Vehicle Replaced per Shared Car[3]

A vast majority of the studies and papers reviewed in this paper conclude, based on the evidence presented, that carsharing has a significant positive effect as a TDM policy, though some argue more studies are needed to assess its magnitude. Shaheen, (2007), for example, argues that: "unfulfilled market potential in new and existing markets is expected to continue to drive carsharing expansion. It will be fueled by the ongoing diffusion of shared-vehicle awareness, expertise, and technologies, which will continue to support carsharing operations in most new and existing locations across the globe." Cervero et al. (2007) concluded that: "Evidence from the results of five surveys of City CarShare members and nonmembers clearly indicates a net reduction in the VMT and fuel consumption of carshare members." Lane (2005) stated that: "With results from Philadelphia, compelling evidence from more than one U.S. city now indicates the

[3] Partially Based on Millard-Ball et al., (2005).

successful potential of carsharing to encourage Americans in central cities to drive fewer and cleaner automobiles, drive fewer miles, and make travel decisions more judiciously."

It appears carsharing studies generate the expectation that carsharing will eventually have a significant impact on travel, where each new carshare vehicle will be used by between 13 to 25 new members, eliminate the use of 3 to 20 cars, and reduce driving time by around 20 to 40 percent. Can these expectations, derived from the most recent studies, be met? Or should we expect a higher or lower performance with the wider implementation of carsharing?

7. Discussion: Overestimated, Underestimated or maybe an Error

In 1999, Karen Worminghaus, the new Executive Director of Boulder Carshare Initiative, posted a question on the world carshare discussion web forum asking for firm data: "What is the actual VMT reduction that results from carshare programs?" and for a set of variables to help in forecasting the VMT reduction: "For instance, the following info is needed: The carshare program in (city name here) found that out of X number of people who initially said they were interested in joining the carshare organization, X (number or percentage) actually applied, and of those X (number or percentage) were accepted as members. Of those members, X report a decrease in motor vehicle use of X miles per week/month since becoming carshare members, etc." She also asked questions about forecasting the market size of carsharing: "How many members and vehicles did you start with? How many vehicles and members do you have now? What was your initial rate of growth? How has your growth rate changed?" These types of questions, asked by planning agencies and policy makers, lead research on carsharing, alongside questions from the business community that studies the potential market and

revenues. In the upcoming sections we will explore the research questions and the methods used to answer them, the way they change over time, and the potential effect of bias on the answers given.

7.1 Forecasting the Market Size

Forecasting the expected market of carsharing is a multi step process in which each step reduces the estimated market, as happened with telecommuting (Tal, 2008); this process is demonstrated schematically in Figure 4. To evaluate and forecast the effect of carsharing, it is crucial to have data on the market size, i.e. who can, who wants to, and who will? Estimating the market based only on one question, either “who will benefit?” or “who wants to?” as is being done with carsharing, will always result in overestimation. While all of the questions were raised qualitatively over the years, only a few were estimated or forecast, and none addressed all the subsets together. It might be that quantitative data is not yet available for a synthetic analysis of market size, and therefore, that any partial analysis based on a single set of questions will inevitably be overestimated.

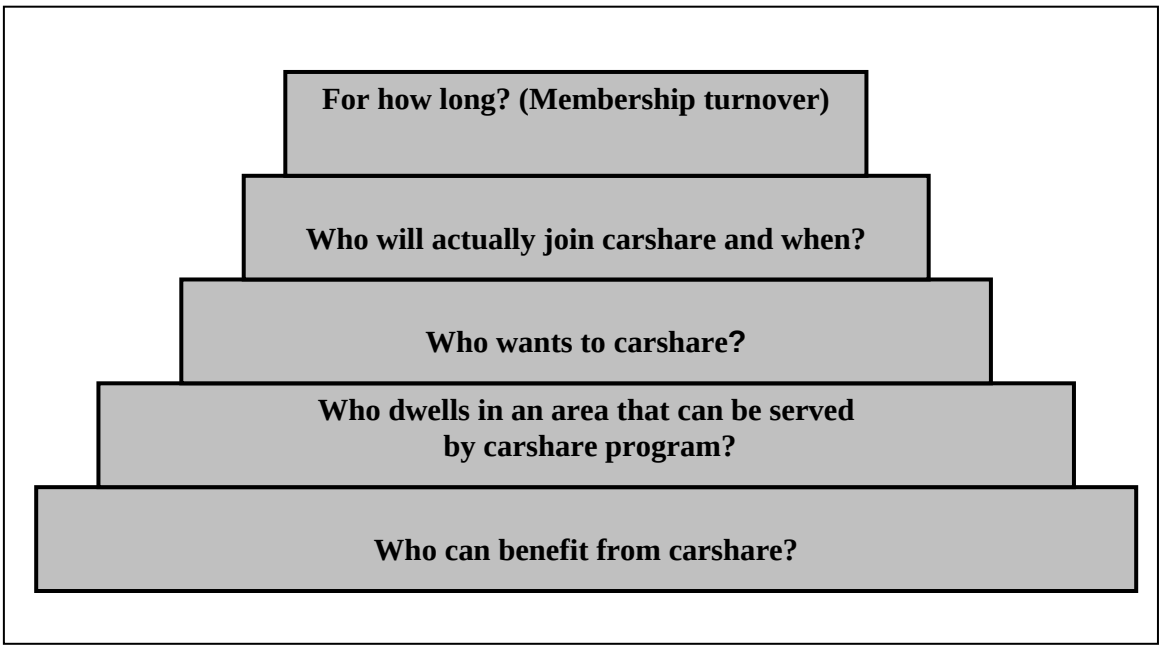

Figure 4: Forecasting Market Subsets

7.2 Forecasting Changes in Travel Behavior

The methods used to estimate travel behavior changes of carshare users are mainly based on actual behavior. Cervero (2004, 2006) suggested a forecasting model, but did not use it to forecast travel behavior of future users. All of the studies reported the average VMT change for the complete sample, and some reports added crosstab data on the VMT change of members with different vehicle ownership levels. The notion that the main motivation for change in VMT is vehicle ownership led some authors to report the change in two categories of users: those with or without vehicle accessibility, and to skip aggregate data.

Shaheen and Cohen (2007) argued the inconsistent results of carsharing impact given by studies can be partially attributed to the differences between the user populations, whether researchers are examining innovators, early adopters, or early majorities. The authors do not elaborate more on these groups or on the expected

correlation of each group with travel behavior. The results are based on the market size of current carsharing operations, which includes less than 4,700 vehicles in the United States and Canada together,[4] and based on studies that suggested carsharing had the potential to replace 4 to 12 percent of vehicles or at least to have a meaningful effect as a policy. Assuming carsharing has a potential higher than current levels, the travel behavior of current users may not reflect the travel behavior of the later users. Based on the potential market analysis and on the actual users' analysis, users join carshare services in order to reduce travel costs and/or to increase mobility. We can assume those first to use the service are those who gain the most from doing it, i.e. individuals with low vehicle availability and individuals who want to reduce travel expenses or the number of vehicles in the household. Early joiners may also reflect a higher environmental conscience. While those formerly without vehicles travel more than before, their total VMT change is small as it includes only the number of carshare trips they used. The other groups were shown to reduce their VMT more dramatically, mainly as the result of car ownership reduction (Lane, 2005; Cervero et all., 2006).

Later joiners to carsharing may wait to do so because they gain fewer benefits from the service. These people are less likely to change their travel behavior, reduce their number of vehicles, or drive less in general. Later joiners may do so because of the sporadic need of another vehicle, because of a need for a different vehicle type, or for a more available long-term car rental with higher availability and shorter waiting times.[5] It appears current users' VMT reductions may not materialize when later joiners start using

[4] Based on Shaheen et al., (2007) "Today, carsharing operates… share nearly 11,700 vehicles as part of organized carsharing services (>60% in Europe)" P1.

[5] See for example the discussion about Zipcar growth strategies into new markets. http://www.inc.com/magazine/20080301/how-fast-can-this-thing-go-anyway.html checked March 2008

carshare. Forecasting the VMT reduction expected from carsharing by using current behavior for a future market will most likely end up being overly optimistic.

7.3 Forecasting as a Social Science Inquiry

Analyzing the carsharing evaluations and forecasting on which forecasts are based as a scientific process reveals that the association between carshare users and VMT change and the association between carshare users and vehicle ownership reduction were both demonstrated quite extensively in the last decade. The time order question was addressed less intensively, especially the question of what happens first: the decision to reduce the number of vehicles in the household or the decision to join and use carsharing. In most cases the time order was addressed qualitatively by using focus groups or a survey with a very small sample size. The problem of nonspuriousness was partially addressed by Cervero at al. (2003-2007) by using an experimental method that included a control group. The nonspuriousness question was not fully answered because individuals were not randomly assigned to the treatment and control groups and thus the different characteristics and travel needs of the carshare users, who changed from one survey to the next. External effects such as changes in gas prices, parking scarcity, and household characteristic may affect carshare use and travel behavior simultaneously, and create a spurious effect. The main problem left unanswered in this case is the selection bias in joining to the carshare program. Theoretically, all three causality requirements can be studied simultaneously, but in most cases establishing association will have to precede the other two criteria. Moreover, establishing nonspuriousness may be difficult task of ruling out all possible external effects.

The process of establishing causality reduces the quantitative estimations of a policy's benefits, as each inquiry into the time order, or the spuriousness questions, reduce the original demonstrated association. In the case of carsharing questions such as "how many users are reducing the number of vehicles regardless of carsharing?" or "how many people joined carsharing because of an external event that caused a change in travel behavior?" always lower the initial demonstrated association that attribute the full change to the impact of carsharing.

7.4 Expected Change in Evaluation and Forecasts Method

The discussion up to this point suggests that the questions asked at the early stages of estimating the impact of carsharing create a partial and overly optimistic picture. This is because the knowledge about the potential users will be incomplete and any new question to be answered (i.e. subset to be estimated) will reduce the initial potential. Also, the partial data about VMT change, with respect to the *ad hoc* gold standard, creates an overestimation bias as the association between carshare users and VMT change is the upper bound (the maximum potential) and any additional study to establish causality will reduce these estimates. As can be inferred from Table 2, overestimation has the potential to be reduced over time with the accumulation of additional knowledge and data.

Table 2: Method Changes Over Time

	Timeline	
	New Policy	**Over Time**
Market size	Quantitative Aggregate "Potential"	Analysis of market subsets Behavior disaggregate
Travel behavior (VMT reduction)	pilot studies analysis of users	Analysis of causality and "Limitations" Analysis of potential users

This difficulty was probably known to the researchers, and may explain why no attempt to forecast VMT change was made. It may be clear to the researchers that the data and knowledge are not sufficient for this type of forecasting, and that most of the data deficiencies are known and have been raised qualitatively, but have not been answered quantitatively. There are two reasons for the lack of models and studies that will allow relatively unbiased forecasts. The first reason is the relatively short time period carsharing has been studied in the United States. The limited resources and relatively short time frame has not allowed for the necessary knowledge and data to be collected, but these deficiencies will be corrected over time. On the other hand, what if the researchers prefer to present only a partial picture that favored carsharing? This may be the case, as the vast majority of the papers support implementation of carsharing prior to the quantitative analysis of its benefits. An adequate analysis of the researchers' possible motivations and effects of their biases on the forecasting and evaluating process would require a separate study. Nevertheless, it is clear that evaluations and forecasts based upon partial data and incomplete knowledge as discussed in this section will be biased in the direction of being overly optimistic, regardless of the authors' intentions.

8. Conclusions

Although there has been a decade of studying the impact of carsharing in the United States, only evaluations of users' behavior and potential market size analysis have been published. The validity of carshare as a travel reduction measure is still not clear in spite of the optimistic results, and analysis presented in this paper questioned the optimism presented in these studies. As presented, early quantitative analysis of carsharing was inevitably biased and overly optimistic. The overestimation van be reduced by using the

process of scientific enquiry suggested in this paper. This process will produce valid forecasts that are most likely lower then the initial estimations. Comparing carsharing to telecommuting, it may take at least a decade to come up with a credible forecast that will take into account quantitative issues that have already been raised qualitatively.

I believe the phenomenon presented in this paper is not unique to carsharing or telecommuting or even to TDM policies alone. Optimism plays an essential role in starting, developing, and disseminating new policies, triggering a process of scientific inquiry The effect of new policies can be only qualitatively estimated, based on limited data that usually points to the policy's potential. These phenomena create an almost unavoidable overestimation of the effect of new policies that will diminish over time.

Policy makers and policy analysts need to pay attention to the level of "ripeness" of forecasts, and to encourage the engagement of skeptical forces in the process. They also need to be aware of the lengthy amount of time it will take to model behavioral change, and the fact that early forecasts will be optimistically biased.

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