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ONE-WAY CARSHARING'S EVOLUTION AND OPERATOR PERSPECTIVES FROM THE AMERICAS

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ABSTRACT

Classic roundtrip carsharing has been documented as a strategy to reduce car ownership and vehicle miles/kilometers traveled in urban areas. The expansion of carsharing and other forms of shared-use mobility have led to a growing interest in understanding the latest models. In recent years, one-way carsharing has gained momentum across the globe with 18 operators providing services in ten countries worldwide. One-way carsharing does not require its users to return the vehicle to the same location from which it was accessed (in contrast to roundtrip carsharing). Users typically pay by the minute versus the hour and do not require a reservation. There are two one-way models: free-floating and station-based. Free-floating carsharing allows vehicles to be picked up and left anywhere within a designated operating area, while station-based requires users to return vehicles to an available station. In Fall 2013, the authors conducted a survey of 26 roundtrip and five one-way carsharing operators in the Americas (U.S., Canada, Mexico, and Brazil) to understand their perspectives on one-way carsharing and its future. Almost 70 % of roundtrip operators viewed one-way carsharing as a complement to roundtrip carsharing, while 19 % viewed it as a competitor. Twelve percent perceived it as both a complement and competitor. Operators noted public transit, smartcard, and electric vehicle integration as key to this model's expansion. Half of respondents believed one-way and roundtrip carsharing have similar social and environmental impacts. Given limited understanding of its impacts, more research is needed to document the benefits of one-way carsharing and to help inform policymaking and urban mobility.

KEY WORDS: roundtrip carsharing, one-way carsharing, free-floating, station-based, survey

INTRODUCTION

According to the Global Health Observatory (GHO) of the World Health Organization (WHO), urban population growth has reached a critical apex. Since 2010, the majority of the world's population lives in cities. By 2050, GHO expects the urban population will almost double, increasing from approximately 3.4 billion in 2009 to 6.4 billion (WHO 2013). Given population growth, many experts are concerned that urban travel patterns are likely to threaten the viability of cities due to traffic congestion, air pollution, and vehicle-related accidents.

For many decades, local and regional governments have tried to curb travel demand and/or limit vehicles in urban areas. Initiatives have risen to discourage drivers by reducing parking and roadway supply and employing road-pricing measures. Typically, pricing policies target "choice" trips in cities but cannot tame unavoidable ones. Thus, alternative transportation solutions are critical to providing solo driving options.

One solution to reducing single occupant vehicle trips is shared-use mobility (e.g., carsharing, bikesharing, ridesharing). Carsharing is generally defined as short-term vehicle access among a group of members who share a vehicle fleet that is maintained, managed, and insured by a third-party organization. It is typically provided through self-service vehicle access on a 24-h basis for short-term trips. Rates include fuel, insurance, and maintenance. There are several models: roundtrip carsharing (vehicles are accessed and returned to the same location), peer-to-peer carsharing (shared use of privately owned vehicles operated by a third-party organization), and one-way carsharing—the focus of this paper. For more information on carsharing models, see Shaheen and Cohen (2012). Note that one source of confusion is the use of the term "carsharing" as carpooling or ridesharing (i.e., the grouping of travelers into common trips by car or van) in the United Kingdom (UK) (Chan and Shaheen 2012). Short-term auto access in the UK is known as "car-sharing" or "car clubs."

A rapidly emerging carsharing model is one-way carsharing, which does not require users to return a vehicle to the same location from which it was accessed, thus allowing users to make one-way trips. Technology has played a major role in the growth of one-way carsharing, including smartphone applications, keyless vehicle access, in-vehicle and mobile global positioning system (GPS) receivers, and hybrid and electric vehicles (EVs). One-way carsharing presents unique challenges, such as vehicle rebalancing and parking management. While one-way carsharing continues to expand, research on this mode is just beginning, particularly with respect to its social and environmental impacts. This paper provides an overview of the history of roundtrip carsharing, early one-way carsharing initiatives, and the current state of one-way carsharing worldwide. The authors also present the results of a Fall 2013 survey of one-way and roundtrip carsharing operators in the U.S., Canada, Mexico, and Brazil on their perceptions of the one-way model.

A BRIEF HISTORY OF ROUNDTRIP CARSHARING

Today's carsharing services are the result of a long evolution. In 1951, French engineer Jacques d'Welles forecasted the negative impacts of an excessive number of privately-owned cars on cities. He proposed the development of an electric small-sized car that members would share. It is surprising how close his conceptual idea of the optimum city car was to the current small-sized car adapted for city traffic (e.g., Autolib' Bluecar) (Welles 1951).

An early form of carsharing was introduced in Zurich, Switzerland in 1948, called "Sefage" (Selbstfahrergemeinschaft) (Schönbeck et al. 1992). It consisted of a club in which members shared the cost of a car, which was a luxury item at the time. This privately shared service, which was based on friendship and not on official agreements, operated for 50 years. The major motivation of early carsharing systems was to gain the benefits of mobility without the cost of automobile ownership (Shaheen et al. 1998). At the same time, it helped to reduce traffic in cities and offered an alternative transportation mode. In the 1950s, the chief objective was improving the well being of citizens through mobility. By the 1980s, growing concerns about pollution fueled its development. The first nation to reach an efficient and successful carsharing system was Switzerland. Mobility Car Sharing Switzerland was founded in 1997 through the merger of AutoTeilet-Genossenschaft (ATG) and ShareCom.

As of October 2012, carsharing was operating in 27 countries and five continents, with an estimated 1,788,000 members sharing over 43,550 vehicles. Carsharing was planned in seven additional countries worldwide. While carsharing began much later than in Europe, North America remains the largest carsharing region in terms of membership, with Europe and North America accounting for 38.7 and 50.8 % of worldwide carsharing members, respectively. Europe, with its lower member-vehicle ratios, still accounts for the majority of fleets deployed in 2012: 47.0 % in contrast to 36.2 % in North America (Shaheen and Cohen 2012a).

Numerous studies have documented the social and environmental benefits associated with carsharing. Studies of roundtrip carsharing in Europe have indicated that an average carsharing user’s carbon dioxide emissions were reduced 39–54 % (Rydén and Morin 2005). Martin and Shaheen (2011) conducted a North American carsharing survey of 6281 respondents in 2008, which revealed an average emission reduction for all respondents of 0.58 metric tons of greenhouse gas emissions per household per one year for the observed impact (based on vehicles sold) and a reduction of 0.84 metric tons over this same period for the full impact (based on vehicles sold and postponed purchases combined) or 31 % to 41 % per year for one household (mean observed and full impact, respectively). The roundtrip carsharing model has also documented that each carsharing vehicle reduces the need for 7–10 privately owned vehicles in Australia, 4–10 cars in Europe, and 9–13 cars in North America (Martin et al. 2010).

European studies indicate that between 15.6 and 34 % of participants sold a vehicle after joining a carsharing program (Shaheen et al. 2003). Similarly, North American studies indicate that between 11 and 29 % of participants sold a vehicle after joining carsharing, and 12–68 % delayed or postponed an automobile purchase (Shaheen and Cohen 2012). Martin et al. (2010) found that approximately 25 % of respondents sold a vehicle and roughly another 25

% of the total North American sample would have considered obtaining a vehicle, if carsharing disappeared. These two subgroups were mutually exclusive; those that shed a vehicle were not counted among those who would consider acquiring a vehicle.

European studies also indicate a large reduction in vehicle miles/kilometers traveled (VMT/VKT), ranging from 28 to 45 % (Shaheen et al. 2003; Rydén and Morin 2005). Martin and Shaheen (2011) found an average decline in VMT/VKT per year of 27 % (observed impact) and 43 % (full impact) in the before and after mean driving distance.

Members are motivated to use carsharing due to its cost savings (e.g., vehicle, insurance, fuel) and convenience. Schaefers (2013) explored various carsharing usage motives. In large cities, some members join a carsharing system to access a parking space, which can be challenging to find. Carsharing has proven to be an efficient transportation alternative, particularly when it complements existing transportation modes or supplements off-peak public transit services (Firnkorn and Müller 2011; Costain et al. 2012).

One-way carsharing has the potential to complement existing modes and provide social and environmental benefits. Given its recent growth, opportunities now exist to document its impacts.

EARLY ONE-WAY CARSHARING SYSTEMS

In this section, the authors provide a synopsis of early one-way carsharing programs and lessons learned, which began in the 1970s in Europe and in the 1990s in Asia and the U.S.

Experimentation in Europe: 1970s–1990s

One-way carsharing began in Europe in the 1970s through experimental programs. Procotip was launched in August 1971 in Montpellier, France with 35 cars and 19 stations. Members would buy tokens and place them in a “Tipmètre,” a kind of parking meter. In May 1973, the project filed for bankruptcy and suffered from technological issues (Biau 1991). Another program, Witkar, opened in Amsterdam in March 1974 with one-way trip making and EVs. Initially, 35 cars and five stations were created in the city center. An additional ten stations and 90 vehicles were planned but were never deployed. The service was terminated in 1986 due to a lack of governmental support, technological limitations, and demands of the vehicle relocation system. Over the 12 years of operations, 4000 members used Witkar (IPC Building and Controls Journal Limited 1974).

One-way services resurfaced in the late-1990s. Liselec launched in 1993 in La Rochelle, France to again test EV use in one-way carsharing. The system was comprised of a fleet of 50 EVs and 106 Peugeot or Saxo électrique, distributed among seven stations in the area (Comox 2006). The program, sponsored by Peugeot-Citroen, was successful and still exists today as Yelómobile. Unlike other EV carsharing programs struggling with economic sustainability, Yelómobile continues to receive governmental support for its operations.

Praxitèle launched in October 1997 in Saint-Quentin-en-Yvelines, a Paris suburb, as an experiment with 50 Renault Clio EVs. Almost 500 members used the service and were able to travel easily from home to the train station and other locations among 14 “Praxiparcs” located near public transit stations and offices. By March 1999, 90 % of the trips were one-way versus roundtrip (Massot 2000). Although the demonstration succeeded in its technical implementation, Praxitèle struggled with costs and in sustaining demand; it ended in July 1999.

Pilot programs in Japan and Singapore: the 1990s

In 1998, Honda Motor Company announced the development of an intelligent community vehicle system (ICVS). Initially formulated in 1994, the ICVS concept included different forms of carsharing services optimized for local needs. The concepts included roundtrip and one-way station systems, as well as transit-based stations. Honda launched pilot programs to demonstrate four different transportation types: (1) an electric-power assisted bicycle (ICVS Racoon), (2) a one-person electric car (Mon Pal), (3) a one-person hybrid car (ICVS Step Deck), and (4) a two-person electric car (ICVS City Pal) (Barth et al. 2007; Honda 1998). In June 2003, Honda also launched Honda DIRACC in Singapore—a carsharing system with 15 Honda Civic Hybrids at three stations. About 50 members could access a car without a reservation and leave it at any other station in the area. In 2006, Honda completed the fleet by adding ten more second-generation Civic Hybrids to the current fleet size of 62; two stations were also opened, which brought the network to 15 stations and 1700 members (Honda Motor Company 2006). However, DIRACC was closed in 2008 because it could no longer maintain service quality and customer satisfaction (Carsharing.US 2008).

Toyota Motor Company also deployed a one-year carsharing experiment in Toyota City, Japan in May 1999, called the Crayon System. Seven hundred members shared 50 Toyota e-com EVs among 13 stations, based at public transit stations and other locations. The Honda and Toyota pilot programs employed advanced technologies including smartcards; automatic vehicle location; a reservation, location, and recharging management system; and a vehicle information and communications system (Barth et al. 2007).

While these experiments were mostly vehicle manufacturer demonstrations, the Japanese government supported some. One such experiment was the intelligent transportation system/carsharing electric vehicle (ITS/CEV) City Car System in Yokohama, conducted by the Association of Electronics Technology for Automobile Traffic and Driving (JSK) with support from the Ministry of Economy, Trade, and Industry; the New Energy and Industrial Technology Development Organization (NEDO); and the Japan Electric Vehicle Association (Takayama 2002). A roundtrip carsharing model was first deployed in the Yokohama areas of Minato Mirai 21 (MM21), Kannai, Motomachi, and Shin-Yokohama. It consisted of seven local EV stations with 30 EVs. A high level of ITS technology enabled the system to add one-way trips among EV stations in September 1999. The CEV Sharing Corporation took over the concept to demonstrate business viability, and the program later became known as Orix Carsharing.

Pilot programs in the United States: 1990s to present

Experiments were also initiated in the U.S. In January 1999, a ten-month research project, CarLink I, was launched at the Dublin/Pleasanton Bay Area Rapid Transit (BART) District station in the East Bay of the San Francisco Bay Area (Shaheen 1999; Shaheen et al. 2000). Twelve compressed natural gas (CNG) Honda Civics were available to drive between the BART station and the Lawrence Livermore National Laboratory (LLNL). CarLink II followed this project and was based at the Caltrain station in Palo Alto, California from July 2001 to June 2002 with approximately 100 users and 27 Honda Civics (Shaheen and Novick 2005). The CarLink program facilitated one-way trips between train stations and home- and work-based trips. One-way tripmaking was implemented by pairing users based upon their commute using public transit, as well as their home and work locations. Some participants lived near the CarLink transit station in the suburbs and took public transit into the city. Others took transit to their suburban workplace and used CarLink to reach their employment site from the public transit station. A third group of users shared the vehicles at the suburban work site throughout the day. Commuters returned the vehicles to the train station at the end of the day, where home-based users picked up the vehicles after taking public transit from the city. At the end of the CarLink II pilot, Flexcar took over the service in July 2002. However, it ceased operations in July 2003 due to cost recovery concerns and limited scale.

Several research programs deployed at the University of California (UC) also piloted one-way carsharing. In March 1999, an intelligent shared EV test bed, UCR IntelliShare, started operating on and around the UC Riverside campus. Three hundred students, faculty, and staff shared 35 Honda EVs, ten Ford Th!nk City EVs, and 11 Global Electric Motor neighborhood EVs among six stations on campus. In 2006, Honda added two CNG Civics that operated between the Downtown Riverside Metrolink station and campus (Barth et al. 2000). The project ended in 2010, after over 10 years of operation.

Similarly, UC Irvine operates the Zero Emission Vehicle Network Enabled Transport (ZEV·NET) service. It was launched in 2002 to facilitate daily trips between the Irvine Transportation Center commuter rail terminal, four employers, and the UC Irvine campus (ZEV·NET 2012). ZEV·NET employs Toyota RAV4 EVs, Mitsubishi iMiEVs, and Scion iQ EVs. In March 2013, 30 iQ EVs were added to the fleet by Toyota; the system still operates today (UC Irvine News 2013).

Since the 1970s, many carsharing business models and advanced technologies have been tested including: instant access, open-ended reservations, and one-way carsharing (Shaheen and Cohen 2012b; Firnkorn and Müller 2011). Despite many successful projects that were well received, many ceased operations. The main reasons include economic viability concerns (e.g., CarLink, Witkar); underuse (e.g., Praxitèle); and insufficient technologies (e.g., Procotip) (Shaheen et al. 1998). At the same time, others have succeeded and still exist today (e.g., Yélomobile). Overall, these early attempts laid the foundation for modern carsharing by increasing awareness and membership, as well as providing greater flexibility (Schwieger and Wagner 2012). Table 1 provides a summary of early one-way carsharing systems and key lessons learned.

In the next section, the authors describe the current state of one-way carsharing operations.

Table 1 Lessons learned from early one-way carsharing systems

Service	Location	Operation dates	Lessons learned
Procotip	Montpellier, France	1971 – 1973	Failed due to lack of proper control systems and technological issues
Witkar	Amsterdam, Netherlands	1974 – 1986	Failed because of high costs, lack of governmental support, and technological limitations
Liselec/ Yélomobile	La Rochelle, France	Since 1993	Successful due to continued governmental support
Praxitèle	Saint-Quentin-en-Yvelines, France	1997 – 1999	Failed because of high costs and low demand

CarLink II	San Francisco Bay Area, USA	2001 – 2002	Terminated after transfer from pilot to third-party operator due to financial concerns; limited scale
UCR Intellishare	University of California, Riverside, USA	1999 – 2010	Successful due to advanced technologies and support from agencies and industry
Honda DIRACC	Singapore	2003 – 2008	Terminated due to declining service quality

CURRENT STATE OF ONE-WAY CARSHARING

Today, one-way carsharing reflects two main models: (1) free-floating carsharing and (2) station-based carsharing. In this section, the authors describe these designs and where they are deployed, provide an overview of the current state of one-way carsharing across the globe, and review the status of research and modeling efforts.

Free-floating carsharing

Free-floating carsharing services enable shared-use vehicles to be picked up and dropped off anywhere within a designated operating area. The first free-floating carsharing service began in October 2008 in Ulm, Germany, known as car2go. Its deployment has enabled expansion throughout Western Europe, the U.S., and Canada. As of December 2013, car2go had a fleet of 8900 gasoline vehicles and 1100 Smart Fortwo EVs, with 600,000 members worldwide (Delong 2014, personal communication). At the time of this writing, car2go was operating in 26 cities in six countries.

BMW-Sixt launched a free-floating carsharing system in 2011 in Munich known as DriveNow. It has since expanded to Berlin, Düsseldorf, Cologne, Hamburg, and San Francisco. Approximately 1000 BMW ActiveE EVs and gasoline vehicles are accessible by 60,000 members. Both car2go and DriveNow have worked with cities to prepay for parking spaces for their free-floating vehicles. Free-floating services currently dominate North American one-way carsharing services.

More recently, the roundtrip carsharing operator, Communauto, launched Auto-mobile—a free-floating carsharing pilot project. Launched in June 2013, the project consists of a fleet of 20 EVs shared in Le Plateau-Mont-Royal, a neighborhood of Montréal, Canada. In October 2013, Auto-mobile expanded to another neighborhood with plans for a third (Communauto 2013). In December 2014, Zipcar announced the launch of its one-way carsharing service in Boston with 200 vehicles. As of July 2014, the one-way operations of car2go, Communauto, and DriveNow represented 24.5 % of North American carsharing fleets, and 26.4 % of members had access to those vehicles (Shaheen and Cohen, unpublished data, which exlude peer-to-peer carsharing numbers).

Station-based one-way carsharing

Several one-way carsharing systems operate a station-based model. In contrast to free-floating carsharing, station-based systems require users to return the vehicle to any designated station. Although this model may be perceived as less flexible, station-based carsharing limits vehicle searching to select locations.

In December 2011, the Autolib' one-way carsharing service was launched by Bolloré in Paris, France. The fleet is comprised exclusively of EV Bluecars provided by Bolloré. Since the beginning of the service, 75,800 inhabitants of the Ile de France region joined Autolib'. A joint commission was created in July 2009 to supervise the entire network, which includes the center of Paris and nearby municipalities (a total of 54 municipalities as of May 24, 2013). As of April 2013, Autolib' had 30,000 members accessing 1800 EVs at 800 stations throughout the city and its suburbs. The system has provided over two million trips (Fairley 2013). A Bolloré evaluation found that 60,000 members are needed to reach system profitability. To meet this goal, Bolloré planned to deploy 3000 Bluecars and 1100 stations before the end of 2013, with hopes to reach its 60,000-member target before 2015 (Georges 2013).

One variation on station-based carsharing is the airport-based model. This service facilitates one-way trips between the airport (i.e., the "station") and destinations, such as the central business district (CBD). Hertz 24/7 launched a one-way service in New York between airports and the city in 2011, and it now offers one-way carsharing in Hoboken, New Jersey; New York City; and Washington, D.C. In June 2012, Volkswagen's Quicar in Hanover, Germany launched a one-way trip service between the airport and Brunswick. Most recently, Carrot launched in July 2013, offering one-way trips between Mexico City's CBD and the Santa Fe business district. Indianapolis, Indiana has announced that it plans to deploy 500 EVs through a new station-based program called, BlueIndy (operated by Bolloré), starting in December 2014 (Swiatek, 2014).

One-way carsharing: the present

As of July 2014, there were approximately 17 one-way carsharing operators with programs in ten countries (Austria, Canada, China, France, Germany, Italy, Japan, Mexico, Spain, and the U.S.). A new program launched in Hangzhou, China at the end of 2013, employs EVs accessed and returned at automated garages (Rogowsky 2013). Daimler launched car2go in London and Birmingham in 2012, but it halted UK operations in May 2014 (car2go UK Ltd 2014). Today, automakers are dominant players in the one-way carsharing industry. BMW-Sixt, Bolloré, Citroën, Daimler, and Renault are among the prominent one-way carsharing operators (Fairley, 2013). In Summer 2014, Zipcar launched a one-way carsharing pilot program in Boston, Massachusetts.

Table 2 provides an overview of major station-based and free-floating one-way carsharing programs worldwide. This table includes two scooter-sharing programs, Motit in Barcelona and Scoot Networks in San Francisco, as they provide a similar mobility solution as one-way carsharing in urban settings.

One-way carsharing continues to expand in large part due to advanced technologies (e.g., vehicle access technologies, smartcards, mobile applications, GPS) (Shaheen and Cohen 2007, 2012b) and public policies that enable private firms to reserve on-street parking (Shaheen and Cohen 2007; Firnkorn and Müller 2012). Many worldwide experts anticipate growth in one-way carsharing to continue (Shaheen and Cohen 2012b).

Table 2 Existing One-Way Carsharing Systems Worldwide

Service	Date Launched	City Launched	Station-based or Free-floating	Vehicles Deployed	Powertrain	Pricing Scheme
Auto-mobile	Jun 2012	Montréal, Canada	Station-based	Various	Gasoline + EV	Subscription fee + annual fee + per use (per km and per minute)
Autolib'	Dec 2011	Paris, France	Station-based	Bolloré Bluecar	EV	*Paris*: 120€/year + 5,50€/30min OR 25€/month + 6,50€/30min OR 9€/30min *Lyon/Bordeaux*: 99€/year + 0,20€/min OR 19,90€/month + 0,23€/min OR 0,30€/min
Bee	Jun 2013	Naples, Italy	Free-floating	Renault Twizy	EV	30€/yr + 0,15€/min
DriveNow	Jun 2011	Munich, Germany	Free-floating	Various BMW / San Francisco 70 ActiveE	EV in San Francisco gasoline + EV elsewhere	*Germany*: 29€ signup fee + 0,31€/min *US*: $39 signup fee + $12/30 min, then $0.32/min OR $60/24hr
car2go	Oct 2008	Ulm, Germany	Free-floating	Daimler Smart Fortwo	EV in Amsterdam, San Diego, Stuttgart gasoline + EV in Austin, Portland, Ulm, Vancouver gasoline elsewhere	*EU*: 20€ signup fee + 0,29€/min or 14,90€/hr *UK*: 29,90£ signup fee + 0,35£/min or 14,90£/hr *US*: $35 signup fee + $0.41/min or $14.99/hr
Carrot	Jul 2013	Mexico City, Mexico	Station-based (Mexico - Santa Fé)	Nissan	Gasoline	90-120$/h+300$subscription+1h extra+3$/km (in Peso)
Choimobi Yokohama	Oct 2013	Yokohama, Japan	Free-floating	Renault Twizy	EV	0,15€/min
Multicity	Sep 2012	Berlin, Germany	Free-floating	Citroën C-Zero	EV	0,28€/min; 39€/day
Enjoy!	Dec 2013	Milan, Italy	Free-floating	Fiat 500 & 500L	Gasoline	0,25€/min (0,10€/min parked) or 60€/day
Hertz 24/7	Oct 2008	New York, USA	Station-based (airport)	Various	Gasoline + EV	Hourly rate depends on vehicle
Moebius	Jul 2010	Rueil Malmaison, France	Free-floating	F-city (FAM) + Ion (Peugeot)	EV	49€ subscription + 10€ for magnetcard + 20ct/min, 12€/hr
Motit	Sep 2013	Barcelona, Spain	Free-floating	Scooters	EV	11€/quarter membership: 0,45€/km or 4€/hr 29€ signup fee: 0,55€/km or 5€/hr Visitor: 6€/hr
Quicar	Jun 2012	Hanover, Germany	Station-based (Hanover Airport - Braunschweig)	Volkswagen	Diesel	20€/ trip
Scoot Networks	Sep 2012	San Francisco, USA	Station-based	Scooters	EV	$29/mo membership: 30 min free, then $3/hr (daytime) or $0.50/hr (nighttime) $5/mo membership: 30 min for $3, then $3/hr (daytime) or $0.50/hr (nighttime) No membership fee: 30 min for $10, then $6/hr
Stadtflitzer	Jun 2012	Hanover, Germany	Free-floating	Various	Gasoline + EV	0,10€/min or 0,50€/hr (<7hr) + 0,23€/km
Ha:Mo ride	Oct 2012	Toyota Ecoful Town, Japan	Station-based	Toyota i-Road	EV	1,5€ first 10 min, then add 0,15€/min
Vélomobile	1993	La Rochelle, France	Station-based	Citroën C-Zero	EV	2€/use + 7€/hr

Recent Research and Modeling Findings

While one-way carsharing provides a flexible service, its operational management is more complex. The need to guarantee a level of vehicle availability coupled with an imbalance between stations could lead to an oversized fleet and underused vehicles (Firnkorn, 2012). According to Nakayama et al. (2002), one-way systems need around twice as many reserved parking spaces as vehicles to function optimally.

In the last few years, researchers have proposed many models to assist decision makers and minimize costs while maintaining member satisfaction. Models have been developed to determine the: (1) optimum fleet size, station location, size and number (Cepolina and Farina 2012; Correia and Antunes 2012); (2) best strategy when demand changes (Fassi et al. 2012); and (3) most efficient vehicle relocation systems. Simulation models serve as tools for comparing one-way and various carsharing services (i.e., trip type, driving duration, relocation, destination). Yoon and Lee (2013) conducted simulation models that revealed that one-way offers a higher utilization ratio for cars compared to roundtrip carsharing. Barrios (2012) developed a simulation-based approach, using agent-based modeling, to measure and predict vehicle accessibility in one-way carsharing. The model has provided reasonable estimates.

System rebalancing (i.e., shuffling vehicles to balance vehicle supply and user demand) is a major research area in one-way carsharing operations and logistics, but remains a complex problem of supply and demand that each depend on the other (Jorge and Correia 2013). Recently, Weikl and Bogenberger (2012) introduced and categorized several rebalancing strategies. Relocation strategies are commonly grouped into two different approaches: (1) user-based relocation and (2) operator-based strategies.

Barth et al. (2004) introduced two user-based rebalancing systems: 1) trip-joining (or ridesharing) and 2) trip-splitting. Whereas the former incentivizes members to share a ride from a low-vehicle-quantity station to a high-vehicle-quantity station, the latter encourages a group of users, departing from a high-vehicle-quantity station, to split into different cars and park at a low-vehicle-quantity station. Di Febbraro et al. (2012) proposed the discrete events system (or DES) model, which provides the optimum drop off station to limit station imbalances. If a member agrees to leave a car at the station suggested by the operator, s/he will receive a trip discount. Although the model determines the optimum drop off station, it does not take into account the fare discount, which depends on the distance between the user-chosen station and the operator-suggested station and the member's willingness to accept it (Di Febbraro et al. 2012). Papanikolaou (2011) addressed the issue of incentive pricing to bring one-way systems into balance exclusively by users. He developed a pricing model where users "buy a car at a station" and then "sell" it at another one. Prices of drop-off and pick-up points are strategically chosen to keep the network balanced.

Kek (2006) introduced two operator-based strategies: the shortest time technique (i.e., vehicles were moved in the shortest possible time) and the inventory balancing technique (i.e., a station with a vehicle shortage was filled with vehicles from a station with an oversupply). Fan et al. (2008) studied the trip allocation approach in which the operator directly accepts or refuses trips to maintain the station balance.

Recently, multi-task models have been developed that can consider simultaneous, strategic decisions (i.e., location, number and size of stations); tactical decisions (i.e., fleet size); and operational decisions (i.e., vehicle relocation) (Jorge et al. 2012; Boyacı et al. 2013). These advanced simulation models optimize highly complex problems by integrating a large number of variables (Kek 2006).

Despite a growing body of research into one-way carsharing modeling and logistics, the impacts of one-way systems have just recently begun to be documented. In a recent study on car2go in Ulm, Germany, Firnkorn (2012) found that more than a quarter of survey respondents were willing to abandon their personal car for a car2go membership. Trepanier et al. (2013) evaluated impacts of Auto-mobile in Montréal, Canada through a series of user surveys. Initial results found the program enables many users to make short and spontaneous trips, with median average trips of 2.0 km and 13 min. Le Vine et al. (2014) conducted a survey of (*n* = 72) one-way carsharing users to determine impacts to travel behavior associated with grocery shopping. One-way carsharing allowed respondents who did not own a vehicle to shop for groceries less frequently, with less travel time, and at fewer stores. A 2014 study of (*n* = 1,169) Autolib' and Mobizen users compared one-way and roundtrip carsharing travel behavior, respectively. It found that Mobizen users reduced VMT/VKT and vehicle ownership more than Autolib' users, but the authors noted that one-way carsharing is still new and its benefits may be more evident in the future (6t 2014).

Further research is needed to understand the impacts and demand for one-way carsharing including member attitudes, travel behavior, environmental impacts, and system operations. This paper explores operator perspectives in the Americas, as one-way carsharing emerges in this region.

AMERICAS' CARSHARING OPERATOR SURVEY

In this section, the authors discuss the results of a carsharing operator survey conducted in Fall 2013 in the Americas (U.S., Canada, Mexico, and Brazil), which compares and contrasts one-way carsharing and roundtrip carsharing.

Methodology

In Fall 2013, the authors conducted online surveys with one-way carsharing and roundtrip carsharing operators in the Americas. Separate surveys were administered to the two operator groups (roundtrip and one-way); each had several similar questions for comparison. Five one-way operators and 26 roundtrip carsharing operators completed the surveys (out of 46 operators in the Americas). One-way operators were asked in greater detail about their respective business model, operations, rate structure, technologies, users, parking policies, and expansion plans. Roundtrip carsharing operators were queried about their awareness and views of one-way carsharing. Both one-way and roundtrip operators were asked about opportunities and challenges for one-way carsharing and likely innovations.

Study limitations

Due to the qualitative nature of the survey questions and the limited number of carsharing operators responding (n = 31), the analysis is focused on key trends and lessons learned rather than a quantitative statistical analysis. The majority of operators responded to the survey (31 out of 46). Five one-way carsharing surveys were completed, representing 100 % of the one-way carsharing operators in the Americas. Not surprisingly, the one-way sample is small due to the nascent nature of this model. Additionally, it is important to note that operators may have provided biased responses, if they believed such answers would positively impact the future of the industry or decisions made by policymakers or their competitors.

Results

Of the 26 classic carsharing responses, 13 operate in the U.S., 14 in Canada, and one operates in Brazil (two companies have operations in both the U.S. and Canada). Five one-way carsharing operators responded: three operate in the U.S., two in Canada, and one operates in Mexico (one company has operations in both the U.S. and Canada). Of the 46 carsharing operators in the Americas, 31 completed either a one-way or roundtrip carsharing survey, yielding a response rate of 67 %.

Definitions and distinctions

Operators were asked for key distinctions between one-way and roundtrip carsharing (see Figure 1). Half (50 %) of classic operators (n = 13/26) mentioned fundamental differences (e.g., point-to-point vs. roundtrip), and 46 % (n = 12/26) noted one-way's more flexible use as key differences. Sixty-nine percent (n = 18/26) viewed one-way carsharing as a complement to roundtrip carsharing. Of these, six operators believed it was a complement by providing another alternative transportation mode, and four believed one-way carsharing served a different trip purpose. Nineteen percent (*n* = 5/26) saw one-way as a competitor. They believed a city is too small to accommodate two carsharing operators, and a user would not choose to be a member of both. Twelve percent of operators (*n* = 3/26) viewed one-way carsharing as both a complement and competitor.

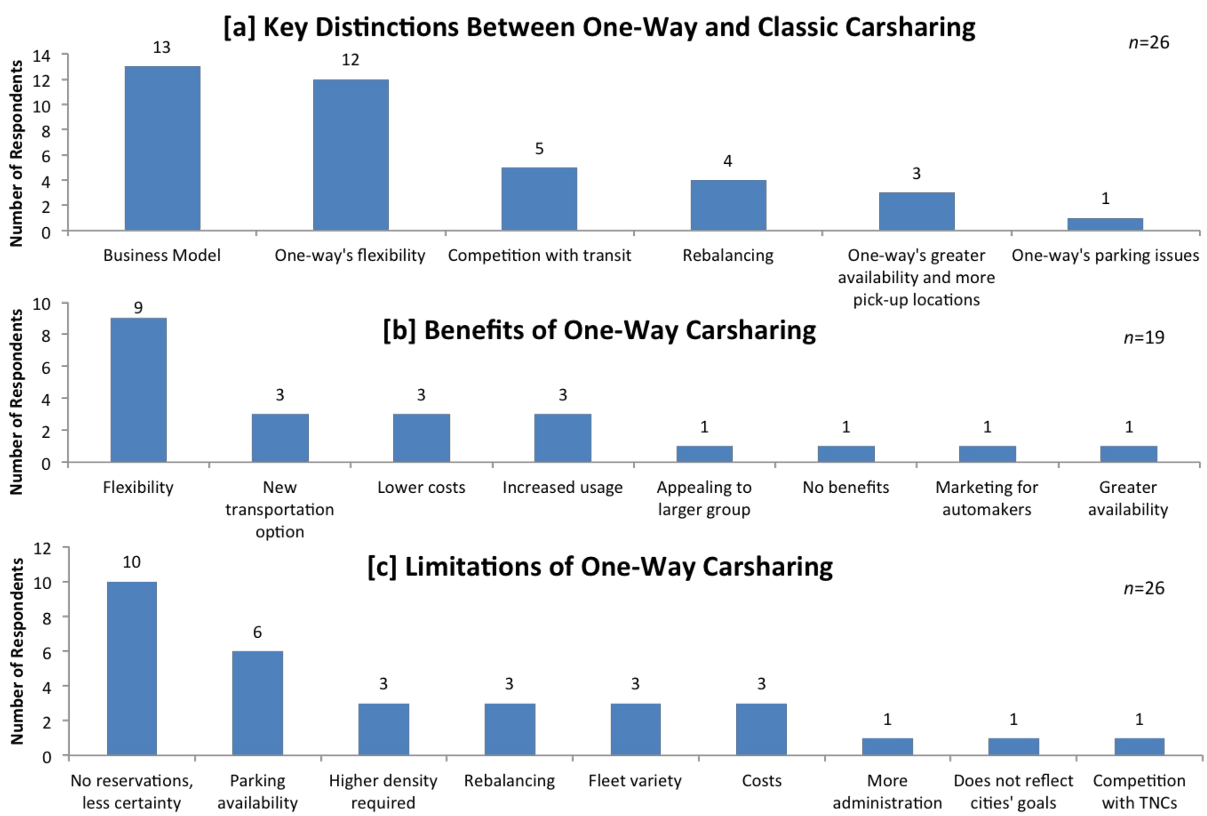

Figure 1 Operator responses on distinctions [a], benefits [b], and limitations [c] of one-way carsharing.

Roundtrip carsharing respondents felt that one-way carsharing competes with public transit, while roundtrip carsharing complements and supports it. Note one-way respondents did not give their views on whether their system complements or competes with public transit.

Sociodemographics of one-way carsharing members

Researchers asked operators differences between early adopters of one-way carsharing and members of roundtrip carsharing. The key difference cited by 19 % (*n* = 5/26) was that one-way users reside in denser city centers. This would appear to be a natural consequence, as operations are typically located in city centers. Several respondents (*n* = 3/26) also noted that early adopters tend to be younger, but this was not widely mentioned among the operators.

Benefits and limitations

Not surprisingly, a key benefit of one-way carsharing most reported by both roundtrip (*n* = 9/19) and one-way operators (*n* = 1/5) was service flexibility. Specifically, one-way is beneficial for trips that involve arriving at a location and staying there for an extended time. This results in cheaper trips for one-way users who will not incur charges when the vehicle is parked. Respondents stated that spontaneous, short trips were best suited for one-way carsharing. See Figure 1b for all other responses on one-way carsharing benefits.

When asked about social and environmental benefits, half of respondents (*n* = 13/26) believed one-way and roundtrip carsharing have similar impacts, particularly in facilitating lower car ownership levels. The other half (*n* = 13/26) felt they have different effects, with many stating that one-way carsharing does not reduce driving, while roundtrip carsharing does. Conflicting views most likely stem from the lack of research quantifying the impacts of one-way carsharing—a few operators cited internal studies.

Several limitations of one-way operations were given (see Figure 1c). Roundtrip operators felt the largest limitation was the reservation-less model (*n* = 10/26), which gives the user less certainty that a vehicle is available at the desired time and location. Similarly, one-way operators stated that users must learn to “trust” that a vehicle will be available at the desired time and location, particularly at airports. One limitation stated by a one-way operator was the challenge of rebalancing vehicles. To accommodate rebalancing, the operator employs a larger per-capita fleet than roundtrip carsharing, thus increasing capital costs. This corroborates the study by Nakayama et al. (2002).

When asked about the greatest obstacles to one-way carsharing's widespread adoption, the majority cited parking management (*n* = 20/26) and system rebalancing (*n* = 18/26). When queried whether or not these were the same obstacles faced by roundtrip carsharing, system balancing (managing supply and demand) was a larger concern (*n* = 9/26), while parking was viewed as less problematic (*n* = 2/26). Marketing and customer awareness/education was noted as a minor issue for one-way expansion.

Expansion of one-way carsharing

Operators believe that one-way carsharing will continue to grow over the next decade, but it will focus on major metropolitan areas, similar to the proliferation of roundtrip carsharing. Moreover, respondents pointed to growing investment from auto manufacturers, which may further spur innovation and growth. When asked about profitability within ten years, 37 % (*n* = 7/19) were uncertain. This may point to the uncertainty of one-way carsharing's financial viability. Four operators (21 %, *n* = 4/19) predicted high profitability, while one (5 %, *n* = 1/19) felt the industry would gradually grow into profitability.

Roundtrip carsharing operators were then asked if they have any plans to expand into one-way carsharing. One operator stated they plan to begin one-way operations in 2014. Thirty-six percent (*n* = 9/25) of respondents expressed interest in offering one-way services or teaming up with a one-way operator to expand service, while 64 % (*n* = 16/25) have no interest (one operator of the 26 did not respond). Many respondents cited little demand for one-way services.

One-way carsharing's potential growth

To capture potential growth opportunities for one-way carsharing, operators were asked what technological innovations they envision. The top three innovations mentioned among roundtrip carsharing were: (1) integration with public transit (*n* = 6/26), (2) smartcard usage (*n* = 4/26), and (3) EV use (*n* = 4/26). One-way operators mentioned the same three innovations: integration with public transit (*n* = 1/5), (3) smartcard usage (*n* = 2/5), and (4) EV use (*n* = 1/5).

Finally, researchers asked one-way carsharing operators about driving forces to social acceptance. Table 3 presents a summary of the key trends.

Table 3 Growth of one-way carsharing: key driving forces

Topic	Description
Cost structure and savings	• Paying by a usage rate (per-hour or per-mi/km) means users are hyperaware of the amount it costs them to use a carsharing vehicle. Users are adverse to the notion of paying for the vehicle to be parked unused. • Car ownership costs are high and increasing. • One-way carsharing provides cost savings for users who do not pay for vehicle “downtime” and the high cost of car ownership.
Convenience in comparison to alternative transportation modes	• Urban mobility is becoming more difficult, with increased traffic congestion and more limited public transportation options. • One-way carsharing, particularly scooter sharing, in urban settings are nearly as fast as private cars or taxis but as affordable as public transit.
Increased vehicle access	• One-way carsharing operators can provide a variety of vehicles, including EVs, hybrid gasoline-electric vehicles, luxury vehicles, etc. to attract more members.
Technology	• Mobile technology (e.g., smartphones, GPS, smartcards) is an enabler of one-way carsharing growth.
Eco-friendly image	• One-way carsharing operators can benefit from an innovative and an environmental-friendly image.

CONCLUSION

One-way carsharing, alongside other aspects of the sharing economy, continues to experience significant growth in North America and globally. Various business models have evolved over the 67-year history of carsharing, with one-way carsharing playing a growing role in cities over the past five years. Today, there are an estimated 17 one-way carsharing operators with programs launched in ten countries and continued growth expected. One-way carsharing may prove to be a suitable complement to roundtrip carsharing, public transit, and other shared-use modes. One-way carsharing can continue to grow through governmental support, supportive policies, use of mobile technologies, and its unique cost structure and flexibility/convenience. Research in the field has focused heavily on modeling and logistics, and the impacts of one-way carsharing are only beginning to be documented. Future research should evaluate one-way carsharing's potential impact on VMT/VKT, auto ownership, and emissions in urban areas. As one-way carsharing has the potential to impact cities, researchers should analyze one-way carsharing's relationship to public policy in the areas of the built environment, parking, environmental impacts, and first- and last-mile solutions.

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