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Free-Floating Carsharing: City-Specific Growth Rates and Success Factors

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Abstract

Free-floating carsharing, a relatively new market segment within carsharing, is expanding through Europe and North America. This type of system allows users to book a car at any point and any time within a specified area. This type of carsharing currently exists in about 34 cities across nine countries, in cities of highly varied demographics and urban form. Shared vehicles could be part of new mobility services that foster inter- and multimodal travel and serve as an essential part of energy and climate strategies in the transport sectors. However, empirical data on use of free-floating carsharing is usually unavailable for research purposes. New data collection methods have to be developed to evaluate the effects of carsharing systems. For five years, InnoZ (Innovationszentrum für Mobilität und gesellschaftlichen Wandel) has been using web mining to acquire a robust set of data about free-floating carsharing vehicles and movements. Since 2011, about 50 million movements have been recorded by using a web-mining script. This paper provides a first look at this dataset, showing that use of the services is generally increasing over time. It also confirms previous research that household size and residential density are key drivers of free-floating carsharing use.

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Keywords: carsharing; free-floating carsharing; mobility services; shared mobility; urban mobility; urban transport; regression analysis

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1. Introduction

Carsharing is the rental of vehicles by the hour or by the minute as opposed to traditional day- or week-long rentals. Members of the system have access to a fleet of vehicles that they can rent on an as-needed basis. The fee charged is based on the length of the rental in hours or minutes and covers maintenance, insurance, fuel, and often parking as well. Carsharing began with vehicles in assigned parking spaces; the vehicle rental could only be considered complete when the vehicle had been returned to the same assigned parking space where the rental had begun.

As this type of "traditional" carsharing began to take hold in Europe and North America, new operators created variations on the original business model. In the newer iterations, known as free-floating carsharing, vehicles do not have home parking spaces but are instead can be parked anywhere within a city's operating area, which can be as large as 100 km^2. Because the vehicles do not need to be returned to their starting point to complete a rental, this service is also known as one-way carsharing.

Ideas for a "second generation" one-way, open-end car sharing service go back to the 1990s. First pilot tests were conducted in the early 2000s (Schwieger 2004). The first one-way carsharing provider was Daimler Inc, through its subsidiary car2go. In 2008, car2go began with a pilot program in Ulm, Germany, providing a fleet of 200 diesel-powered Smart ForTwo vehicles for Ulm residents to use. Vehicles could be picked up or dropped off anywhere within the operating area, which encompassed most of the city center. The service uses GPS technology to track the location of each vehicle. While the vehicles can be driven outside of the operating area, the rental period can only be ended when the vehicle returns to the operating area.

Since 2008, car2go has expanded around the world, with operations throughout Europe and North America. In certain cities (Amsterdam and San Diego, California, for example), the fleet is entirely composed of electric-drive Smart ForTwos; in other European cities, the fleets are diesel-powered, and in North American cities, most fleets are gasoline-powered. As of January 2016, car2go operates in 32 cities and is the largest carsharing program in the world (PR Newswire 2014).

A second carsharing program that is operating worldwide is DriveNow. The DriveNow fleets are mainly composed of Mini Coopers and the BMW 1-series, both of which are manufactured by BMW. DriveNow began in Munich in June 2011 and is now operating throughout Germany and in several neighboring countries (Kopp et al. 2013). Free-floating carsharing services are further evolving and new players, often operated by local organizations, are also entering the market. These systems are often operated by local organizations. Examples are Communauto in Montreal and Quebec, Enjoy in four Italian cities (Milan, Rome, Turin, Florence) or flow>K in Osnabrück.

Free-floating carsharing services allow greater flexibility than traditional carsharing providers, as the user does not need to return the vehicle to a certain point. This flexibility is one of the factors fueling the growth of the services, along with a worldwide focus on increased sustainability of transport systems and variety of travel options.

This paper uses web-scraped data from free-floating carsharing service providers to consider the growth of free-floating carsharing services across the European and North American continents, providing a comparative description of service growth rates across cities, regions, and continents. It also analyzes factors that may be having an effect on these various growth rates, with an eye toward clarifying what makes a free-floating carsharing service particularly successful.

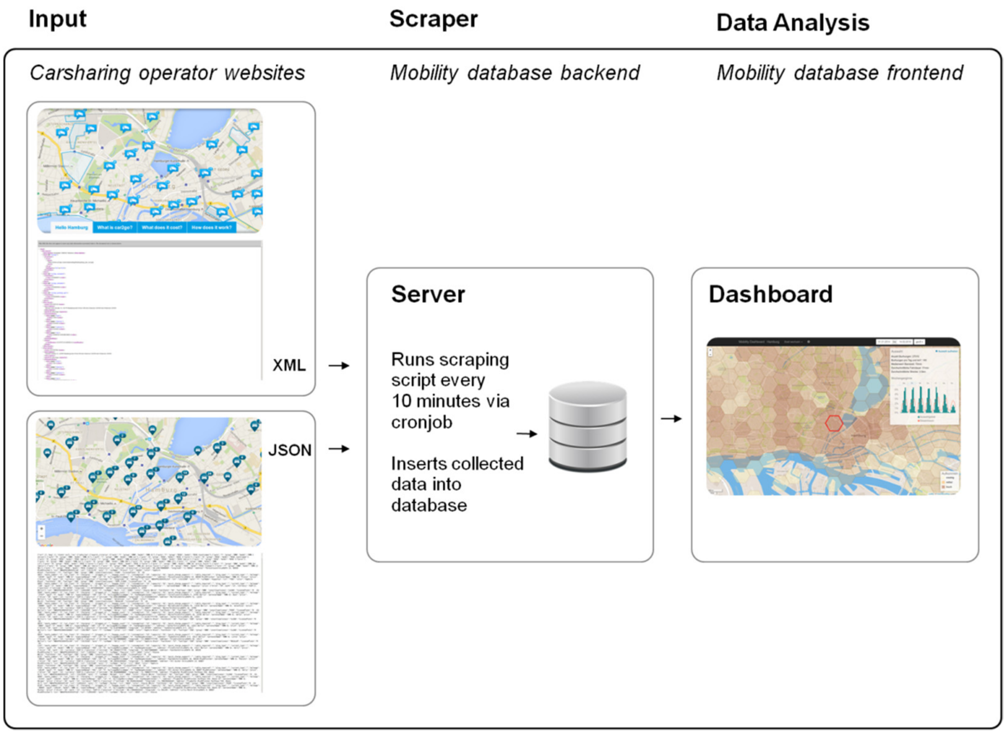
Our objective is to explain the variation in free-floating carsharing service diffusion rates and saturation rates among cities using a variety of city-specific data sources. This includes demographic data (age distributions, gender ratios, education levels, household structure, vehicle ownership levels), economic data (average incomes, unemployment rates, employment by sector, cost of living), and land use data (residential density, employment density, transit availability, availability of other transportation services). In particular, we examine differences between European and North American cities. We expect to find that using the robust set of web-scraped data to analyse carsharing use over time will confirm results found previous literature about factors determining carsharing use, such as user age, income, and household size and density. We also expect that these determinants will vary from city to city.

2. Background

Other studies on free-floating carsharing have analyzed environmental effects (Firnkorn 2011), user preferences and use patterns (Kopp et al. 2015) and methods to improve operation of such systems (Weikl and Bogenberger 2015). Determinants of carsharing use have also been analyzed across the globe. For example, income, age, and transit use have all been found to be strong predictors of carsharing use (e.g., Burkhardt & Millard-Ball, 2006; Ciari & Weis, 2013; Efthymiou et al, 2013; Le Vine et al, 2014), as have less easily quantifiable characteristics such as environmentalist tendencies (Burkhardt & Millard-Ball, 2006; Efthymiou et al, 2013; Schröder & Wolf, 2016).

Much of the previous work has used individuals (carsharing members) as the unit of analysis, often with one city (or occasionally one relatively small country) as the data set. In comparison, we examine growth rates of free-floating carsharing at the city level, where cities across multiple continents are the unit of analysis. In our analysis, we select 33 cities where this type of service operates and compare the growth rates of the service from launch of the service until November 2015. In a second step, we combine our results on carsharing use with demographic, economic, and land use data for a subset of the cities to determine what factors are significant in understanding the growth of this type of mobility service.

Figure 1: Web scraping Process



The data used in this paper have been developed by InnoZ using web mining to acquire a robust set of data about free-floating carsharing vehicles and movements. Web scraping scripts and applications simulate a person viewing a web site with a browser. Web scraping (or screen scraping) enables the researcher to connect to a web page and request certain information, exactly as a browser would do. Scripts are used to perform automated requests and extract structured content from a web page. Because the data is easily available online, the legality of the method is not in question; web scraping merely is an automated way to collect the large amounts of real-time data that companies make available to the public.

In the case of this study, web scraping is used to send requests periodically to web pages operated by carsharing providers. When a customer wants to book a vehicle online, information is communicated to the customer through a web map on which geo-coordinates of current locations and status of available vehicles can be found. Once a car has been booked, it disappears from the map. After finishing the booking process and becoming available to rent again, vehicles reappear on the map. A continuous scraping obtains information on start and end point of the movement. To provide the web map, typical service data and information is needed to place the markers correctly on the map. This data is usually machine-readable, commonly in JSON or XML data formats. A script sends a request to the webpage and retrieves information about the vehicles. Combined with a cronjob, scripts can be run periodically, such as every ten minutes. Finally, the data is inserted in a postgresql database, which is able to deal with spatial objects. Since 2011, about 50 million movements of carsharing vehicles have been collected in this way. The data provide adequate spatial and temporal information on vehicle movements. However, three particular problems could impair the data quality. First, errors could occur on the provider level. This was most commonly seen in malfunctions of the provider's web page. Second, similar errors could occur on the scraping server. Usually, these two types of errors lead only to short outages. Greater difficulties may arise if providers change the structure of their web pages, a third source of potential error. In this case scraping scripts have to be adjusted as soon as possible. For this paper, the data includes records through April 20, 2015. At this time, the data set included more than thirty cities with free-floating carsharing at the time of our analysis, shown in Table 1 below. These cities represent all cities with at least one free-floating carsharing operator at the time; some cities contained multiple operators, as shown in the last column of the table.

Table 1: Cities with free-floating carsharing data

City	Country	Continent	Data Start	Data End	No. of providers
Amsterdam	Netherlands	Europe	19 December 2011	1 November 2015	1
Berlin	Germany	Europe	12 December 2011	1 November 2015	4
Birmingham	UK	Europe	28 August 2013	1 November 2015	1
Cologne	Germany	Europe	15 July 2013	1 November 2015	2
Copenhagen	Denmark	Europe	1 September 2014	1 November 2015	2
Düsseldorf	Germany	Europe	29 January 2012	1 November 2015	2
Florence	Italy	Europe	1 July 2014	1 November 2015	2
Frankfurt	Germany	Europe	1 August 2014	1 November 2015	1
Hamburg	Germany	Europe	30 Mai 2011	1 November 2015	2
London	UK	Europe	5 December 2012	1 November 2015	2
Milan	Italy	Europe	28 August 2013	1 November 2015	3
Munich	Germany	Europe	10 June 2011	1 November 2015	2
Rome	Italy	Europe	1 April 2014	1 November 2015	2
Stockholm	Sweden	Europe	1 November 2014	1 November 2015	1
Stuttgart	Germany	Europe	5 December 2012	1 November 2015	1
Turin	Italy	Europe	8 April 2015	1 November 2015	2
Ulm	Germany	Europe	30 Mai 2011	31 December 2014	1
Vienna	Austria	Europe	20 December 2011	1 November 2015	2
Austin	USA	North America	31 Mai 2011	1 November 2015	1
Calgary	Canada	North America	10 July 2012	1 November 2015	1
Columbus	USA	North America	1 January 2014	1 November 2015	1
Denver	USA	North America	28 August 2013	1 November 2015	1
Los Angeles	USA	North America	1 June 2014	1 June 2015	1

Miami	USA	North America	13 July 2012	1 November 2015	1
Minneapolis	USA	North America	13 September 2013	1 November 2015	1
Montreal	Canada	North America	1 January 2014	1 November 2015	2
New York City	USA	North America	1 October 2014	1 November 2015	1
Portland	USA	North America	4 July 2012	1 November 2015	1
San Diego	USA	North America	7 Mai 2012	1 November 2015	1
Seattle	USA	North America	28 August 2013	1 November 2015	1
Toronto	Canada	North America	4 July 2012	1 November 2015	1
Vancouver	Canada	North America	1 July 2011	1 November 2015	2
Washington DC	USA	North America	4 July 2012	1 November 2015	1

3. Discussion of Growth Rates

The use growth rates in free-floating carsharing cities have varied considerably since the programs began. Figures 2-7 below show sample growth rates of the cities, and the variation is clear. The charts show the daily fluctuation in use (measured in bookings) in gray, with the solid black line representing a 60-day moving average. Note that the y-axis is at a different scale for each graph. In general, the growth charts all show general upward trends; free-floating carsharing is expanding in nearly every city in which it operates.

Jumps in use often indicate a second service coming online. The noticeable decreases in use that can be seen in many of the older services, however, is not due to actual changes in operations but generally due to quirks in the web scraping data as the algorithms for conducting the scraping were improved.

It is important to note that the service has been operating for significantly different amounts of times in the different cities, reflected in the range of timelines shown on the x-axis of each graph. The first free-floating carsharing city was Ulm, Germany, with other German cities following. Austin represents the first free-floating carsharing in North America.

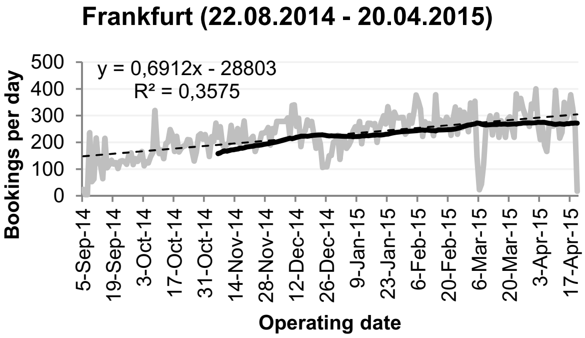
Some cities (Berlin, Calgary, Florence, Frankfurt, Köln, Minneapolis, Munich, San Francisco, Rome, Vienna, and Washington DC) show what appears to be a saturation rate. Growth has slowed considerably, and the service is continuing to operate at a nearly steady-state level, at least with current conditions. These conditions may include the size of the fleet, the pricing structure, and the size of the geofenced operational area. This has the potential to be altered slightly if a new provider enters the market; in this case, it is expected that use would increase as city residents begin to use the new service in addition to the existing operators. In general, however, these cities represent relatively stable markets where significant growth is not expected unless a provider notably changes the operating area, pricing structure, or fleet size.

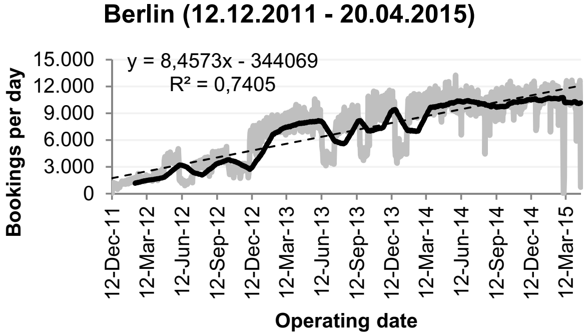
Other cities have shown only moderate growth in carsharing use since the service began (Amsterdam, Los Angeles, Miami, and New York). These cities may already be well-served by existing transportation options, including transit and traditional carsharing options. Since the data collection for this paper, car2go, which was Los Angeles' only free-floating carsharing provider, has since left the market.

Figures 2 through 8 provide a closer look at the data from sample cities in Germany, the United States, and across the world. In Figures 2 and 3, Berlin and Frankfurt are generally representative of German city growth, with the exception of the town of Ulm; car2go was the free-floating carsharing provider in Ulm and has ceased service at the end of 2014, as discussed later.

With four free-floating carsharing services, Berlin has the most providers of any city in the world. It shows a strong growth over the years, with noticeable jumps in use when a new service entered the city. Frankfurt is a much newer city for free-floating services, and it shows a generally positive growth trend. With less than one full year of data, however, it is too soon to draw concrete conclusions about the city's performance.

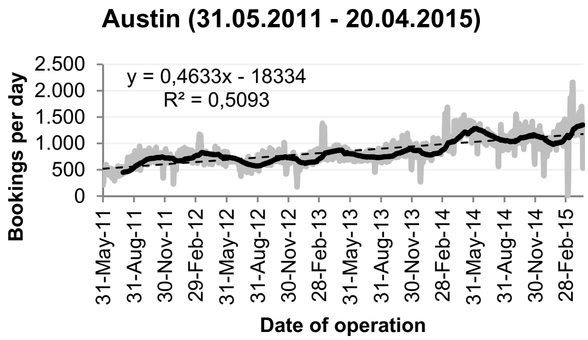
Figures 2 and 3: Carsharing bookings, Germany

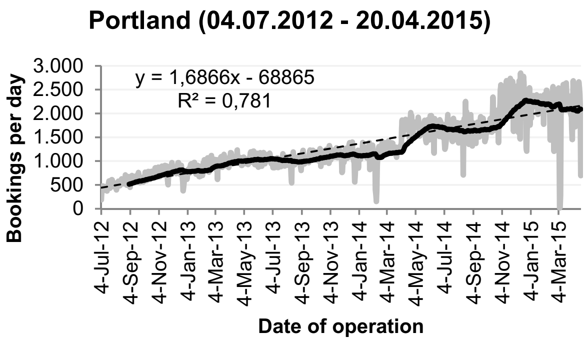




Figures 4 and 5 show two sample American cities. Austin was the first city with free-floating carsharing in North America, as represented by its very long duration of service (shown on the x-axis). It performed steadily for several years, showing increases in use as the operating area and, later, the fleet of vehicles was expanded. Portland has also seen solid growth over its free-floating carsharing tenure. The two significant increases in vehicle use represent increase in the vehicle fleet size.

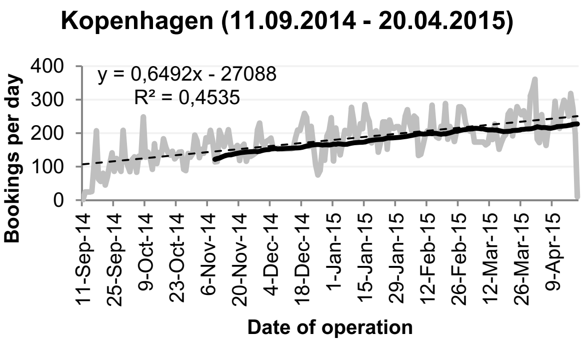
Figures 4 and 5: Carsharing bookings, United States

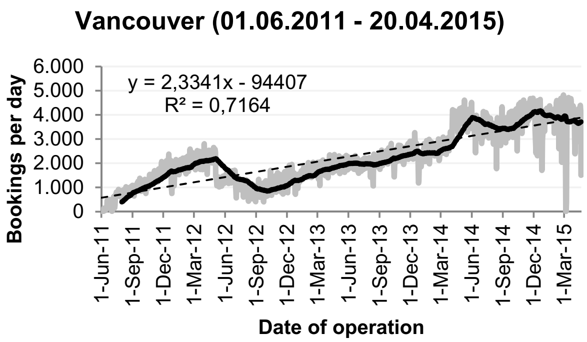




Figures 6 and 7 show other international city performance. Copenhagen is representative of cities that are experiencing general growth without any sign of a saturation point yet. Copenhagen had been in operation for less than a year as of April 2015, when the data were taken, and its growth may yet plateau, increase, or decrease. Vancouver, on the other hand, has been in operation since April 28, 2011, and it appears to also be slowing a bit in its growth rates. Nonetheless, it and many other cities have seen marked increases in use as the carsharing operators increased fleet sizes, expanded their marketing efforts, and became more ingrained in the city's daily transportation options.

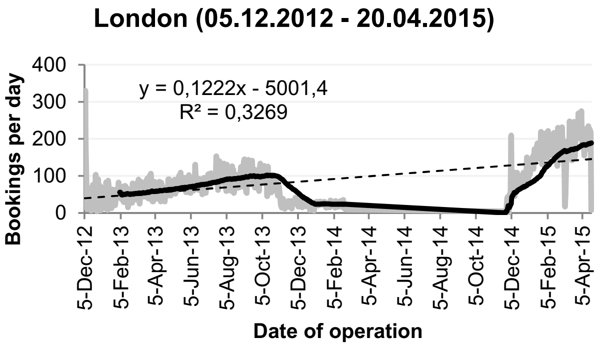
Figures 6 and 7: Carsharing bookings, other international





In several cities, free-floating services began but later shut down. This is the case in both London and Birmingham, where car2go began operations in 2012, but closed a little over a year later due to logistical and operational challenges (BBC 2014). Ulm, the founding city of car2go, is also a city where the service has closed down at the end of 2014; it was the smallest of the free-floating carsharing cities by far, and proved unsustainable in the long run (Jordan 2014). Ulm was also a city in which car2go attempted a variety of operational experiments, and is therefore not representative of carsharing cities and operations in general. As would be expected, London, Birmingham, and Ulm show minimal use rates, followed by a sudden cessation of use. In London, however, DriveNow has since begun operations (Tovey 2014) and therefore free-floating carsharing is again available in the city (see Figure 8).

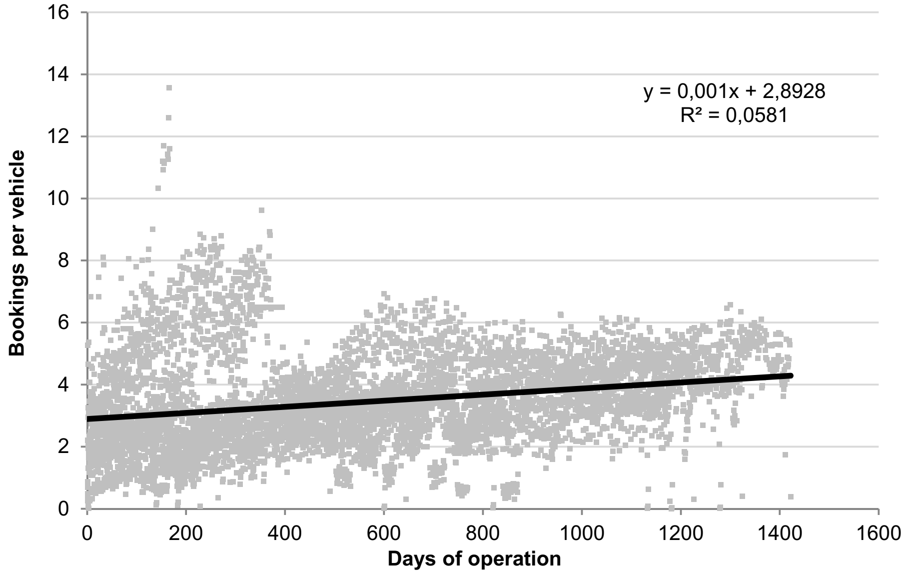
Figure 8: Carsharing bookings, London



Overall, the use growth rates show that growth is most certainly not linear and steady in most cities, but it nonetheless follows an upward trend. There are some exceptions, and in these cities (London and Ulm, for example), the carsharing operators have ceased operations due to a number of logistical and operational hurdles. When additional free-floating carsharing operators enter a city's market, there are typically jumps in use. This is due in part to the novelty of the new service and a new round of marketing and incentives for potential users, but the increases in use generally are sustained.

As carsharing programs become more established in a city and earn a place among existing transportation systems, their use continues to increase. Figure 9 below shows this clearly.

Figure 9: Duration of service vs. bookings per day, all German free-floating carsharing cities (except Ulm)



There is a clear cluster of points that are well above the regression line during the first 300 days; these points are not due to particular operational or service characteristics, but are instead a result of quirks in the web scraping process. However, even overlooking these early outliers, there is a clear positive trend in the data. As the service continues to operate, the number of bookings per day continues to increase. This may be due to operational adjustments (increased or decreased geo-fenced area, changes in marketing, increased fleet size), but it likely also represents the free-floating carsharing service becoming a more integral part of the city's entire transportation network. It is impossible to state definitively without considering the number of users of the service (information that was not available through the web scraping process used here, but as the service matures, residents may be relying on it to a greater degree. If the number of users is holding steady, then the bookings per member is increasing. On the other hand, if the number of users is increasing, the service is therefore expanding its scope to reach a larger proportion of the population. Either way, this is a strong indicator that free-floating carsharing services will continue to expand overall, even as they see setbacks in individual cities.

Similar to the German cities, American cities also show a clear upward trend in bookings per vehicle over time of operation (Figure 10). San Diego and San Francisco are excluded because of missing data. Again, it is difficult to tell from such an aggregate graph how many operational adjustments are affecting the trend, but the overall growth trend within existing cities is certainly positive. More specific information can be found in Table 2, which analyzes each city individually in terms of the duration of service, to see how that single variable affects the daily bookings. In every case, the duration of the service is a statistically significant variable, usually strikingly so. These results are not due to a high sample size based on the millions of web-scraped records, as the variable analyzed is the city's growth rate, resulting in only nineteen data points.

In the linear regression (results shown in Table 2 below), we also considered income, household size, homeownership rates, age distribution, educational levels, and residential density, although these values did not prove to be statistically significant. In part, as discussed above, this is because of the disparities between the German and American cities. German cities had lower household sizes, homeownership rates, and income levels than all of the American cities. Because of the stark differences in the values for the two sets of cities, these variables proved not to be statistically significant when using both countries' data. In future analyses, each country's data could be analyzed separately, which is likely to result in a greater set of significant independent variables.

Figure 10: Duration of service vs. bookings per day, all US free-floating carsharing cities (except San Diego and San Francisco)

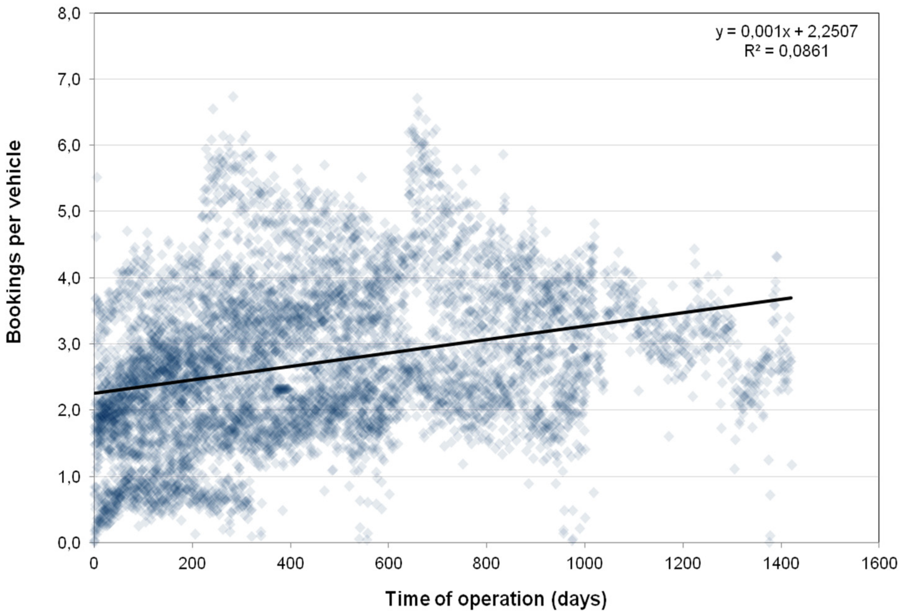


Table 2: Linear regression: City-specific factors influencing daily bookings

city	factor	B	Beta	t-stat	sig.	adj. R^2
Berlin	constant	2.965		44.397	***	0.106
	duration of service (days)	0.001	0.327	12.108	***	
Düsseldorf	constant	1.718		44.882	***	0.184
	duration of service (days)	0.001	0.430	16.322	***	
Frankfurt/Main	constant	0.744		18.461	***	0.353
	duration of service (days)	0.003	0.596	11.164	***	
Hamburg	constant	5.323		82.966	***	0.012
	duration of service (days)	0.000	0.114	-4.335	***	
Cologne	constant	2.288		46.870	***	0.284
	duration of service (days)	0.002	0.534	16.015	***	
Munich	constant	3.678		50.837	***	0.004
	duration of service (days)	0.000	-0.071	-2.668	**	
Osnabrück	constant	2.943		8.560	***	0.085
	duration of service (days)	0.014	0.299	4.246	***	
Stuttgart	constant	2.020		56.647	***	0.386
	duration of service (days)	0.002	0.622	23.298	***	
Ulm	constant	5.065		77.370	***	0.459
	duration of service (days)	-0.003	-0.678	-33.301	***	
Austin	constant	2.195		76.549	***	0.173
	duration of service (days)	0.001	0.416	17.257	***	
Columbus	constant	2.008		42.616	***	0.012
	duration of service (days)	0.001	0.123	2.415	*	
Denver	constant	2.550		45.912	***	0.094
	duration of service (days)	0.001	0.308	7.931	***	
Los Angeles	constant	0.606		24.713	***	0.028
	duration of service (days)	0.000	0.176	3.196	**	
Miami	constant	1.518		56.944	***	0.127
	duration of service (days)	0.001	0.357	12.095	***	
Minneapolis	constant	0.651		21.590	***	0.639
	duration of service (days)	0.003	0.800	32.173	***	
New York City	constant	2.085		24.482	***	0.063
	duration of service (days)	0.003	0.262	3.576	***	
Portland	constant	2.590		51.693	***	0.342
	duration of service (days)	0.002	0.585	22.997	***	
Seattle	constant	3.984		61.724	***	0.070
	duration of service (days)	0.001	0.267	6.771	***	
Washington DC	constant	2.780		67.712	***	0.227
	duration of service (days)	0.001	0.477	17.309	***	

4. Regression Analysis on Factors Affecting Growth Rates

This analysis also uses regression analysis to determine what factors may affect the growth rates of free-floating carsharing systems. No two cities are exactly alike, and the service’s operations are affected by everything from demographic factors to economic factors to land use and development factors.

For this analysis, we focused on cities in the United States and in Germany, in part because of relatively consistency among free-floating carsharing cities within these countries; this resulted in a total sample size of 19 cities.. Using data from the United States Census and the German Federal Statistical Office, we collected a range of demographic and economic descriptors for each of these cities and performed linear regression analyses to determine which of these factors may play a determining role in the success levels of the carsharing services' performance.

The demographic factors include population, gender breakdown, median age, education levels, and average household size. Possible explanatory economic factors include a city's median household income and per capita income; we also collected land use and density data for each of the German and American cities used in the analysis, as this is a significant factor in the operations of all kinds of transportation services, not just free-floating carsharing. However, many of these variables proved to be quite different, on average, between the United States and Germany. For example, even in Germany's high-income cities, per capita incomes were still significantly lower than all American cities, and other variables such as household size and homeownership rates were also quite different between the two countries. German household sizes, for example, ranged from 1.67 (in Berlin) to 1.91(in Ulm) persons per household while American household sizes ranged from 2.08 (in Seattle) to 2.83 (in Los Angeles.

Use of the carsharing services can be measured using several different metrics. One is the number of vehicle rentals per day; another is rentals per day per vehicle. Rentals per vehicle per day are a key consideration for carsharing operators. Vehicles that are in heavy use are the most profitable for the company. Not only is the operator making the most possible use of its depreciating assets, but each trip is a source of revenue, leading to a better chance of an overall profit. Cities with heavy fleet utilization are strong candidates for fleet expansions. General information about service operations for the free-floating carsharing cities are shown below in Table 3.

Table 3: Selected operational characteristics of free-floating carsharing cities

City	Service start	Data end date	Service duration, days	Median daily bookings	Median daily vehicles available	Average daily bookings per vehicle
Austin	5/31/2011	4/20/2015	1421	786	294	2.6
Berlin	12/12/2011	4/20/2015	1225	7789	2088	3.7
Columbus	4/2/2014	4/20/2015	383	610	290	2.1
Denver	8/28/2013	4/20/2015	600	1072	297	2.9
Düsseldorf	1/29/2012	4/20/2015	1177	1305	543	2.3
Frankfurt	9/5/2014	4/20/2015	227	232	197	1.1
Hamburg	5/30/2011	4/20/2015	1421	2938	546	5.1
Köln	7/15/2013	4/20/2015	644	2302	739	3.0
LA	6/4/2014	4/20/2015	320	79	103	0.7
Miami	7/24/2012	4/20/2015	1000	451	233	1.6
Minneapolis	9/13/2013	4/20/2015	584	629	344	1.1
München	6/10/2011	4/20/2015	1410	1383	459	3.5
New York	10/24/2014	4/20/2015	178	906	360	2.3
Osnabrück	10/16/2014	4/20/2015	186	111	29	4.2
Portland	7/4/2012	4/20/2015	1020	1142	29	3.6
Seattle	8/28/2013	4/20/2015	600	2233	493	4.4
Stuttgart	12/5/2012	4/20/2015	866	1340	493	2.7
Ulm	5/30/2011	12/30/2014	1310	754	493	3.2
Washington	7/4/2012	4/20/2015	1020	1521	518	3.4

Using the daily bookings per vehicle as a dependent variable, the results are shown in Table 4.

Table 4: Factors influencing daily bookings per vehicle

	Coefficient	Standard Error	t stat	P-value
Intercept	3.74	1.66	2.26	0.040
Persons per household	-0.90	0.67	-1.34	0.203
Days in operation as of 31 Dec 2014	1.30E-03	5.30E-04	2.44	0.028

As discussed above, daily bookings per vehicle is a strong metric of the use rate of a service that is also closely connected to the overall profitability of a carsharing service. The more the vehicles are used, the more useful the service is to travelers and the more profit the service can make. Of all demographic and economic variables, the strongest is the duration of the service. Each additional day that the service is in operation increases the average number of trips per day of each vehicle by 0.0013. This is a small value, but one that can increase dramatically over time; over one year, that is approximately an extra 0.5 trips each day. While it is too early to tell if a linear relationship continues to exist over time, a service that is in operation for a decade could see an additional five trips per day simply by virtue of its longevity.

Another factor of interest is the average number persons per household in a city. Each additional person in a household, on average, reduces the average vehicle trips by nearly one trip per day (0.9 trips per day, specifically). This value is statistically significant at approximately the 80% level; this significance is not strong enough to declare that household size is truly a determining factor, but indicates that it is worth continuing to study as free-floating carsharing continues to expand into additional cities.

It is also possible to analyze the cities in terms of their growth rate. Table 5 shows the results of using the same set of possible explanatory variables and a dependent variable of the bookings per day growth rate.

Table 5: Factors influencing the growth rate of daily bookings

	Coefficient	Standard Error	t Stat	P-value
Intercept	0.43	0.11	4.10	0.001
Persons per household	-0.12	0.045	-2.72	0.017
Residential density (persons per km^2)	1.34E-05	5.30E-06	2.52	0.026
Days in operation as of 31 Dec 2014	-1.20E-04	3.42E-05	-3.62	0.003

When using the growth rate as the dependent variable instead of the bookings per vehicle, stronger statistical results occur. As expected, both in comparison with the model shown in Table 4 and compared with existing literature, increased average household sizes decrease the expected growth rate of the services. The city’s residential density has a positive effect, indicating that increased development density leads to a faster growth rate – again, an unsurprising finding, although its confirmation is encouraging. Finally, the length of the service is also a factor; services that have been in operation the longest have seen the greatest growth rates. All three of these factors are strongly statistically significant.

5. Conclusion

The descriptions and analyses presented here are the result of a vast data set developed by InnoZ over the last five years, containing the movements of all vehicles in all cities where free-floating carsharing operates. These results are only the beginning of the analyses that are possible with this webscraped data set, but they show some of the possibilities of the analyses that InnoZ will be completing over the coming months and years.

Many previous analyses had looked at free-floating carsharing operations in a single city, but this paper represents the first known attempt to consider all free-floating carsharing cities in the aggregate. Using the actual data from existing operations, it is clear that carsharing is continuing to become a more integral part of city transportation networks. In most cities, use increases in proportion with the service's duration, indicating that more residents are using carsharing, existing members are increasing their use of the carsharing vehicles, or both. Despite this, cities show a wide variety of growth patterns. Some appear to have reached a saturation point without further changes such as an increased fleet size or additional service entering the market. Other cities are continuing to grow, whether in a steady linear fashion or in fits and starts.

Car2go has already become the largest carsharing program in the world, and both it and similar services are continuing to expand. To date, much of the expansion has been in highly-developed countries in Europe and North America, although nearly all sharing operators are also considering entering the developing markets of India, China, and South America. A better understanding of existing operations will be key to these services as they create their expansion plans. Further analysis of the existing operations will allow the operators, along with city planning officials and policy makers, to encourage the development of these and other sustainable modes of transportation.

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