Analyzing the Impacts of Car-Sharing Programs in New York City and Rochester, NY Metropolitan Areas

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Word count: 4,159 words text + 2 tables x 250 words (each) = 4,659 words

Submission date: December 15, 2023

ABSTRACT

The number of users participating in global shared mobility is on the rise. However, regarding car-sharing, the trend in global program usage appears to be stable. This stability suggests a need for further research to enhance the promotion of car-sharing programs. A key strategy involves understanding the target groups and advocating for these programs effectively. This study specifically examines the impacts of car-sharing programs on several factors in the New York City and Rochester metropolitan regions: the number of vehicles per household, the availability of other shared mobility options, and the miles traveled by individuals. The Poisson regression analysis method was used in this study. The findings from both regions indicate that the availability of various shared mobility options and a reduction in household vehicle ownership are influential factors in the usage of car-sharing programs. In Rochester, the miles individuals traveled also significantly affected car-sharing program usage.

shared-mobility, Car-sharing, Poisson

ANALYZING THE IMPACTS OF CAR-SHARING PROGRAMS IN NEW YORK CITY AND ROCHESTER, NY METROPOLITAN AREAS

1.0. INTRODUCTION

In recent years, there has been a rapid global integration of new mobility systems and technologies into urban transportation networks (Barnes et al., 2020). Projections indicate that the number of users in the shared transportation market is expected to reach approximately 3,467 million by 2027 (Figure 1). This reflects a growing preference for shared transportation solutions among consumers. The shared transportation economy includes shared mobility systems, autonomous and connected vehicles, and Mobility as Service (MaaS) (e Silva & Baburajan, 2023). Mobility as a Service (MaaS) offers a comprehensive platform that integrates all shared mobility modes in a single application. Self-driving autonomous and connected vehicles leverage advanced technologies such as artificial intelligence and sensors instead of relying on human drivers. These vehicles operate autonomously without human intervention, making them a key component in the future of transportation.

Shared mobility is a transportation strategy where passengers can request and gain short-term access to specific transportation modes. Users can access various transportation services, including hailing a driver, renting vehicles such as cars, bicycles, and scooters, and using their internet-enabled smartphones or other devices. For example, Car-sharing services like Zipcar or Car2Go allow individuals to rent cars for short periods, often by the hour. It is typically used by people who need temporary access to a vehicle and do not want the expense or hassle of owning a car. Ride-hailing services like Uber and Lyft allow users to book rides on-demand through a smartphone app. Drivers use their personal vehicles to provide the service. The bike-sharing system has shown a remarkable increase in user adoption. Shared mobility services such as Citi Bike, Lift, Bixi, Lime, and others do not charge membership fees but follow a pay-per-use approach (Becker et al., 2020).

The majority of shared systems have focused on intracity travel, particularly in large cities, and recently, they have been expanded to inner-city and have extended their services to smaller urban areas as well (e Silva & Baburajan, 2023). According to Figure 1, from 2017 to 2022, the number of bike-sharing users grew from 513 million to 762 million. In contrast to other shared mobility services, taxi sharing has experienced a decrease in its user base. This decline might be attributed to alternative shared transportation options' increasing availability and convenience. The limited utilization of car-sharing programs, coupled with their steady use, necessitates further research to understand and potentially increase their adoption among the public. This investigation is essential to identify the factors influencing the usage patterns of car-sharing programs and to develop strategies to encourage more widespread use.

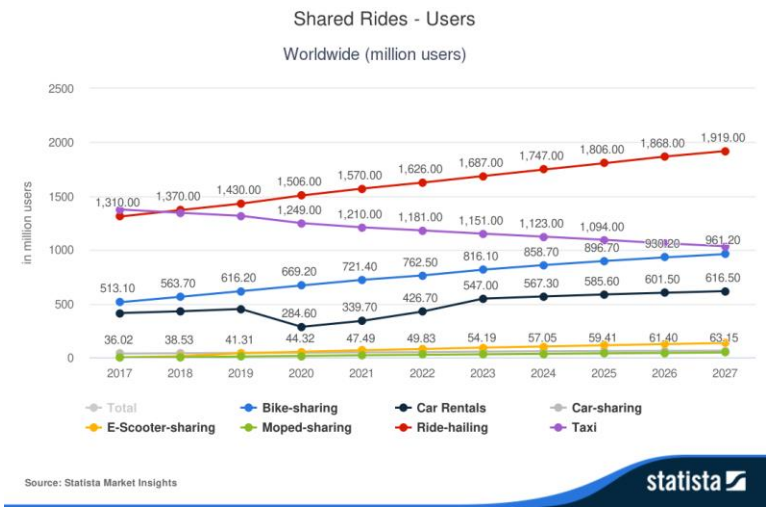

Figure 1: Global shared mobility market from 2017 to 2027
Source: https://www.statista.com/outlook/mmo/shared-mobility/shared-rides/worldwide

CAR SHARING

Car sharing allows users to book an entire car for a short term based on hourly or distance-based payment. The main differences between traditional car rentals and car sharing are related to the longer duration of the rental; in the former, a more streamlined way of picking up the vehicle, and the latter. These systems provide an opportunity for more sustainable transportation as they aim to shift people away from private mobility by reducing the need for car ownership, the number of cars on the road, car parking, and, consequently, the environmental impact. Individuals who give up ownership of private vehicles in favor of joining a car-sharing organization subsequently exhibit a reduced frequency in their use of shared vehicles compared to their prior usage of personal cars (Loose et al., 2006). Car-sharing programs enable travelers to enjoy the perks of a car without bearing the ownership cost and associated responsibilities (fuel, maintenance, insurance). The largest car-sharing networks are Zipcar and Car2Go, each with over 900,000 members and 11,000-12,000 vehicles in multiple countries (Laporte et al., 2015).

Car-sharing companies have used different business models: roundtrip, one-way, fractional ownership, and peer-to-peer car-sharing. roundtrip car-sharing and peer-to-peer car-sharing systems require individuals to return vehicles to the location from which they were borrowed. One-way services allow users to pick up and drop off their car at different locations, increasing the service's flexibility and adaptability to respond to first- and last-mile connectivity. One-way services could be free-floating or station-based. Fractional ownership of vehicles is an innovative concept where a single vehicle is subscribed to or co-leased by multiple individuals who collectively share its usage. This approach is exemplified by programs like Audi Unite, where a group of people enters into a shared ownership or leasing agreement for a car (Barnes et al., 2020).

The primary goal of this study is to identify factors influencing the use of car-sharing programs in the New York City and Rochester metropolitan areas. However, these models are scalable and can be used in any geographical region based on the data availability. Aligned with the main objective, this study investigates the following three hypotheses:

H1: The availability of other shared mobility options influences users' usage of car-sharing services.
H2: The increased car ownership among residents negatively affects the usage of car-share services.
H3: Total travel miles by individuals increased with the usage of car-sharing programs.

2.0. LITERATURE REVIEW

The success and sustainability of the car-sharing economy depend on consumer participation. To ensure the growth and success of the car-sharing industry within the larger sharing economy, it's essential to have a deep understanding of the underlying drivers that motivate consumer engagement. By addressing these factors effectively, the car-sharing sector can flourish and thrive in the long run. Joo (2017) found convenience and timesaving emerge as dominant factors driving consumer motivation towards car-sharing, overshadowing other considerations such as cost savings and societal benefits. Consumers have a lower priority for the wider social and environmental benefits that come with car-sharing, such as mitigating environmental pollution, reducing traffic congestion, conserving energy, and optimizing parking space utilization (Joo, 2017).

In North America, factors like low vehicle ownership, high levels of education and income, as well as the age group of 30 to 50 years with middle to higher income, have a significant impact on car-sharing members. For instance, a significant 48% of car-sharing members have postgraduate or advanced degrees (Millard-Ball, 2005). More men, young people, and those with higher incomes tend to use free-floating car services compared to other types of car-sharing. Also, people who use round-trip car-sharing services generally have less education compared to users of other car-sharing services. However, those who are members of round-trip car-sharing services might lead a more efficient and environmentally friendly lifestyle than those who use one-way car-sharing systems (Amirnazmiafshar & Diana, 2022).

Several studies have investigated the impact of car-sharing programs on household vehicle ownership. The results suggest that such programs can lead to a reduction in the number of vehicles owned by a household. Specifically, individuals may choose to give up purchasing a second or third

vehicle since they have access to car-sharing services. However, some studies found that while the availability of car-sharing programs does have some effect on people's decision to own a car, the impact is relatively minor (Zhou et al., 2020). The decision to switch from private vehicles to car-sharing is influenced by several key factors of the trip. One such factor is the location of the car-sharing parking area, which has an impact on the feasibility of using car-sharing programs for commuting purposes. Studies have shown that people are willing to walk up to a maximum of 5 minutes to access the car, making the proximity of the parking area a crucial determinant of car-sharing usage. In particular, the availability and accessibility of car-sharing services at the end of the workday can influence the decision to adopt this mode of transportation (Diana & Ceccato, 2022). In addition to those factors, travel time, travel costs, maintenance charges, and membership fees were found to affect car-sharing programs (Ali Aden et al., 2022).

Car-sharing activities are mainly used for discretionary activities. Discretionary activities refer to non-essential activities individuals engage in based on personal preference, leisure, or recreational purposes. These activities are not mandatory or obligatory, unlike activities such as work or school, which are often categorized as non-discretionary. Discretionary activities can include various activities, such as socializing with friends or family, dining out at restaurants, and shopping for non-essentials. Researchers indicate that users prefer car-sharing systems to access areas within or closer to the inner city with more workplaces and shopping but limited car parking access.

Some studies focus on the public perceptions of car-sharing. Magnani & Re (2020) mentioned young adults have conflicting ideas about car-sharing. For example, people do not consider car ownership to represent their identity, but at the same time, they believe car ownership represents their social status. They mentioned sometimes its a shame to use the car-sharing programs (Magnani & Re, 2020).

3.0. STUDY AREA

Two metropolitan areas, namely New York City and Rochester, New York metropolitan areas, were chosen for this study. The former is the largest populous metropolitan area in the USA, comprising five Boroughs: Brooklyn, Queens, Manhattan, the Bronx, and Staten Island. The population of the New York City metropolitan region was 8,335,897 in 2022, making it a globally recognized city and a global economic center. The Rochester metropolitan area comprises six counties in Western New York. Farming is one of the main income sources in this area. Based on the census data, the population was 1,090,135 in 2020.

Figure 2: The five boroughs of New York City metropolitan region

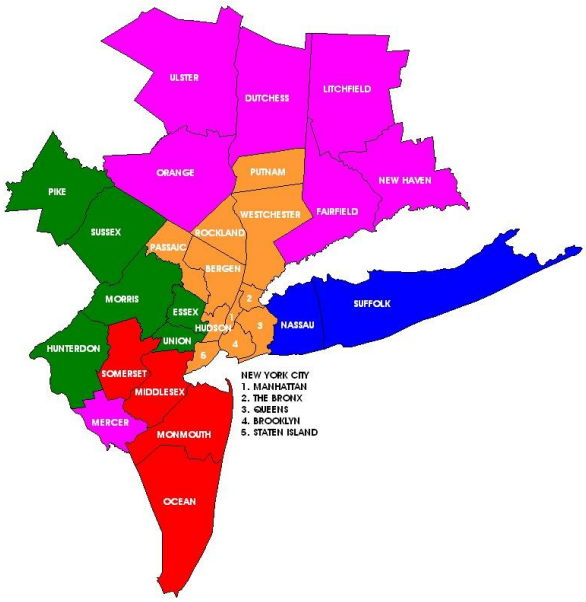

Figure 3: Components of the Rochester–Batavia–Seneca Falls combined statistical area.

TRANSPORTATION PLAN FOR NEW YORK CITY: Plan 2040

Plan 2040: A Shared Vision for Sustainable Growth, the New York Metropolitan Transportation Council's (NYMTC) Regional Transportation Plan discussed how and where investments are made for regional sustainable development. New York's metropolitan region population is expected to grow from 12.6 million in 2015 to 14.3 million in 2040, which is required to improve and maintain the existing transportation network. This plan strongly encourages walking, bicycling, carpooling, and reducing greenhouse gas emissions. In addition to that, Plan 2040 focuses on transportation systems that can withstand disasters such as floods and storms. Plan 2040 has seven shared goals, and they are:

- Enhance the regional environment.
- Improve the regional economy.
- Improve the regional quality of life.
- Provide a convenient and flexible transportation system within the region.
- Enhance the safety and security of the transportation system for all users.
- Build the case for obtaining resources to implement regional investments.
- Improve the resiliency of the regional transportation system.

Some of the actions to reach these goals are implementing car-sharing, pedestrian, and bicycle projects. The Plan 2040 expected the mobility of NYMTC residents, workers, and visitors by providing a wide range of economical transportation modes and increasing parking availability. New York City approved an amendment to its zoning regulations, defining car sharing and setting specific rules for car-shared parking. These vehicles are now allowed to park in both public parking areas and private parking facilities linked to residential and commercial properties. However, the number of parking spaces allocated for car sharing is limited, depending on the type of facility, its zoning area, and its size.
In July 2012, the City of Long Beach initiated a bike share program with approximately 16 rental kiosks, providing a fleet of 400 bicycles. The Plan 2040 aims to expand its services in the future by developing bicycle trails and establishing designated parking areas for bicycles (https://www.nymtc.org/Portals/0/Pdf/RTP/Plan%202040%20Main%20Document.pdf).

The New York City Department of Transportation (NYC DOT) has been actively working on expanding shared mobility systems, particularly focusing on car-sharing programs. The NYC DOT has

started a major expansion of its on-street carshare program. This includes installing new curbside parking spaces dedicated to carsharing vehicles across Brooklyn, Queens, and the Bronx, with an emphasis on equitable distribution (https://www.nyc.gov/html/dot/html/pr2023/expansion-on-street-carshare.shtml).

TRANSPORTATION PLANS FOR ROCHESTER, NY: THE LONG-RANGE TRANSPORTATION PLAN FOR THE GENESEE-FINGER LAKES REGION 2045 (LRTP 2045)

The Long-Range Transportation Plan for the Genesee-Finger Lakes Region 2045 (LRTP 2045) is aimed at addressing the current challenges faced by the regional transportation system, including improving standards of safety and existing infrastructure, improving the alternative travel modes, and making transportation services more equitable and accessible for everyone. The current transportation system caters more to personal vehicles, making it difficult for those who rely on public transit, walking, bicycling, and other active modes of transportation. To make the system more inclusive, ~~the~~ LRTP 2045 aims to increase transportation choices and protect vulnerable users, thus creating a more sustainable and inclusive system. LRTP 2045 has several objectives:

- Support the regional economic growth of the region..
- Increase the safety of the transportation system.
- Facilitate partnerships in planning, financing, and executing transportation projects.
- Increase the accessibility and mobility options available to people and freight.
- Promote efficient system management and operations.
- Protect and enhance the environment missions.

The Regional Transit Service (RTS) has established a partnership with the Transit app to provide easily accessible real-time transit information. The Transit app is designed to assist users in planning their trips by displaying walking and cycling times and routes, as well as ride-hailing options. The introduction of mobile phone payments and rechargeable fare cards has made paying for transit fares more convenient. These services are now easily managed online. The Pace bike share program was launched in Rochester in 2017, providing a simple, accessible way to access bicycles and reducing the need for personal vehicles. While this service was discontinued, RTS and the City of Rochester have plans for expanding the bike share service across Monroe County with a new operator in 2021. Additionally, LRTP 2045 has prioritized the Mobility as a Service (MaaS) concept to improve mobility.

4.0. METHODOLOGY

DATA COLLECTION AND DATA PROCESSING

The National Household Travel Survey (NHTS) is a detailed survey that tracks how people in the United States travel, using all different kinds of transport and for various reasons. It covers all 50 states and the District of Columbia. This survey is very useful for understanding how well current transportation systems are working and for making plans for the future, particularly for long-term projects. The NHTS has data from the years 1995, 2001, 2009, 2017, and 2022. This study specifically uses information from the 2017 survey. This survey was carried out between April 19, 2016, and April 25, 2017, and it gathered its data by selecting a random group of U.S. households in a structured way. This study focused on the New York City and Rochester metropolitan regions. Data from an individual data file was used for this study.

The data set under consideration includes survey responses from 1945 individuals in New York City and 10,922 individuals in the Rocester region. Our analysis focused on several variables, including car-sharing usage, ride-sharing usage, bike-sharing usage, public transit usage, household vehicles, and miles driven in all vehicles. We first filtered out the values for these variables and then removed all negative values related to distance and count of car-shared program usage. However, we kept the negative values from other variables to maintain the sample size. The remaining data has a sample size of 1212 and

6,194 for the New York City and Rochester areas, respectively. The remaining data was then used for our analysis.

ANALYSIS METHOD

The dependent variable in this study is car-sharing program usage, represented by positive integer values. Numerous statistical techniques are available for analyzing count data, including binomial models and Poisson regression models. For this study, we utilized the Poisson regression model for analysis. Our study considered the count of bike share program usage, count of rideshare app usage, count of public transit usage, count of household vehicles, and miles personally driven in all vehicles as independent variables.

5.0. RESULTS

The Poisson regression model for New York City indicates that three variables have a significant statistical impact (p-value< 0.05) on the outcome. These variables are the count of bike share program usage, the count of rideshare app usage, and the count of household vehicles. The count of household vehicles has a negative impact on car-sharing programs, whereas the other two variables have a positive impact (refer to Table 1 for detailed information).

Table 1: Summary of Coefficients Used count of care-sharing program usage for New York City Metropolitan region.

	Estimated parameter	Z statistic	P-value
Count of Car Share Program Usage			
Intercept	-8.786e-01	-1.425	
count of bike share program usage	5.189e-01	3.894	9.86e-05
count of rideshare app usage	6.088e-01	3.035	0.00241
count of public transit usage	4.600e-02	0.758	0.44864
count of household vehicles	-2.581e+00	-4.508	6.54e-06
miles were personally driven in all vehicles as an independent	1.597e-05	0.441	0.65890
Null deviance	153.96 on 1211 degrees of freedom		
Residual deviance	108.99 on 1206 degrees of freedom		
AIC	133.55		
Number of Fisher scoring iterations	13		

According to the Posson models, all five variables in Rochester have been found to be statistically significant. Apart from the count of household vehicles, all other variables have a positive impact (refer to Table 2 for detailed information).

Table 2: Summary of Coefficients Used count of care-sharing program usage Rochester, NY Metropolitan region.

	Estimated parameter	Z statistic	P-value
Count of Car Share Program Usage			
Intercept	-2.821e+00	-12.753	
count of bike share program usage	3.255e-02	6.989	2.77e-12
count of rideshare app usage	5.116e-02	5.999	1.98e-09
count of public transit usage	2.757e-02	2.730	0.00633
count of household vehicles	-1.080e+00	-8.291	<2e-16

miles were personally driven in all vehicles as an independent	3.307e-05	7.528	5.15e-14
Null deviance	1186.10 on 6193 degrees of freedom		
Residual deviance	954.81 on 6188 degrees of freedom		
AIC	1124.1		
Number of Fisher scoring iterations	12		

6.0. DISCUSSION

The sample size obtained by the NHTS dataset for the New York City metropolitan region is 1212, which is 6194 for the Rochester metropolitan region. The New York City metropolitan area has a population approximately eight times larger than that of the Rochester metropolitan area. However, despite being the largest populous city in the USA, the sample size of New York City is much smaller. This limited sample size adversely affects the accuracy of the result. Moreover, the dataset contains many zeros, which can potentially affect the accuracy of the analysis. To mitigate this issue, Zero-Inflated Models can be used as an alternative statistical method.

The focus of the car-sharing program usage in this study was limited to five variables, which resulted in reduced accuracy. Nonetheless, previous research has shown that various factors, such as household size, income, and education level, significantly influence car-sharing program usage. Therefore, incorporating additional parameters in the models can enhance their accuracy.

The New York City car-sharing program's model shows that three variables have a significant impact on people's usage of car-sharing programs. These variables are the number of times people use bike-sharing programs, the number of times they use ride-sharing apps, and the number of household vehicles they own. The positive correlation between bike-sharing and ride-sharing programs with car-sharing programs indicates that people who use other shared mobility services are more likely to use car-sharing programs as well. Furthermore, when the number of household vehicles decreases, people tend to use car-sharing programs more often, which suggests that individuals with fewer household vehicles are more likely to use these programs. However, based on the p-value analysis, the car-sharing programs have no effect on the number of miles driven by each individual. Thus, we can conclude that car-sharing programs do not significantly impact the mobility of people in New York City.

The Rochester metropolitan car-sharing program usage shows all five variables are statistically significant based on the p-value. When all other variables have a positive relationship with car-sharing program usage, household vehicle count has a negative relationship similar to the New York City model.

The Rochester car-sharing model shows a positive correlation between the number of vehicle miles traveled by individuals and the usage of car-sharing programs, in contrast to the New York City model, which shows no such effect. This indicates that in Rochester, individuals who travel more using vehicles are more likely to use car-sharing programs. This trend may be attributable to factors such as the cost of owning a car and parking difficulties. Therefore, we can assume that car-sharing programs may increase the mobility of people in the Rochester area. However, further research is needed to verify these ideas.

Previous studies indicate a negative correlation between the availability of household vehicles and the success of car-sharing programs. In line with the long-term regional transportation plans of New York City and Rochester regions, efforts are being made to ensure equitable transportation access for individuals with limited access to private vehicles within each region.

7.0. CONCLUSION AND RECOMMENDATIONS

The primary objective of this study is to find the factors that affect car-sharing program usage. This study used the National Household Travel data from 2017. The dependent variable is the count of car-sharing program usage. The independent variables are the count of bike-sharing program usage, ride-hailing program usage, public transportation usage, number of household vehicles, and vehicle miles

traveled by individuals. Based on the result of the Poisson regression model, there are similarities between the New York City and Rochester car-sharing models. For both metropolitan regions, the availability of other car-sharing programs and the number of household vehicles affect car-sharing programs positively and negatively, respectively. In addition to that individual's total vehicle miles positively affect car-sharing programs in Rochester city.

Based on the findings, it appears that in Rochester, individuals who often travel longer distances by vehicle are more inclined to utilize car-sharing programs. Car-sharing programs can find the places frequently visited by these long-distance travelers and implement more car-sharing programs in these areas. In addition to that, car-sharing companies can focus on offering special rates and low membership rates for people who travel long distances frequently. In addition to that, in both metropolitan areas, multi-mode transportation options can be beneficial.

. The study requires additional refinement by incorporating a larger sample size and including more independent variables to enhance the accuracy of the results. The accuracy of the predicted models is affected by two factors - the presence of excess zero values and limited data range. The current study recommends several steps to improve future predictions, including expanding the data range to include more metropolitan regions, observing the trend of car-sharing program usage over time, and incorporating other variables like socioeconomic factors and comparative analysis with different models.

REFERENCES

Ali Aden, W., Zheng, J., Ullah, I., & Safdar, M. (2022). Public preferences towards car sharing service: the case of Djibouti. *Frontiers in Environmental Science*, *10*, 449.

Amirnazmiafshar, E., & Diana, M. (2022). A review of the socio-demographic characteristics affecting the demand for different car-sharing operational schemes. *Transportation Research Interdisciplinary Perspectives*, *14*, 100616.

Barnes, S. J., Guo, Y., & Borgo, R. (2020). Sharing the air: Transient impacts of ride-hailing introduction on pollution in China. *Transportation research part D: transport and environment*, *86*, 102434.

Becker, H., Balac, M., Ciari, F., & Axhausen, K. W. (2020). Assessing the welfare impacts of Shared Mobility and Mobility as a Service (MaaS). *Transportation Research Part A: Policy and Practice*, *131*, 228-243.

Diana, M., & Ceccato, R. (2022). A multimodal perspective in the study of car sharing switching intentions. *Transportation Letters*, *14*(4), 317-323.

e Silva, J. d. A., & Baburajan, V. (2023). 20. New mobility systems and land use. *Handbook on Transport and Land Use: A Holistic Approach in an Age of Rapid Technological Change*, 350.

Joo, J.-H. (2017). Motives for participating in sharing economy: Intentions to use car sharing services. *Journal of Distribution Science*, *15*(2), 21-26.

Laporte, G., Meunier, F., & Wolfler Calvo, R. (2015). Shared mobility systems. *4OR*, *13*(4), 341-360. https://doi.org/10.1007/s10288-015-0301-z

Loose, W., Mohr, M., & Nobis, C. (2006). Assessment of the future development of car sharing in Germany and related opportunities. *Transport Reviews*, *26*(3), 365-382.

Magnani, G., & Re, B. (2020). Lived experiences about car sharing in young adults: Emerging paradoxes. *Italian Journal of Marketing*, *2020*(2-3), 207-229.

Millard-Ball, A. (2005). *Car-sharing: Where and how it succeeds* (Vol. 60). Transportation Research Board.

Zhou, F., Zheng, Z., Whitehead, J., Perrons, R. K., Washington, S., & Page, L. (2020). Examining the impact of car-sharing on private vehicle ownership. *Transportation Research Part A: Policy and Practice*, *138*, 322-341.