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Car Clubs Rapid Evidence Assessment

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CoMoUK (Collaborative Mobility UK) is the national charity dedicated to the social, economic and environmental benefits of shared transport. CoMoUK supported NatCen in the delivery of the rapid evidence assessment by: advising on draft versions of the research tools, outputs and analysis; providing CoMoUK published reports and carrying out analysis of their car club data; and identifying wider grey literature through a call for evidence.

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Executive summary

Car clubs provide a variety of social, economic, and environmental benefits by giving people low cost, flexible access to cars. The Vehicle Emissions Trading Schemes Order 2023 that implements the zero emission vehicle mandate includes a bonus credit available to vehicle manufacturers that sell zero emission cars or vans to car clubs, and grant funding for car club chargepoints is available through the Local Electric Vehicle Infrastructure fund. This is intended to encourage greater access to zero emission vehicles in communities. The Government also provides guidance for local authorities implementing car clubs through the *Local Authority Transport Decarbonisation Toolkit: Car Clubs*.

The Department for Transport commissioned a rapid evidence assessment to build on these policies to capture robust evidence about the benefits of car clubs, which allow members to rent cars for a short period of time, typically using an app or a card, without the need for a staff member. Car clubs also represent the largest and growing market within shared travel. The Department for Transport wanted to understand the reasons users engage with car clubs, the benefits and barriers, potential trends for future vehicle ownership models and wider impacts (e.g. on the environment). This research is intended to help inform further policy considerations.

The report presents findings from 37 pieces of literature that were selected following a process of systematic searching, screening, prioritisation and extraction of the evidence. The evidence reviewed predominantly comprised primary research with participants of car club schemes however, overall, the review found a lack of use of more rigorous research methodologies, such as control groups or longitudinal studies.

Definitions and car club user characteristics

The term car club is used throughout this report to refer to the short-term renting of vehicles, typically using an app or a card, without the need for a staff member. There are different types of car club referenced in this report, which are defined in detail in the introduction section. Briefly, these are:

- **Commercial car clubs** – car sharing platforms that are hosted by a business that also own the cars. Commercial car clubs commonly take two forms:
    - Back-to-bay – typically members must return vehicles to their unique, designated parking place.
    - Free-floating - members can pick up a car and return it to another location within a wider area.
- **Peer-to-peer car clubs –** car sharing platform that allows members to offer privately-owned vehicles for rent to others.

The literature reviewed provided an overview of car club user profiles. Car club members tended to be male, be based in urban areas, have higher than average education and income, and use public transport and active travel modes more frequently than the general population.

Car club members used car club cars for a variety of journey purposes, including leisure, shopping, visiting friends and family, work-related trips, medical appointments, and volunteering or caring responsibilities.

Headline findings:

- The review found evidence relating to the impact of car clubs on: (1) vehicle ownership; (2) annual distance and mileage members travelled in any type of car (i.e. including private and shared cars); (3) some wider societal factors like the environment. Evidence was also found on barriers to car club participation.
- There was a lack of literature available dealing with the impact of car clubs on other societal factors like congestion, public health and integration into mobility hubs. There was, however, evidence for the relationship between car clubs and access to opportunities (including employment, health and social opportunities).
- There was a lack of literature available on how impacts vary by the different procurement models used to deliver car clubs.

(1) Vehicle ownership

Car club membership was found to be associated with a reduction in private vehicle ownership.

- Car club users in the US, UK and Europe reported relinquishing a household vehicle (between 9.5% and 33.1% of members).
- Car club users tended not to acquire an additional household vehicle (27% of UK car club members claimed they would have bought or leased a car if they had not joined a car club).

Studies based in Germany and Canada found that certain factors increased the likelihood of relinquishing a car, including being a member of a back-to-bay car club service rather than a free-floating car club service, members having owned more cars prior to joining a car club scheme, and if members' motivation to join a car club was due to associated cost savings or to reduce pollution or fuel consumption.

However, one European study suggested that the relationship between car club membership and a reduction in vehicle ownership is over-stated when viewing the impact of car clubs through the lens of regional and national motorisation growth rates (passenger cars per 1000 inhabitants).

(2) Distance and vehicle mileage

There was evidence that, on average, the annual distance car club users travel in any type of car decreases once they start participating in car clubs.

- One UK study highlighted that the average car club member reduced their annual distance travelled by car by 170 miles.
- This reduction occurred despite the finding that car club members were able to take trips that would not have been possible without their membership. (UK evidence found that 22% of members would not have been able to take their most common car club trip were it not for their membership.)
- For the majority of members, joining a car club scheme has limited impact on levels of public transport use and participation in active travel modes, such as walking and cycling.

(3) Societal impacts

Emissions and environmental impacts is one of the areas with the highest volume of available research. The evidence demonstrated that a reduction in emissions as a result of car clubs is linked to a range of factors, including:

- Car occupancy levels – *where there was a higher occupancy rate*
- Car ownership – *through reduction in vehicle ownership and use*
- Vehicle technology – *through the use of lighter vehicle fleets and electric vehicles*

A UK study drawing on car club fleet analysis indicated that in 2020, the average car club car emitted 27% less CO_2e per kilometre than the average car in the UK.

(4) Barriers to car club participation

The biggest limiting factors on the growth of car clubs include local availability, accessibility, and reach.

- A US study focusing on peer-to-peer car clubs found a general lack of car availability caused difficulty for members.
- One literature review reported that if car club depots are not placed in easily accessible locations, adoption of the service remains low.
- Another study from Norway reported that users want good access to the types of cars they actually want.
- Certain demographic groups were underrepresented among car club user profiles, including lower socio-economic groups, older age groups, and people living in rural areas.

These observations indicate areas of car club schemes that could be improved and specific groups to engage to increase growth and reach a wider user base.

1 Introduction

This report presents findings from a rapid evidence assessment which aims to understand the reasons users engage with car clubs, the benefits and barriers related to car clubs, and the impact of car clubs in areas such as vehicle ownership, travel choices and wider impacts (e.g. on the environment). The rapid evidence assessment also seeks to understand to what extent and how these impacts may vary according to different factors, such as type of area, journey purpose and demographic and socioeconomic factors. NatCen worked in partnership with CoMoUK throughout this rapid evidence assessment. NatCen led on the delivery of the research and CoMoUK provided expert advice and quality assurance on our tools and outputs.

1.1 Background to review

This report focuses specifically on car clubs. Car clubs allow people to rent or access cars for a short period of time. Variations of car clubs are described comprehensively below, but they include commercial car clubs and peer-to-peer car clubs.

The Department for Transport has already undertaken several projects focusing on consumer characteristics and barriers and motivations to using car clubs. However, they are lacking a robust understanding of the specific impacts of these services on vehicle ownership, the environment and travel choices. To address this gap, and to build on current policies related to car clubs the Department for Transport commissioned a rapid evidence assessment to provide a comprehensive synthesis of the existing literature.

Although this rapid evidence assessment focuses on the impacts of car clubs specifically, the environment in which car clubs operate is also an important consideration. The potential for car clubs to have an impact depends on adjacent policies and practices, such as parking policies, provision of active travel infrastructure and public transport service levels. The environment car clubs operate in, therefore, provide important context to the impacts they can create.

1.2 Definitions

1.2.1 Types of car clubs

The literature reviewed in this rapid evidence assessment focuses specifically on car clubs. The different types of car clubs considered in the report are described below:

- **Commercial car clubs** – car sharing platforms that are hosted by a business that also own the cars that are rented out by the hour, typically using a card or an app, without the need for a staff member. Commercial car clubs commonly take two forms:
  - Back-to-bay (also referred to as two-way, round-trip or station-based services in the literature) – typically members have to return vehicles to their unique, designated parking place.
  - Free-floating (also referred to as one-way or flexible in the literature) – members can pick up a car and return it to another location within a wide area (note there are currently no car club operators in the UK that exclusively offer a one-way scheme).
  - The terminology used throughout this report will be “back-to-bay” and “free-floating”.
- **Peer-to-peer car clubs** – car sharing platform that allows members to offer privately-owned vehicles for rent to others.

Multi-occupancy vehicles and services (i.e. carpooling, lift-sharing and ride-sharing) were regarded as out of scope in this rapid evidence assessment.

1.2.2 Car club user characteristics

Profiling car club users was not a key aim of this rapid evidence assessment, but the literature reviewed provided some contextual evidence about users.

The evidence reviewed suggested car club users are more likely to:

- be male (CoMoUK, 2022; Wiegmann, et al., 2020; Giesel & Nobis, 2016; Esfandabadi, et al., 2022)
- be based in urban areas (Giesel & Nobis, 2016; Nenseth & Ellis, 2022; Esfandabadi, et al., 2022; Goddeke, et al., 2022)
- have higher than average education and income (Chicco, et al., 2022; Wiegmann, et al., 2020; Giesel & Nobis, 2016; Nenseth & Ellis, 2022; Esfandabadi, et al., 2022; Goddeke, et al., 2022)
- use public transport and active travel modes more frequently than the general population (CoMoUK, 2022; Nenseth & Ellis, 2022; Goddeke, et al., 2022; Kopp, et al., 2015)

The literature found that car club users are motivated to participate in car clubs for a variety of reasons, including:

- Not needing a car very often (CoMoUK, 2022; Wiegmann, et al., 2020)
- Car club use is cheaper overall than owning a car (Nenseth & Ellis, 2022)
- Avoiding the hassle of ownership (Nenseth & Ellis, 2022)
- Additionally, free-floating car club service users highlighted car clubs as being more flexible than public transport (Wiegmann, et al., 2020)

The literature also suggested that car club members use these cars for a variety of reasons, including: leisure; shopping; visiting friends and family; work-related trips; medical appointments; and volunteering or caring responsibilities.

Additionally, free-floating car club service users indicated car club use for getting to the airport (CoMoUK, 2022; Wiegmann, et al., 2020). Conversely, the trips that car clubs are less likely to be used for tend to be those that are taken every day, such as for commuting purposes.

1.3 Research questions

The review focused on the following key priority research question:

1. What is the measured impact of car club options on:
   a. Vehicle ownership
   b. Environmental impacts
      i. PM2.5 emissions (and concentrations)
      ii. NOx emissions (and concentrations)
      iii. Greenhouse gas emissions
   c. Transport mode choice (number of walking/cycling trips, public transport trips and trips made by car)
   d. Vehicle mileage, total journey time and trip generation
   e. Access to opportunities and services (e.g. employment, education, socialising, healthcare, key services)
   f. Congestion
   g. Public health

Secondary research questions were also considered where evidence was available:

2. To what extent are the impacts heterogeneous across:
   a. different areas (urban vs. rural),
   b. journey purposes,
   c. demographics,
   d. socio-economic groupings,
   e. accessibility needs?
   f. Are the above differences quantified and robustly measured?
3. What is the impact on car clubs when they are integrated into shared mobility hubs[1]?
4. To what extent do the car club operating models (e.g. back-to-bay, back to area, and one-way or flexible) encourage greater use of car clubs?

[1] A hub where sustainable transport modes, such as shared mobility, public transport and active travel are integrated.

5. How do impacts vary according to the different procurement models (e.g., service arrangement, concession[2]) used to deliver car clubs?
6. What are the barriers and opportunities to encouraging car clubs?
7. For all answers, what is the quality of evidence? Are there any evidence gaps and what further questions could be explored in additional research?

1.4 Overview of approach

The study used a rapid evidence assessment methodology. A rapid evidence assessment sits between a literature review and systematic review: it follows rigorous and explicit methods for searching, screening, assessing and synthesising evidence, whilst making informed compromises on aspects of the systematic review process in order to deliver findings quickly.

The rapid evidence assessment involved a review and assessment of academic texts, grey literature and published car club data collected and analysed by CoMoUK. Academic texts were identified through complex search strings. Grey literature was provided by CoMoUK and their contacts. A total of **136** sources were identified as meeting the inclusion criteria and **37** sources were selected for inclusion in the review after following a rigorous prioritisation process. The final source list includes quality assured data[3] on commercial car clubs provided by CoMoUK and data provided by their contacts. Further details on methodology can be found in chapter 2.

When reading this report, it should be noted that a number of the prioritised primary research studies use convenience sampling approaches. There is limited evidence that uses more rigorous methodologies, such as randomised control trials and forms of sampling, such as non-probability based and quota sampling, to provide more robust evidence. A full assessment of the quality of research included in this rapid evidence assessment can be found in chapter 9.

1.5 Report structure

The report structure is as follows:

- Chapter 2: detailed methodology used to conduct the REA

[2] Definition of these procurement models:
- a concession agreement – where a supplier is invited to operate and receive all the revenue from a scheme, without being funded by the local authority, usually without restrictions on key business and operational decisions
- a traditional services arrangement – where a local authority procures a specific service and contributes funding to the scheme (for example, through the operator charging the council a management or operating fee

[3] The data CoMoUK collate is from accredited car clubs. It goes through a series of checks internally through senior staff reviews and is then externally verified by an independent transport research company with many years of experience in the field.

- Chapters 3 to 7: cover the impact of car clubs on: vehicle ownership; vehicle mileage, total journey time and trip generation; mode choice; environmental impacts; and access to opportunities, public health and congestion (address research questions 1, 2 and 4)
- Chapter 8: covers the barriers and opportunities of car club use (address research question 6)
- Chapter 9: covers the quality of evidence (address research question 7)
- Further research: summarises the availability of evidence and suggests areas for further research

2 Methodology

This chapter provides a summary of the methodological approach used to complete this rapid evidence assessment, including the criteria and processes for the search strategy, screening, data extraction and synthesis.

2.1 Search strategy

The study involved a search for academic literature. Grey literature sources were provided by CoMoUK and included: data collected and analysed by them on predominantly commercial car clubs; research produced by regional and national transport organisations; case studies on specific car club organisations. Data provided by car club organisations was included, as it provided high-quality evidence and analysis to effectively answer the research questions, maximising the value of this exercise.

Academic literature was searched for using complex search strings in academic databases including, Scopus, Transport Research International Documentation (TRID), EconLit, GreenFILE and PsycInfo.

Grey literature was provided by CoMoUK and their contacts. The literature was selected based on the research priorities.

2.2 Screening

Academic papers were screened at two stages – at title and abstract and at full text. A total of **1773** papers were screened at the title and abstract stage. **136** sources were taken to the full text screening stage. After full text screening, **111** papers met the inclusion criteria (outlined in Appendix A). A systematic prioritisation process was undertaken based on assessing the relevance and quality of each paper and a total of **37** papers were included in this study. A detailed overview of this process can be found in Appendix A. Table 1 outlines the results of the search and screening stages completed.

Table 1 Result of each screening stage

Stage	*Academic Sources*	*Grey sources*
Identification	N=1773 papers identified through academic database searches	N=7 grey literature sources provided by CoMoUK
Screening	N=136 papers met the inclusion criteria at title and abstract screening stage	N=7 grey literature sources met the inclusion criteria at title and summary screening stage
Eligibility	N=111 papers met the inclusion criteria at the full text screening stage	N=5 grey literature sources met the inclusion criteria at the full text screening stage

Included	N=32 papers prioritised for inclusion in the rapid evidence assessment	N=5 grey literature sources prioritised for inclusion in the rapid evidence assessment

2.3 Data extraction and synthesis

A thematic framework was developed to help organise the evidence extracted from the prioritised papers. The framework was structured by the key themes included in the research questions, including the potential impact areas; factors that might influence impacts; barriers and opportunities of car club use; quality of evidence and evidence gaps. Members of the research team read each paper in full and populated the framework with the relevant evidence.

Once extraction was complete, the evidence was synthesised by research question. This was done by using a ‘framework method’, employing an analytical matrix incorporating the primary and secondary research questions.

3 Vehicle ownership

This chapter explores whether car clubs have an impact on levels of private vehicle ownership. The literature suggests that there is an association between car clubs and vehicle ownership reduction. Factors that influence the strength of this relationship are also explored.

3.1 The evidence base

Twelve sources are considered in this chapter. There was substantial evidence found in the literature highlighting a relationship between car clubs and a reduction in vehicle ownership. The evidence presented in most of the sources was based on online surveys of car club members. There were limitations to this methodology: surveys were distributed via car club providers and participation was on a voluntary basis, with relatively low response rates across sources (see chapter 9 for a more detailed discussion of this) – there are therefore issues with representation and most papers did not conduct any weighting of the data. In all but one of the papers, the surveys did not engage non-car club users, therefore there were no control groups. Two sources drew on wider data sources. One of these sources stressed that one of the main challenges for car club studies is collecting reliable data on car club services. This study acknowledged that, although various data sources were analysed, data on some car club services could have been missing or inaccurate, which would have impacted their results (Bucsky & Juhasz, 2022).

3.2 Key findings

- The main finding from the literature was that participating in car clubs is associated with a reduction in vehicle ownership. The reduction in vehicle ownership was illustrated in the literature in two main ways:
  - That car club members relinquished previously owned vehicles (sources suggested that between 9.5% and 33.1% of car club users reported having relinquished a vehicle).
  - That car club members avoided purchasing additional vehicles (one UK report found that 27% of car club members claimed they would have bought or leased a car if they had not joined a car club).
- Evidence from the application of binomial regression models suggested that certain factors were associated with a high likelihood to decrease vehicle ownership. These factors, based on research in Canada and Germany, included:
  - If membership was to a back-to-bay car club scheme, rather than a free-floating car club scheme.
  - Owning more cars prior to joining a car club scheme.

  - If the motivation to join a car club scheme was because car clubs provided cost savings compared to owning/leasing a car; or to reduce pollution or fuel consumption.

- One study looked at motorisation growth rates (number of registered passenger cars per 1000 inhabitants) across regions in the European Union before and after a car sharing scheme was introduced. The study concluded that the difference in average annual motorisation rates between the regions and the countries they were in remained almost consistent before and after the introduction of a car sharing system. The study therefore concluded that the potential for car sharing to have an impact on vehicle reduction was marginal. The authors collected data on 129 car sharing services across 26 EU countries using desktop research. The Eurostat database and national statistics were used to collect available background data to assess potential impacts. This methodology differed from the other sources in this section that largely relied on online surveys with car club members.
- Two sources hypothesised on the potential for car clubs to act as a gateway for users to increase their vehicle ownership. However, these sources found little evidence to support this hypothesis.

3.3 Car clubs and the impact on vehicle ownership

The majority of the evidence related to car clubs and vehicle ownership came from surveys conducted among car club users. The data from these surveys strongly indicated that there is a relationship between car club membership and a reduction in vehicle ownership. The evidence focused on two main points: 1) that car club users relinquished previously owned cars; and 2) that car club users avoided purchasing additional cars.

3.3.1 Evidence for relinquished vehicles

There was extensive evidence that participating in car clubs was associated with users relinquishing privately-owned vehicles. This finding was illustrated in different ways within the literature:

- Five studies, based on online survey data, reported that between 9.5% and 33.1% of car club members had decreased their vehicle ownership since they joined a car club.
- Two studies, based on online survey data, reported a significant decrease (between 0.1 and 0.43) in the average number of vehicles owned by participants before and after they started participating in car clubs.
- One study reported that for each additional free-floating car club vehicle in a city, three fewer vehicles were sold.

The proportion of car club users that reported having relinquished a car varied in each of the five studies considered. Studies also varied in the parameters they considered, three focused on whether participants themselves had relinquished a vehicle, while two considered whether a vehicle had been

relinquished within a participants' household. There were also differences in whether findings were presented at a total sample level, or if the sample was divided by car club service type. The data presented in each survey is summarised in Table 2.

Table 2 Data on relinquishing cars

Source	*Country*	*Question phrasing*	*Car club service type*	*Proportion of car club users that reported having relinquished a car*
(Giesel & Nobis, 2016)	Berlin & Munich, Germany	Asked at the household level	Free-floating	~9.5%
(Giesel & Nobis, 2016)	Berlin & Munich, Germany	Asked at the household level	Back-to-bay	~21.8%
(Weigmann et al., 2020)	Brussels, Belgium	Asked at the participant level	Free-floating	13.6%
(Weigmann et al., 2020)	Brussels, Belgium	Asked at the participant level	Back-to-bay	33.1%
(CoMoUK, 2022)	UK	Asked at the household level	Mixture – but predominantly back-to-bay	19%
(Nenseth & Ellis, 2022)	Bergen, Norway	Asked at the participant level	Mixture – but predominantly back-to-bay	25%
(Shaheen et al., 2021)	US	Asked at the participant level	Peer-to-peer	~14%

There was limited evidence available to suggest the reasons why car club users relinquished their cars. One study reported that car club members relinquished ownership because of their car club membership, the high costs associated with a private car, and because a private car was no longer needed. However, despite evidence that a car club membership can contribute to the decision to relinquish cars, two studies reported that participants do not always give car

club membership as a reason for reducing their vehicle ownership (Giesel & Nobis, 2016; Shaheen, et al., 2021).

The two studies that reported a significant decrease in the average number of vehicles owned before and after joining a car club used similar time intervals to measure this. “Before” was given as 12 months before joining a car club and “after” was defined as the time of the survey (Namazu & Dowlatabadi, 2018; Chicco, et al., 2022). One study, based in Vancouver, reported that households who joined a free-floating car club saw a drop in average car ownership rates from 1.08 to 0.98, while members of a back-to-bay car club saw a reduction from 0.68 to 0.36 (Namazu & Dowlatabadi, 2018). The second study, which focused on three German inner-city areas, found a reduction from 1.13 to 0.9 for free-floating members and 0.61 to 0.18 for back-to-bay members. This study noted that the most significant decrease in average number of vehicles owned happened in the twelve months leading up to joining a car club service, casting uncertainty on the causal relationship between car club participation and vehicle ownership reduction (Chicco, et al., 2022).

One study found that an additional free-floating car club vehicle in a city meant that three fewer vehicles were sold annually on average. To produce this finding, the study compared monthly data on car club service launch dates and fleet sizes in German cities with monthly data on new car registrations. The study took this approach to avoid the potential for overestimation that they associated with voluntary surveys of car club users. The decline was explained by a decrease in the sales of small, compact and medium-sized models specifically. Sales of larger and more expensive models were not affected (Schmidt, 2020).

Another source suggested that studies that rely on data generated from car club member surveys over-state the potential for vehicle reduction. This source reported that car sharing has the potential to have a marginal impact on vehicle ownership. This finding was based on a consideration of motorisation growth rates (passenger cars per 1000 inhabitants) across the NUTS2 regions (groupings of regional authorities) within European Union countries before and after a car sharing scheme was introduced. The study compared these regional growth rates with the national growth rates for the countries each region was in before and after the introduction of a regional car sharing scheme. In both periods, the average national growth rates were higher, and the difference between regional and national rates remained similar before and after the introduction of the car sharing system (Bucsky & Juhasz, 2022).

3.3.2 Reduction in car purchasing

Evidence of a relationship between car club membership and vehicle reduction was presented in the form of users avoiding obtaining a first or an additional car. This evidence was presented in different ways in the literature:

- A UK study reported that 27% of members claimed they would have bought or leased a car if they had not joined a car club (CoMoUK, 2022).
- One study, based on an online survey of Brussels car club members, found that one reason car club members joined a car club was because it was an alternative to buying a second vehicle (Wiegmann, et al., 2020).
- Another study, based on an online survey among car club members in Bergen, Norway, reported that half the car club users surveyed reported they had not bought a car because of car clubs (Nenseth & Ellis, 2022).
- Four further studies, conducted in Vancouver, Germany, Oregon and the Netherlands, used online surveys to explore the perceived likelihood for car club members to get either a first car or an additional car, were car clubs to not exist. In each study it was found that a proportion of participants indicated that they would buy another car in the circumstance that car clubs did not exist (Namazu & Dowlatabadi, 2018; Chicco, et al., 2022; Dill, et al., 2017; Nijland & van Meerkerk, 2017).

3.4 Factors that impact the level of reduction

Three sources covering Germany and Canada listed factors that could predict the likelihood of decreasing vehicle ownership among car club members. These findings tended to be based on logistic regression models. In the absence of much data related to why car club members reduce their vehicle ownership, this analysis provided useful suggestions for influencing factors. Ordered by how frequently they appeared across sources and strength of impact, the factors that were suggested to be associated with a high likelihood to relinquish vehicles were:

- Membership to a back-to-bay car club scheme, as opposed to a free-floating car club scheme
- Owning more cars prior to joining a car club scheme
- If the motivation to join a car club was:
  - Cost savings compared to owning or leasing a car
  - To reduce pollution or fuel consumption

Certain factors were also identified as being associated with a low likelihood to relinquish vehicles. The key factors found were:

- The more people there are in the household
- The more a private car is used
- If car clubs are used for going to restaurants or bars

Frequency of use of car club schemes was also found to be an influencing factor. However, studies disagreed on whether it was more frequent use or less frequent use that led to reduced ownership. Giesel & Nobis (2016) considered free-floating car club members only and found that more frequent use of car clubs was associated with a decrease in car ownership. Two papers found the opposite: that less frequent use led to decreased ownership (Namazu &

Dowlatabadi, 2018; Chicco, et al., 2022). More detailed findings are presented in Table 3.

Table 3 Factors that influence vehicle ownership reduction

Factors that were associated with a high likelihood to relinquish vehicles	*Factors that were associated with a low likelihood to relinquish vehicles*	*Factors where the likelihood to relinquish vehicles is unclear*
Membership to a back-to-bay car club scheme (Chicco, et al., 2022)[4], (Namazu & Dowlatabadi, 2018)[5]	As household size increases (Namazu & Dowlatabadi, 2018)	Frequency of use (Chicco, et al., 2022; Giesel & Nobis, 2016; Namazu & Dowlatabadi, 2018)
Memberships to both a back-to-bay car club scheme and a free-floating car club scheme (Chicco, et al., 2022) (Namazu & Dowlatabadi, 2018) (Giesel & Nobis, 2016)[6]	The more a private car is used/The more a car club is considered as an additional alternative to a private car (Giesel & Nobis, 2016) (Chicco, et al., 2022)	
The more cars that are owned prior to joining a car club (Chicco, et al., 2022) (Namazu & Dowlatabadi, 2018)	If a car club is used for: going to restaurants or bars (Namazu & Dowlatabadi, 2018)	
If the motivation to join a car club was: cost savings compared to owning/leasing a car (Namazu & Dowlatabadi, 2018)	As number of driving licenses in the household increase (Chicco, et al., 2022)	
If the motivation to join a car club was: to reduce pollution/fuel consumption (Namazu & Dowlatabadi, 2018)		

A description of the logistic regression models used in each study can be found in the footnotes of this page.

[4] The results referenced in this paper were based on a model which looked at members who owned a car at the time of registration and then later reduced vehicle ownership.
[5] The model referenced in this paper excluded participants who did not own a car when they became a car club user. The model was said to be moderately to highly accurate.
[6] The model developed was only based on free-floating car club users and was said to have a relatively high accuracy.

3.5 Car clubs and increasing vehicle ownership

Two sources considered the potential for car clubs to be associated with an increase in vehicle ownership. There is very limited evidence to support this idea, but what is available is summarised below:

- One study, focused on peer-to-peer members in the US, found that 2% of users suggested they had purchased a vehicle because of a peer-to-peer car club. The main reason given was to loan a car through the scheme (Shaheen, et al., 2021).
- Another study used a binary logistic regression model to explore factors that might explain why certain car club members reported a desire to purchase another car (Giesel & Nobis, 2016). The factors associated with this were:
  - The larger the household size.
  - The more important a private car is deemed to be.
  - If a person assessed that car clubs were more comfortable than public transport.

4 Vehicle mileage, total journey time and trip generation

This section explores the impact of participation in car clubs on vehicle mileage (travelled by private and shared vehicles, rather than by public transport), total journey time and trip generation (i.e. the potential for car clubs to influence the number and type of trips taken). The literature reviewed primarily focused on changes in vehicle mileage and trip generation associated with car clubs, rather than total journey time.

4.1 The evidence base

There was limited literature available focusing on the impact of car club schemes on the vehicle mileage and trip generation of car club users, and a lack of focus on the impact on total journey time. Four sources are cited in this chapter. Most of these sources were based on quantitative surveys among car club users, which collected self-reported data on distances travelled and trips taken before and after joining a car club scheme. This methodology poses limitations for accurate measurement of vehicle mileage and trip numbers, since it relies on participant recall. One study tracked participant cars using GPS data, providing a more accurate measurement method.

4.2 Key findings

There was limited literature available exploring an association between car club membership and changes in vehicle mileage and trip generation.

- Evidence found that car club members decreased the distance they travelled in any type of car annually after becoming members. One study in the Netherlands measured this decrease as 1760km, while a UK study measured the average decrease as 170 miles.
    - The study in the Netherlands identified a decrease in private vehicle ownership as leading to this outcome.
- Car clubs were also found to be associated with a decrease in private car use specifically.
- There was evidence to suggest that car clubs supported increased trip generation in the form of trips that would not have been possible without car club membership. One Netherlands study suggested that 15% of the kilometres driven by car among car club members would not have been travelled without their membership.
    - Despite this increase in trip generation, the evidence still pointed towards an overall decrease in distance travelled by car.

4.3 The impact of car club membership on vehicle mileage, total journey time and trip generation

There is evidence to show that joining a car club scheme is associated with a reduction in the annual distance travelled by car. The impact on use of any type of car (i.e. including both private and shared car use) will be explored first, followed by private car use specifically.

Impact of car clubs on distance travelled in any type of car:

- One source, based on an online survey with car club users in the UK, found that the average member of a commercial car club scheme decreased the distance they travelled by car in a year by 170 miles since becoming a member (CoMoUK, 2022).
- Another source, based on an online survey with car club users in the Netherlands, found that the annual distance travelled by car of car club members decreased from an average of 9220km before they became a member to around 7460km at the time of the survey (Nijland & van Meerkerk, 2017). At the time of the survey, most participants had been engaging in car clubs for between one and three years. This source reported that this decrease was driven by users who had disposed of a privately-owned car, and consequently drove less since doing so (for more detail on the relationship between car clubs and private vehicle reduction, see chapter 3).
- A final source provided a different perspective. This source, based on a survey conducted among peer-to-peer car club members in the US, identified an increase in driving. It found that 27% of respondents drove “more often” as a result of peer-to-peer vehicle access (Shaheen, et al., 2021). The authors connected this finding to an overall increase in trips taken, suggesting this was due to improved mobility. However, there was no evidence shared relating to specific vehicle mileage or journey time.

Impact of car clubs on distance travelled in private cars:

- The Netherlands study referenced above reported that 1850km of the average annual distance car club members travelled by car were made using a shared car. Of those 1850km, 34% were previously travelled by another type of car (Nijland & van Meerkerk, 2017).
- 68% of UK business-to-business car club members used a car club vehicle for their usual business travel. Of these individuals, 51% previously used a private car for these trips (Clark, et al., 2015).
- A UK study by CoMoUK (2022) also found that if car clubs were not available, 8% of car club members would swap back to using a rental or private car for the journeys they currently take using car club vehicles.

Car club use was also found to be associated with trip generation in the form of trips that would not have been possible without a car club membership. In one study in the UK, 22% of users said they would not have taken their most

common car club trip if car clubs were not available (CoMoUK, 2022). Another source, which reported that 1850km of the average annual distance car club members travelled by car were made using a shared car, reported that 15% of these kilometres would not have been travelled were it not for the availability of a shared car (Nijland & van Meerkerk, 2017). Both these studies reported a reduction in annual distance travelled by car since joining a car club scheme, demonstrating that despite the fact car clubs made new trips possible, they still had the overall impact of reducing distances travelled by car.

One source, drawing on an online survey and GPS data of car owners who rented out their cars via a peer-to-peer scheme in the US, suggested the potential for car clubs to increase total journey time. This source found that, overall, owners who rented their cars out drove for an extra 3.8 minutes a day one year after joining a peer-to-peer scheme (Dill, et al., 2019). Looking at individual behaviour change, the study found that despite an overall increase in total journey time, 39% of owners did actually reduce their driving by 10% or more, as measured by minutes per day. Further analysis using a binomial logit model[7] showed that owners who used their car more frequently before joining the scheme, and who rented out their car more frequently when on the scheme were more likely to reduce their use a year later.

[7] A multivariate analysis to predict whether owners reduced their vehicle use while their vehicle was available for rental. The accuracy of the model was not provided.

5 Mode choice

This section explores the impact of participation in car clubs on the number of walking and cycling trips and public transport trips members make. It starts by discussing the key findings before exploring in detail the impact of participation in car club schemes on public transport and active travel use, as well as the key factors that can influence this impact.

5.1 The evidence base

Nine papers are cited in this chapter. There was a good amount of evidence in the literature investigating the impact of different car club schemes on members' wider transport behaviours. These sources tended to draw on data from online surveys carried out with different types of cars club users. Only a minority of studies included the use of follow-up interviews to explore the reasons behind changes in travel choices.

There are methodological limitations within some of these studies, as they generated data from presenting hypothetical scenarios to participants, rather than reporting on participants' actual behaviours. Examples of this are highlighted when the sources are referenced.

5.2 Key findings

There was evidence within the literature that car clubs can contribute to changes in the way members choose to travel.

- The weight of the evidence, including from the UK and the US, suggested that, for the majority of members, joining a car club scheme has limited impact on levels of use of public transport and active travel modes.
- Among the minority of members who did report a change in their travel behaviour, there was mixed evidence for whether their use of public transport or active travel modes increased or decreased.
- The direction of impact car club membership has on levels of public transport use is influenced by the type of car club scheme being used.
  - Two studies, from Spain and Belgium, found that participation in back-to-bay car club schemes was more likely to lead to an increase in public transport use, whilst participation in a free-floating car club scheme was more likely to lead to a decrease in public transport use.

5.3 The impact of car club schemes on public transport and active travel use

The literature considered whether use of public and active transport modes changed after members joined car clubs. The evidence reviewed found that, for the majority of members, car club membership does not impact their levels of

public transport and active travel use. To come to this conclusion, studies compared self-reported public transport and active travel use before and after joining a car club scheme. This meant that studies had to rely on participant recall of how they travelled pre-membership.

- One study, based on an area of New York in the US, by Stasko, et al., (2013) found that 80% of car club members reported no change in their levels of public transport and active travel mode use.
- A study from Brussels, Belgium reported that the majority of car club members (~62% of free-floating members and ~72% of station-based members) stated their frequency of public transport use remained unchanged since becoming a member.
- In the UK, one study found that 80% of car club members who reported that cycling was their typical mode of travel for business trips, still said this was the case after joining a business-to-business car club scheme[8] (Clark, et al., 2015).
- One study presented a contrary view, as it suggested that the majority of car club members changed their behaviour in relation to public transport after becoming members. Caulfield & Kehoe (2021) found that 64% of car club members in Dublin reported using less public transport since they joined an online-booking based car club scheme.

Among the studies that found that only the minority of car club users demonstrated a change in public transport and active travel use, there was mixed evidence for the direction of this change. The US study, based on an area of New York, by Stasko, et al. (2013), which found that 80% of members reported no change in their levels of public transport and active travel use, also found that while 9% of respondents reported an increase in public transport use post-car club membership, 11% reported a decrease in public transport use. Similarly, 14% of respondents reported an increase in cycling and walking post car club membership, while 4% reported a decrease.

Two studies provided evidence that car club membership was associated with a decrease in public transport use:

- Section 4.3 referenced a study that reported that the annual distance car club members travelled by car reduced from 9220km to 7460km post-membership. Of those 7460km travelled, a shared car was used to travel 1850km. Prior to joining a car club, 41% of the trips associated with that 1850km were made by train (Nijland & van Meerkerk, 2017).
- When car club members in the UK were asked hypothetically, what transport modes they would use if car clubs were not available, 19% indicated that they would use public transport while only 1% said they would replace this with cycling and walking (CoMoUK, 2022).

[8] A business-to-business car club scheme refers to a scheme where a commercial car club rents out cars specifically to other businesses

On the other side, two studies focusing on peer-to-peer car clubs demonstrated evidence for an increase in public transport or active travel use following car club membership:

- Dill, et al., (2017) reported that, in Portland in the US: 28% of peer-to-peer car club members increased their levels of public transport use, 31% increased the amount they walked and 32% increased the amount they cycled.
  - Follow-up interviews suggested that this increase was down to users having less access to their private car while it was being used in the scheme; they in turn used this as a motivation to take up other modes of transport.
- Another US study by Shaheen, et al., (2021) which asked about walking, cycling and public transport found that peer-to-peer car clubs had no impact on public transport use. Despite this, they found that 15% of respondents reported walking more or much more often than before peer-to-peer and 10% of respondents reported cycling more or much more often.

5.4 Factors that influence the impact of car clubs on transport mode choice

The likelihood of car club membership influencing wider transport behaviours was found to be influenced by the type of car club scheme used. Research comparing free-floating car club users and back-to-bay car club users tended to show that the former reduced public transport use post-membership, while the latter increased it.

- One study in Belgium found that ~31% of free-floating car club users self-reported using public transport less or much less often since they joined (Wiegmann, et al., 2020). In comparison, ~18% of back-to-bay car club users, self-reported that they used public transport more or much more since they joined the scheme.
- A study by Silvestri, et al., (2021) in Spain produced similar findings. This study compared free-floating car club and back-to-bay car club schemes by conducting semi-structured interviews with their users. The study found that members using free-floating car clubs only reported an overall decrease in public transport use, whereas back-to-bay car club users reported either no change or in some cases, an increase.

Silvestri, et al (2021) investigated why back-to-bay car club members increased their public transport use. Members reported that the car club pick-up points were well connected with public transport, therefore they tended to use public transport to travel to or from the car locations.

6 Environmental impacts

This chapter provides an overview of the impacts of car clubs on the environment. The first section presents evidence on whether car clubs lead to a decrease in CO_2 and other greenhouse gas emissions. The next section analyses the factors that determine the strength of the environmental impact of car clubs.

6.1 The evidence base

Eighteen papers discussed the environmental impacts of car clubs, although only eight papers had a major focus on this topic.

- Eight papers which reported on environmental impacts of car clubs based their findings on car club users' survey data. In some cases, the surveys were conducted at one time point, which might impact the accuracy of the findings (e.g. issues with participant recall when asking respondents about vehicle usage prior to joining the car club scheme).
- Seven papers with a major environmental focus used scenario modelling to analyse environmental impacts of car clubs. The models were developed to assess the environmental impacts in the event of wider expansion of car clubs or, for example, if current car club fleets were replaced with electric cars. The scenarios drew on a range of sources, including national statistics, economic and environmental data and findings from other peer-reviewed literature and user surveys.
- Other sources of evidence referred to in this section included two evidence reviews, four progress reports for UK car clubs and European car club projects, a road test experiment involving test drives and one paper using the social life cycle assessment method (a method to assess the social impacts of products and services along the life cycle).

In terms of coverage of different environmental emission indicators, the majority of papers report on CO_2 emissions and other greenhouse gas emissions. There is limited data specifically on emissions such as NOx or PM2.5 emissions.

6.2 Key findings

The evidence base of this review demonstrated that car clubs lead to a decrease in emissions. However, the strength of the impact of car clubs on emissions was dependent on a range of factors, which included:

- Transport mode choice (e.g. whether users used car-free or car-dependent means of transport prior to joining a car club)
- Occupancy levels (e.g. the number of passengers travelling in car club vehicles)
- Car ownership (e.g. whether car clubs were associated with a slower growth rate of car ownership)

- Vehicle technology employed in a car club fleet (e.g. the use of newer, lighter, and electric vehicle fleets)

6.3 Evidence of impacts of car clubs on emissions

Several sources found a decrease in emissions as a result of car club use, though the estimates differed between papers as they employed different methodologies and units of analysis (e.g. different types of car clubs or types of emissions - CO_2 specifically, total-mobility related emissions or transport-related energy use).

- A study of car club users in the Netherlands aimed to quantify the savings in CO_2 emissions (Nijland & van Meerkerk, 2017). The authors conducted a survey of business-to-consumer and peer-to-peer car club users and used these findings to estimate the impact of car clubs on emissions. Their model accounted for emissions generated through vehicle use and vehicle ownership (linked to emissions at manufacturing and end-of-life stages). They concluded that car clubs led to an average reduction of between 236 and 392 kg of CO_2 per person per year, an estimated reduction of around 13%–18% compared to past emissions.
- One study (Amatuni, et al., 2020) evaluated changes in total mobility-related emissions for business-to-consumer car clubs in three case study areas – the Netherlands, San Francisco and Calgary. They employed a before-and-after user survey analysis and showed a reduction between 3-18% in total annual mobility-related emissions (3% in Calgary, 7-10% in the Netherlands and 16-18% in San Francisco). The authors noted the calculated impacts were lesser than in other studies of the same cases, as their model considered additional factors (such as the rebound effects of more intensive use of other transport options while decreasing driving) and the potential shifting lifetime of shared vehicles due to increased use.
- A study of car clubs in the USA (Chen & Kockelman, 2016) cited in a literature review (Esfandabadi, et al., 2022) looked at the lifecycle impacts of car clubs on energy use and greenhouse gas emissions. The authors reported a 5% reduction in all household transport-related energy use and greenhouse gas emissions and adjusted this figure down to 3%, as they assumed that a part of the travel-cost saving would be spent on other goods and services.
- CoMoUK's Annual Car Club Report (CoMoUK, 2022) provides evidence that car club fleets in the UK emitted less than an average car. For example, in 2020, the average car club car in the UK emitted 27% less CO_2e per kilometre than the average car. The report authors attribute this difference to the fact that car club fleets use newer vehicles and have a higher share of electric cars than the average UK fleet (the report found that in 2022, 14% of car club cars in the UK were electric and less than 2% of all cars in the UK were).

The evidence base included a discussion covering factors determining the extent of environmental impacts. Papers which employed scenario modelling

tested different assumptions about the degree to which these factors would decrease emissions as a result of car club use. The section below outlines the key issues referred to in the literature and categorises them into factors related to user behaviour and factors related to car technology.

6.4 Factors affecting the impact of car clubs on emissions – user behaviour

6.4.1 Transport mode choice

Mode choice was cited extensively as a key factor affecting the impacts of car clubs on emissions. An in-depth look at the relationship between car clubs and mode choice is provided in chapter 5. The key takeaway from across the literature was that there is a net decrease in emissions from participation in car clubs, but the environmental benefits of car clubs are partially offset by the fact that some users who previously used more environmentally-friendly modes increase their car use by joining a car club.

This observation was central to the analysis in the evaluation of effects of car clubs in Amsterdam which measured the effects of both business-to-consumer and peer-to-peer car club fleets on transport-related emissions (Arbeláez Vélez & Plepys, 2021). The paper at first estimated average travel habits based on a mobility survey conducted by Statistics Netherlands and grouped users into car-dependent and car-free individuals. They then applied this data to a model and calculated that that those who shifted from car-dependent to car club travel reduced their greenhouse gas emissions by about two-thirds (68.68% for peer-to-peer and 69.92% for business-to-consumer car clubs). Contrary to that, those who shifted from a position of being car-free to using car clubs increased their emissions by 11.63% for business-to-consumer users and 12.51% for peer-to-peer users.

The impact of mode choice on emission reduction was also considered in another Dutch study of car club users (Nijland & van Meerkerk, 2017). The authors estimated that reduction in vehicle use as a result of car clubs leads to a 279 kg reduction in CO_2, but adjusted their estimate by 168 kg given that some groups who previously used more environmentally friendly modes of transport will be increasing their car use, which decreased the reduction to 111 kg. Both papers, however, concluded that the savings in emissions from those who shift from car-dependent modes are higher than the increase in emissions from those who migrate from car-free travel habits. The mode choice findings from this study are outlined in further detail in chapter 5.

A study of car clubs in Ireland (Rabbitt & Ghosh, 2016) estimated the potential economic and environmental impacts of switching to car clubs using hypothetical travel behaviour change scenarios. Their estimates showed that car owners who travel predominantly on alternative modes (such as active

travel or public transport) could also make significant CO_2 emission savings through car clubs. Car owners who use active travel modes could reduce their CO_2 emissions by 65% and car owners using public transport by 14-20%. Non-car owners joining car clubs would increase their CO_2 emissions slightly.

Two papers (Chicco & Diana, 2021) and (Rabbitt & Ghosh, 2016) also suggested that having a more modern fleet of cars (either less pollutant or electric) would outweigh the increased emissions from previously car-free users. The impact on car technology will be discussed in more detail in section 6.5.

6.4.2 Occupancy levels

Two papers suggested that occupancy levels should be a key factor to consider when analysing the environmental impacts of car clubs, as modes of transport attracting a greater number of passengers lead to lower emissions. A study compared the greenhouse gas emissions of transport modes with different occupancy rates: car clubs, carpooling and car ownership (Fernando, et al., 2020). Carpooling was found to cause the lowest greenhouse gas emissions which was attributed to a higher occupancy rate than car clubs or private cars. The paper concluded that the highest reduction in the total greenhouse gas impact can be achieved through higher occupancy rates in combination with the development of vehicle technology (discussed further in section 6.5). Another study (Amatuni, et al., 2020) argued that, based on the study findings around lifetime shift rebound effect, if the number of kilometres a driver travels would not change as a result of car sharing, then ride-sharing or carpooling would have a higher impact on reducing total mobility-related emissions due to higher occupancy levels. However, this hypothesis was not tested.

6.4.3 Car ownership reduction

Two studies highlighted that car ownership reduction as a result of car clubs is a crucial factor when trying to lower emissions. A study of car clubs in Ireland (Rabbitt & Ghosh, 2016), which used hypothetical travel behaviour scenarios estimated that the long-term benefits of car club services included a slower growth rate of car-ownership and reduction in number of car trips, contributing to significant CO_2 savings of up to 84 kt for Dublin and 229 kt for Ireland. A study of car clubs in Belgium (Chapman, et al., 2020) tested a number of counterfactual scenarios and concluded that the impact of car clubs on car use is highly dependent on the reduction in vehicle ownership. As a result, the environmental benefits of car clubs may be realised only if a significant number of users reduce their car ownership. The relationship between car clubs and car ownership reduction is discussed in detail in chapter 3.

6.5 Factors related to car technology

6.5.1 Newer, light vehicle fleets

A number of papers discussed having newer, lighter cars in car club fleets as a factor affecting emissions. A study on car clubs in Vancouver, Canada (Namazu & Dowlatabadi, 2015) cited in a literature review (Esfandabadi, et al., 2022) showed that using newer and optimised car club fleets in Canada could reduce greenhouse gas emissions by more than 30% regardless of mode choice. The newer fleet of cars was attributed as a key factor which led to lower emissions for UK car clubs as well (CoMoUK, 2022). As stated in the CoMoUK 2022 annual report, in 2022 58% of car club cars were under 2 years old and almost 100% were under 5 years old. Using lightweight vehicles was also discussed as a factor which lowered CO_2 emissions across car clubs, carpooling and private car use (Fernando, et al., 2020).

6.5.2 Electric vehicles

Several papers pointed to the electrification of vehicles as a factor that can impact emissions. Baptista, et al., 2015 tested different vehicle technology scenarios applied to car clubs in Lisbon, Portugal, and found that shifting to more efficient vehicle technologies (hybrid and electric vehicles) led to greater reductions in Well-to-Wheel (WTW) energy consumption and CO_2 emissions. The use of electric batteries was also mentioned as a factor which led to lower emissions from car clubs (CoMoUK, 2022). In 2022 14% of the UK car club fleet used electric cars compared with less than 2% of all UK cars (CoMoUK, 2022). The Tisbury Electric Car Club (a community car club based in a rural area of the UK) estimates that by using a fully electric fleet they have saved 5.5 tons of CO_2 emissions (Tisbury Electric Car Club, 2023).

One study reported on the findings of an experiment to analyse the CO_2 emissions from different types of engines used for car club vehicles (Kubik, et al., 2023). It revealed that the electric car, regardless of road conditions, achieved lower carbon dioxide emissions ranging from savings of 10–65% compared to cars with a combustion engine. A paper modelling the impacts of car clubs in Turin, Italy found that impacts on emissions would be more positive if current car club fleets were substituted with electric ones, minimising the increase in emissions as a result of mode switch (Chicco & Diana, 2021).

The discussion of the environmental benefits of switching to electric vehicles in the context of car clubs also points at a number of factors which affect the extent to which the benefits of electric power are realised. These factors are relevant to car use more widely, and include:

- The power sources used - two papers highlighted that the electricity grid mix used to generate power for electric vehicles needs to be taken into account when considering the total emissions of an electric car, as the majority of greenhouse gas are caused by electrical power generation (Fernando, et al., 2020; Amatuni, et al., 2020).

- Eco-friendly driving style - maintaining a conservative driving style helps to charge the car battery less often and as a result contributes to a reduction in CO_2 emissions. This was especially important when travelling in low temperatures, as temperature was found to have the greatest impact on battery life (Kubik, et al., 2023). The paper did not contain empirical data on car club users driving style. Instead, it discussed potential incentives to encourage drivers to follow this driving style, such as implementation of a kilometre fee rather than a minute fee, or a rewards system for the manner of driving.
- Manufacturing phase - The manufacturing phase is an important step to consider when assessing the emissions across all lifecycle phases. According to one study, electric vehicles generated more greenhouse gas emissions during that phase than for internal combustion engine vehicles. However, the authors note that the greenhouse gas emissions overall were still lower for electric vehicles (Fernando, et al., 2020).

7 Access to opportunities, public health and congestion

This section explores evidence related to whether car club membership impacts on access to opportunities (e.g., employment, education, socialising, healthcare, key services), public health and congestion.

7.1 Evidence base

Three sources are cited in this chapter. There was limited evidence available on the impact of car clubs across the three areas described above. The three sources all draw on online surveys of car club users. The limitations of this are that participation was often on a voluntary basis, so findings may not be representative of the car club population. Control groups, in the form of non-car club users were not used.

7.2 Key findings

- There is evidence to suggest that car clubs can make trips possible that would not be otherwise.
- Car clubs were used for a range of reasons in the UK, including to visit family and friends, attend medical appointments and to make work-related trips.
- Car clubs might free-up road space because of the space saved by a reduction in private vehicle ownership.

7.3 Access to opportunities and public health

There was evidence that car clubs support users to make trips that would otherwise be difficult to make. A source drawing on survey data from members of the main commercial car club operators in the UK found that:

- 22% of car club members would not have been able to take their most common car club trip were it not for their car club membership (CoMoUK, 2022).
- 26% of members with a constraining health condition would not have made their last trip without a car club (CoMoUK, 2022).
- Members on lower incomes were more likely to say that they would not have made their last trip without a car club compared to users with higher incomes (29% of members with less than £10 000 annual personal income compared to 18% of those where that figure is more than £50 000) (CoMoUK, 2022).

There was also evidence on the types of journeys car clubs are used for. Journey purposes included trips related to leisure activities, visiting people, employment, health, and caring responsibilities. These purposes suggest that

car clubs have some association with access to both economic opportunities and public health (CoMoUK, 2022; Wiegmann, et al., 2020; Dill, et al., 2017). Additionally, among free-floating car club users, car clubs were specifically used for going to the airport (Wiegmann, et al., 2020).

7.4 Congestion and spatial planning

The relationship between car clubs and road space is not explored in reference to congestion in the literature, but in the form of parking road space saved because of a reduction in private car ownership. One study estimated that, in the UK, 150 hectares of space previously used for parking was freed up because of the reduction of private vehicle ownership associated with commercial car clubs (CoMoUK, 2022). This estimate was based on online survey data conducted among users of the main commercial car club operators in the UK.

8 Barriers and opportunities

This chapter provides an overview of opportunities and barriers to greater utilisation of car club schemes. It identifies that dependability, accessibility and convenience of car club services help to encourage greater use. It then discusses related shortcomings and opportunities for improvement. Finally, it explores opportunity areas associated with the reasons people join and use car clubs.

8.1 The evidence base

A total of thirteen papers are cited in this chapter. Seven of the papers applied quantitative methods, while others were either qualitative studies, mixed methods studies or literature reviews. There were limitations to the quantitative studies in that all bar two focused on existing car club users, with no comparison group, while in all of them representativeness was compromised due to the voluntary nature of participation. Furthermore, one paper used secondary data collected by different car club companies and cautioned that the information collected may be inconsistent (such as missing car services or different publicised fleet sizes), thus impacting the results. One qualitative study showed limitations in that it tried to quantify the data and give weight to more frequent views. Finally, the literature reviews did not indicate that the process included a quality appraisal of the sources.

8.2 Key findings

- Two key barriers to the use of car club services identified in the literature were poor or inconvenient access to vehicles and lack of accessibility. These represent key areas that could be improved to increase growth.
    - Opportunities to improve accessibility included having smarter booking systems, placing car club vehicles in more convenient locations, improving peer-to-peer services for owners and renters, and being able to use car clubs in conjunction with other transport services.
- People in lower income groups, older age groups and those living in remote areas are underrepresented among members of car club schemes. A targeted approach for these groups could enable car clubs to reach a wider user base.
    - To reach lower income groups, the literature suggested reducing the cost of car clubs relative to car ownership and promoting peer-to-peer car club services in low-income areas.
    - The evidence suggested aiming campaigns at older people and those whose households are reducing in size (for example when children leave home) as car clubs suit their travel needs.

  - To reach more remote areas, the evidence suggested providing better infrastructure such as motorways, tax incentives and workplace mobility management schemes.

- Evidence found that people joined car club schemes because of perceived environmental benefits, and the benefits and flexibility that car clubs provide compared to owning a car or using public transport. Members mostly used car clubs for leisure purposes, shopping, and visiting friends and family.

8.3 Accessibility and convenience of car club services

The literature found that it was a barrier to use if car clubs were not convenient or straight forward to access. This section explores how access to car club services can be improved by taking a range of actions:

- Smarter booking systems - Improvements highlighted by car club users who participated in studies in Spain and Bergen, Norway, respectively, included: the ability to control everything by smart phone (Silvestri et al., 2021); and for the booking system to be simple to use (Nenseth & Ellis, 2022). Furthermore, as car clubs require the use of a smartphone, which not everyone has, as well as the installation of apps that may conflict with users' wishes to protect their privacy, a study based in Copenhagen recommended that such barriers should be overcome by offering routes to access that improve accessibility for all (Haustein, 2021).
- Convenient location of cars - Several papers found a positive link between convenient location of cars and use of car clubs. A literature review looking into the role of car clubs in sustainable urban transport worldwide, reported that if car club depots are not placed in easily accessible locations, adoption of the service remains low (Jain et al, 2016; Correia & Antunes, 2012 cited in Esfandabadi et al., 2022). Thus, to increase use of car clubs, a study from Norway found that cars must be a close to where users live (Nenseth & Ellis, 2022); while Diana & Ceccatto (2019) found that in Turin, Italy, both personal car drivers and public transport users are willing to walk up to 5 minutes to reach a car club vehicle (cited in Esfandabadi et al., 2022).
- Suitable vehicles - Drawing on a quantitative survey of car club users in Bergen, Norway, it was suggested that companies should pay attention to the types of cars car club members need. It was found that participants required access to small city cars, vans and station wagons, but there was less demand for larger cars, such as SUVs and 9-seaters (Nenseth & Ellis, 2022).
- Using car clubs with other transport services - Evidence highlighted opportunities to improve access to car clubs by using them in conjunction with other transport services. Esfandabadi et al. (2022) drew on the findings of a study based in Turin, Italy, which highlighted that people who have multi-modal travel habits were more willing to engage with new transport modes such as car clubs (Ceccato et al., 2021). Furthermore, Haustein's (2021) study looking at free-floating car clubs in Copenhagen, suggested that to prevent people who do not own a car from feeling that they need one, there must be better opportunities to use free-floating car clubs in

combination with car rental, different modes of transport (for example via MaaS solutions), as well as with other car club systems.

- A study of peer-to-peer car renters and owners in Portland, Oregon found that peer-to-peer renters faced difficulties using the service because of owners not responding to or honouring reservations/requests from renters (33% of renters surveyed reported this as the worst thing about peer-to-peer) and because of a lack of general car availability and/or an unclear scheduling process (24% reported this as the worst thing about peer-to-peer) (Dill, et al., 2017). Peer-to-peer car owners also faced obstacles to renting out their cars including that they did not get enough rental requests (84% of owners surveyed), that their vehicle was at risk of damage in the rental process (24% reported this as the worst thing about peer-to-peer), or that peer-to-peer technology did not function properly (15% reported this as the worst thing about peer-to-peer). Overall, 49% of peer-to-peer car owners surveyed in Portland, Oregon, stated that renting out their car was a hassle and not worth it. Dill et al.'s (2017) research findings from Portland, Oregon, suggested that concerns related to peer-to-peer would be reduced by:
  - Having an instant rental option, which allows the renter to reserve and drive the car without having to wait for the owner's approval
  - A larger customer base to make it more worthwhile for owners to rent their cars out
  - Improving functionality of the technology, including web and mobile platforms and GPS monitoring devices
- A dependable car club market – A case study looking into a community-based electric car club in a rural area of the UK, cited cases of established car club providers setting up and then pulling out or folding, which the case study suggested would have a discouraging effect for people thinking of using car club services.

8.4 Reach and inclusivity of car club services

There was evidence that some groups are underrepresented among car club members. A number of suggestions were therefore made in the literature about the barriers and facilitators to attracting a wider and more diverse user base:

- Lower socio-economic groups: A study looking into car clubs in the Brussels region concluded that those with lower socio-economic status are underrepresented (Wiegmann et al., 2020). Further evidence suggested that the desire to save money by joining car clubs is not being realised to its full potential due to users being dissatisfied with the cost. This is evidenced by findings from the CoMoUK Annual Car Club Report, UK (2022), which found that while 34% of car club users surveyed said that saving money was a reason for joining a car club, price ranked lowest of nine aspects on which user satisfaction was measured.
- Additionally, while some sources, such as Rabbitt and Ghosh's (2016) Ireland-based study, suggested that car clubs are more cost-effective compared to owning a car, a case study into the Tisbury Electric Car Club (a community car club based in a rural area of the UK) found that for those who

need a car every day, the price of a car club is likely to exceed their budget for transport (Tisbury Electric Car Club, 2023).

- To help reach lower-income groups, Silvestri et al.'s (2021) qualitative study in Spain found that lower cost of car clubs when compared with owning a vehicle was a motivator to use. Through analysis of the geographic distribution of car club vehicles in Portland, Oregon, Dill et al. (2017) stated that the peer-to-peer car club model has the potential to reach a greater number of lower-income households than other car club services. However, the authors stressed that this will be dependent on how the service is priced and marketed to these populations.
- Older age groups: Haustein's (2021) study into free-floating car clubs in Copenhagen reported that car club services tended to target the young and mobile urban population. However, referring to previous research, the author noted that older people represent a suitable target group to promote car clubs to. This group have become more physically and socially active, more often wish to retain their driver's license until later in life (Haustein and Siren, 2015, 2013, cited in Haustein 2021), and are increasingly more likely to use a smartphone (Statista, 2015 cited in Haustein, 2021). Haustein argued that this, combined with the overall lower car demand of retired people, makes free-floating car clubs a good option for older people. Furthermore, Haustein's study found that decreasing household size is associated with choosing to relinquish a car, and thus also recommended promoting car clubs to people when their household reduces in size, such as when children leave home, when they may be re-assessing their need to own a car.
- Remote areas: In their analysis of European Research and Innovation projects available in the Transport Research and Innovation Monitoring and Information System (TRIMIS) database, Ortega Hortelano et al. (2022) found that most car club projects focused on the urban environment. The authors also cited a recommendation by the European Urban Mobility Framework that shared and on-demand mobility be extended to rural areas. In order to make this happen, in their Europe-wide study Bucsky and Juhasz (2022) suggested the need for higher quality infrastructure, such as motorways, to sustain these services, while a study into car clubs in Ireland suggested that governmental policy support, such as tax incentives and workplace mobility management schemes, may help to make car clubs viable in medium-density areas (Rabbitt and Ghosh, 2016).

8.5 Reasons for joining car clubs

A better understanding of what motivates car club users to join schemes, as well as how they use the service, could inform how car clubs are marketed and communicated, and therefore potentially increase the user base. Below is an overview of the motivators to joining a car club scheme:

- Benefits compared to car ownership and public transport - The CoMoUK Annual Car Club Report, UK (2022) found that car club users joined the scheme for the following reasons: 71% do not need a car very often, 46% wanted to avoid the hassle of car ownership, 25% wanted access to a van, and 25% because they found parking difficult or expensive where they live. Furthermore, in their report on car clubs in the Brussels region, Wiegmann

et al (2020) found that 57% of free-floating car club users said that car clubs are a more flexible option compared to public transport.

- Environmental benefits - Looking at car clubs in Spain, Silvestri et al (2021) found that car club users were motivated by using a more environmentally friendly mode of transport compared to a private car; while the CoMoUK Annual Car Club Report, UK (2022) found that 35% of UK-wide users joined car clubs in order to reduce their environmental impact.
- Journey types associated with car club schemes - Across three sources, drawing on data from the UK, London and the Brussels region, the most common reasons for using car clubs were for leisure purposes, shopping and visiting friends and family. In the Brussels region, free-floating car clubs were used for trips to the airport. Other, less common reasons for using car clubs UK-wide were for regular commuting, children's activities, other business trips, DIY/moving large loads, medical appointments and volunteering or caring responsibilities. (CoMoUK 2022; Wiegmann et al, 2020).

9 Quality of Evidence

The evidence base across the review drew on academic and grey literature sources which utilised a range of methodologies. The methods included surveys, scenario modelling, monitoring data analysis, qualitative interviews and focus groups, evidence reviews, life cycle analysis methods (a method to assess the impacts of products and services along the entire life cycle), and GPS tracking or road test experiments (involving test drives to measure emissions). The majority of sources (35) presented evidence on impacts of car clubs from Europe and Northern America. Only three studies discussed impacts of car clubs in the UK context specifically.

A substantial part of the evidence that focused on understanding impacts on vehicle ownership, mode choice, vehicle mileage and trip generation and access to opportunities was based on surveys, with the majority of studies surveying car club user groups. The representativeness of the survey samples varied. Participants were often recruited through an opt-in approach, which could skew the sample towards early adopters of the technology with a different demographic profile (e.g. male, younger, inner city residents) or more engaged users. Only one in three studies which used survey methods reported on response rates. For studies which stated the response rate, it varied between 3%-38%. Some studies used methods to help control for this, such as including comparison groups (e.g. non users or the general population) or weighting the sample.

There were some examples of studies with a longitudinal design, but these tended to be limited. Most were conducted at one time point. In these cases, they often relied on participant self-assessment, which could be prone to under or over estimation. For example, participants were asked to respond to a hypothetical scenario assessing if they would own a car if they had not joined a car club and estimating their vehicle mileage prior to joining the scheme. As the surveys were conducted at one point, the direction of the impact was not possible to determine, e.g. if car clubs were causing people to switch to different modes, or if people who use car clubs were more inclined to switch to different transport modes because of other factors.

A number of studies focused on understanding environmental impacts of car clubs developed scenarios based on different sources of empirical data (e.g. census data, environmental and economic data, national statistics and findings from peer-reviewed literature). In a few studies the scenarios were modelled on survey data, which led to similar limitations as discussed above. For example, survey data was used to develop counterfactuals e.g. whether a person would own a vehicle if they had not joined a car club scheme. The use of different metrics to measure decarbonisation and different units of analysis across the included studies made drawing comparisons across the evidence base challenging.

There were also some issues with the quality of the data which authors used to analyse car club impacts, such as inconsistencies in the monitoring data collected by different car club companies which made comparisons more difficult. In cases where GPS tracker data was used, the kits did not record the location continuously but at regular intervals, which impacted the accuracy of the mileage calculations.

Further research

This section of the report highlights potential areas for future research, based on gaps in the literature.

Suggested further research by methodology

The limitations listed in chapter 9 suggest methodological gaps in current car club research. The recommended methods for further research on impacts of car clubs therefore include:

- Greater use of robust quantitative methodologies, such as the use of weighting, control groups and longitudinal survey approaches to understand the changes in car use and car ownership and how car user groups compare to the general population.
- Further development of innovative approaches such as GPS tracking to understand the impacts of car clubs on vehicle mileage and trip generation. When developing such methods, great care needs to be taken around personal data.
- Conducting studies with other groups that show promise of take up e.g. lower income groups, older people, people outside of urban areas.

Suggested further research by topic

High priority areas for further research relate to areas of interest that had limited or no coverage in the literature. Research suggestions are summarised below according to the research area they relate to.

- Measured impact of car clubs on:
  - Access to opportunities – while there was evidence on the types of trips car clubs are used for, there was very limited consideration of which journeys would not have been possible without car clubs.
  - There is potential for further research to quantify the potential for car clubs to provide unique access to certain opportunities, including employment, health and social opportunities. A caveat to this is that such a study may require an experimental or quasi-experimental design which tend to require large budgetary investments.
  - Congestion – some estimations were provided in the literature for the amount of parking space freed up by a reduction in vehicle ownership, but the relationship between car clubs and congestion could be explored further.
  - Public health – while it would be difficult to prove a causal link between car clubs and public health benefits, there are two areas that could be explored: 1) impact on public health of reduced emissions associated with car clubs (identified in chapter 6), 2) impact on public health of increased active travel associated with car clubs (identified in chapter 5).

- The impact on car clubs when integrated into shared mobility hubs - as more mobility hubs are introduced in Europe, this provides an opportunity to observe the before and after impacts on car club integration within hubs.
- Whether the impacts of car clubs vary by different procurement models used to deliver car clubs – it would be most effective to explore this as part of a broader consideration of the overall quality of car club services.

Lower priority areas for consideration for future research relate to the impacts where a reasonable level of evidence was found. Suggestions for further research are summarised below.

- Vehicle ownership – an investigation into the potential for car clubs to reduce vehicle ownership, based on car club industry data, purchasing data and wider vehicle usage data. It must be noted that it would be difficult to prove a causal link between car clubs and vehicle ownership change, due to the variety of other factors likely to contribute to the decision to relinquish a car.
  - A qualitative exploration of the reasons why car club users relinquish their vehicles or avoid getting additional cars would provide a more nuanced understanding of behaviour change.
- Vehicle-mileage, total journey time and trip generation – a qualitative investigation to explore the reasons for the decrease in annual mileage observed. Again, it would be difficult to prove a causal link between car clubs and mileage decrease, due to the variety of other factors likely to contribute to this decision. Impact of car clubs on total journey time could be explored further.
- Mode choice – a qualitative investigation into what factors or situations lead people to switch from public transport or private vehicle use to car clubs. Studies used estimations and modelling to suggest that mode choice impacts environmental emissions, therefore future research could explore whether there is real world evidence for this.
- Environment – further research in this area could explore wider methodologies and integrate different approaches of data collection e.g. combining emission models and user behaviour data (the literature reviewed in this report largely relied on car club user survey data and scenario modelling)
- Barriers and opportunities – further research is needed to develop an understanding of how: car club operators can be supported to provide their services; and how harder-to-reach groups, such as people in less urbanised areas, low-income groups and older people can be encouraged and supported to participate in car clubs.

The recommendations made in this section relate specifically to the research questions initially posed, but it is also important to consider the environment within which car clubs operate. The impacts car clubs can have heavily depend on external factors, such as parking policies, provision of active travel infrastructure and public transport service levels. Research into these conditions and international best practices would therefore also be highly useful.

Appendix A. Approach to prioritisation

Title and abstract screening identified a total of 136 sources which looked potentially relevant. These sources were then read in full and the prioritisation described in this report is based on this full text review. As a first step, we immediately screened out sources that were found to not be relevant based on location or content. We then took a staged approach to prioritisation of the remaining sources:

1. We initially selected papers considering a combination of the overall score a source received, and the depth of information it provided on the key research question. Sources received a score between 1 and 3 for each sub-theme related to the key research question they covered, where 3 means the sub-theme is covered in a high amount of detail and 1 means it is covered in a low amount of detail. For each source, it was also noted which secondary research questions were covered. Sources received 1 point if at least 1 secondary research question was covered. Sources that had a score of at least 2 for one of the sub-themes related to the key research question and an overall score of at least 4 were initially selected.
2. The remaining sources that had an overall score of at least 3 were considered and additional sources were selected based on the following criteria:
    a. the source focused on a shared mobility mode with less representation e.g. peer-to-peer or
    b. the source had a score of 3 for one of the sub-themes related to the key research question or
    c. the source covered a sub-theme that had less representation e.g. access to opportunities
3. The sources selected were reviewed and removals were made for any sources that:
    a. were based purely on theoretical simulations
    b. focused primarily on car pooling
    c. received a score of less than 3 in relation to the Weight of Evidence Framework which was used to assess the quality of the source. Using this framework the quality of sources was assessed on four questions:
        i. Is there a clear statement of the aims/objectives or clear research questions?
        ii. Is the sampling strategy (or data selection strategy if not collecting primary data) clearly described and appropriate?
        iii. Is the method of data collection clearly described, and appropriate to answer the aims/research questions?
        iv. Are there any concerns regarding accuracy (e.g. discrepancies within the report)?

4. The date range of the sources was checked to ensure they were not weighted towards the pre-pandemic years, which had an impact on travel habits

Appendix B. Bibliography

Amatuni, L., Ottelin, J., Steubing, B. & Mogollón, J. M. (2020) 'Does car sharing reduce greenhouse gas emissions? Assessing the modal shift and lifetime shift rebound effects from a life cycle perspective', Journal of Cleaner Production, 266

Arbeláez Vélez, A. M. & Plepys, A. (2021) 'Car Sharing as a Strategy to Address GHG Emissions in the Transport System: Evaluation of Effects of Car Sharing in Amsterdam', Sustainability, 13(4)

Baptista, P., Melo, S. & Rolim, C. (2014) 'Energy, Environmental and Mobility Impacts of Car-sharing systems. Empirical results from Lisbon, Portugal' Procedia – Social and Behavioural Sciences, 111, pp. 28-37

Becker, H., Ciari, F. & Axhausen, K. W., (2018) 'Measuring the car ownership impact of free-floating car-sharing - A case study in Basel, Switzerland' Transportation Research Part D: Transport and Environment, 65, pp. 51-62

Bucsky, P. & Juhász, M. (2022) 'Is car ownership reduction impact of car sharing lower than expected? A Europe wide empirical evidence' Case Studies on Transport Policy, 10(4), pp. 2208-2217

Caulfield, B. & Kehoe, J. (2021) 'Usage patterns and preference for car sharing: A case study of Dublin' Case Studies on Transport Policy, 9(1), pp. 253-259

Ceccato, R. & Diana, M. (2021) 'Substitution and complementarity patterns between traditional transport means and car sharing: a person and trip level analysis' Transportation, 48, pp. 1523-1540

Chapman, D. A., Eyckmans, J. & Van Acker, K. (2020) 'Does Car-Sharing Reduce Car-Use? An Impact Evaluation of Car-Sharing in Flanders, Belgium' Sustainability, 12(19)

Chicco, A. & Diana, M. (2021) 'Air emissions impacts of modal diversion patterns induced by one-way car sharing: A case study from the city of Turin' Transportation Research Part D: Transport and Environment, 91

Chicco, A., Diana, M., Loose, W. & Nehrke, G. (2022) 'Comparing car ownership reduction patterns among members of different car sharing schemes operating in three German inner-city areas' Transportation Research Part A: Policy and Practice, 163, pp. 370-385

Clark, M., Gifford, K., Anable, J. & Le Vine, S. (2015) 'Business-to-business carsharing: evidence from Britain of factors associated with employer-based carsharing membership and its impacts' Transportation, 42, pp. 471-495

CoMoUK (2022) 'CoMoUK Annual Car Club Report UK' Available at: https://www.como.org.uk/documents/car-club-annual-report-uk-2022

Cyriac, G. & Julsrud, T. E. (2019) 'Cars and the sharing economy: The emergence and impacts of shared automobility in the urban environment' in Advances in Transport Policy and Planning, 4, pp. 7-38

Dill, J., McNeil, N. & Howland, S. (2017) 'Peer-To-Peer Carsharing: Short-Term Effects on Travel Behaviour in Portland, OR' Transportation Research and Education Center (TREC)

Dill, J., McNeil, N. & Howland, S. (2019) ‘Effects of peer-to-peer carsharing on vehicle owners' travel behavior’ Transportation Research Part C: Emerging Technologies, 101, pp. 70-78

Enochsson, L., Voytenko Palgan, Y., Plepys, A. & Mont, O. (2021) ‘Impacts of the Sharing Economy on Urban Sustainability: The Perceptions of Municipal Governments and Sharing Organisations’ Sustainability, 13(8)

Esfandabadi, Z. S., Diana, M. & Zanetti, M. C. (2022) ‘Carsharing services in sustainable urban transport: An inclusive science map of the field’ Journal of Cleaner Production, 357

Fernando, C., Soo, V. K., Compston, P., Kim, H.C., De Kleine, R., Weigl, D., Keith, D.R. & Doolan, M. (2020) ‘Life cycle environmental assessment of a transition to mobility’ Procedia CIRP, 90, pp. 238-243.

Giesel, F. & Nobis, C. (2016) ‘The Impact of Carsharing on Car Ownership in German Cities’ Transportation Research Procedia, 19, pp. 215-224.

Göddeke, D., Krauss, K. & Gnann, T. (2022) ‘What is the role of carsharing toward a more sustainable transport behaviour? Analysis of data from 80 major cities’ International Journal of Sustainable Transportation, 16(9), pp. 861-873

Gompf, K., Traverso, M. & Hetterich, J. (2022) ‘Applying social life cycle assessment to evaluate the use phase of mobility services: a case study in Berlin’ The International Journal of Life Cycle Assessment, 27(4), pp. 603-622

Harris, S., Mata, E., Plepys, A. & Katzeff, C. (2021) ‘Sharing is daring, but is it sustainable? An assessment of sharing cars, electric tools and offices in Sweden’ Resources, Conservation and Recycling, 170

Haustein, S. (2021) ‘What role does free-floating car sharing play for changes in car ownership? Evidence from longitudinal survey data and population segments in Copenhagen’ Travel Behaviour and Society, 24, pp. 181-194

Ortega Hortelano, A., Tsakalidis, A., Haq, G., Gkoumas, K., Stepniak, M., Marques dos Santos, F., Grosso, M., & Pekár, F. (2022) ‘Research and innovation in car sharing in Europe: An assessment based on the Transport Research and Innovation Monitoring and Information Systems (TRIMIS)’ EUR 30998 EN, Publications Office of the European Union, Luxembourg

Kopp, J., Gerike, R. & Axhausen, K. W. (2015) ‘Do Sharing people behave differently? An empirical evaluation of the distinctive mobility patterns of free-floating car-sharing members’ Transportation, 42, pp. 449-469

Kubik, A., Turoń, K., Folęga, P. & Chen, F. (2023) ‘CO2 Emissions—Evidence from Internal Combustion and Electric Engine Vehicles from Car-Sharing Systems’ Energies, 16(5)

Namazu, M. & Dowlatabadi, H. (2018) ‘Vehicle ownership reduction: A comparison of one-way and two-way carsharing systems’ Transport Policy, 64, pp. 38-50.

Nenseth, V. & Ellis, I. O. (2022) ‘Car sharing in Bergen - experiences and effects’ Oslo: Institute of Transport Economics Norwegian Centre for Transport Research.

Nijland , H. & van Meerkerk, J. (2017) ‘Mobility and environmental impacts of car sharing in the Netherlands’ Environmental Innovation and Societal Transitions, 23, pp. 84-91.

Pede, E. & Staricco, L. (2021) ‘Car sharing and social-spatial justice: evidences from the three Italian cities’ Town Planning Review, 92(4), pp. 479-505

Rabbitt, N. & Ghosh, B. (2016) ‘Economic and environmental impacts of organised Car Sharing Services: A case study of Ireland’ Research in Transportation Economics, 57, pp. 3-12.

Schmidt, P. (2020) ‘The effect of car sharing on car sales’ International Journal of Industrial Organization, 71

Shaheen, S., Martin, E. & Hoffman-Stapleton, M. (2021) ‘Shared mobility and urban form impacts: a case study of peer-to-peer (P2P) carsharing in the US’ Journal of Urban Design, 26(2), pp. 141-158.

Silvestri, A., Foudi, S., Galarraga, I. & Ansuategi, A. (2021) ‘The contribution of carsharing to low carbon mobility: Complementarity and substitution with other modes’ Research in Transportation Economics, 85

Stasko, T., Buck, A. B. & Gao, O. H. (2013) ‘Carsharing in a university setting: Impacts on vehicle ownership, parking demand, and mobility in Ithaca, NY’ Transport Policy, 30, pp. 262-268.

Tisbury Electric Car Club (2023) Case study of a local community car club. UK

Wiegmann, M., Keserü, I. & Macharis, C. (2020) ‘Carsharing in the Brussels region’ Brussels Studies, 146