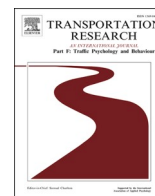


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Car dependence and car ownership among carsharing users and the mitigating effect of having multiple carsharing memberships: A moderated mediation analysis

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ABSTRACT

As business-to-consumer carsharing continues to expand on a global scale, it is probable that a growing number of carsharing users will become enrolled in multiple carsharing services concurrently, particularly in major cities. However, extant literature offers scant insight into whether and to what extent enrollment in multiple services shapes the perception of carsharing as a substitute for car ownership. In addressing this gap, this paper aims to examine how having multiple carsharing memberships affects the relationship between carsharing users' perceived car dependence, their perception of the suitability of carsharing to meet their car travel needs, and, consequently, their car ownership. To this end, a moderated mediation analysis was conducted with a sample of 788 carsharing users (including 362 individuals with multiple memberships) in the inner city of Hamburg, Germany. The findings suggest that heightened car dependence diminishes the perception of carsharing as a substitute for car ownership, thereby increasing the odds of car ownership. However, having multiple carsharing memberships was found to mitigate this effect. While surveyed carsharing users with more than one membership reported higher levels of car dependence compared to users with only one membership, they were more inclined to perceive carsharing as a viable alternative to car ownership. The moderating influence of multiple carsharing memberships was particularly pronounced among carsharing users with relatively high levels of car dependence, while among carsharing users with relatively low levels of car dependence, having multiple memberships did not lead to significantly more positive perceptions of carsharing or significantly lower car ownership.

1. Introduction and background

Urban centers around the world are grappling with the social and environmental impacts of private car ownership and use. Common problems resulting from extensive car use include traffic congestion, traffic accidents, noise, air pollution, and conflicts over street space. These problems are particularly acute in large cities, which serve as population and economic centers. Projected growth in both the urban population ([United Nations 2019](#)) and the global number of cars ([Gross 2016](#)) is likely to exacerbate these problems. In response to these challenges, transportation researchers are tasked with advising policymakers and planners on effective strategies to reduce the number of cars on the streets.

Innovative mobility solutions that prioritize shared access to vehicles over private ownership have received increasing attention as

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potential catalysts for sustainable mobility. Most notably, business-to-consumer (B2C) carsharing has gained prominence worldwide (Shaheen and Cohen 2020) and is seen as a viable tool to reduce private vehicle ownership and promote sustainable travel behavior in urban areas. A substantial body of research across diverse geographical regions has underscored the beneficial impacts of carsharing. Research indicates a correlation between carsharing use and reduced car ownership (Becker et al. 2017, Le Vine and Polak 2019, Jochem et al. 2020, Chicco et al. 2022) and reduced overall car use (Martin and Shaheen 2011b, Nijland and van Meerkerk 2017, Haustein 2021). Moreover, earlier studies have identified a positive association between carsharing and the use of other environmentally friendly transport modes such as public or active transport (Carmen et al. 2021, Kent 2014, Liao and Correia 2022, Martin and Shaheen 2011a). Consequently, carsharing has been linked to a net reduction in users' carbon footprint (Martin and Shaheen 2011b, Nijland and van Meerkerk 2017), even when accounting for rebound effects such as the shorter lifetime of shared vehicles (Amatuni et al. 2020) or changes in consumption patterns (Vélez 2023).

However, carsharing can also have negative effects. For individuals who already practice a car-free lifestyle, or for households that use carsharing in addition to private car ownership, it can lead to increased vehicle kilometers traveled and a larger carbon footprint. Research suggests that these negative effects are outweighed by the reduction in car use by households that give up private cars for carsharing (Martin and Shaheen 2011b, Vélez 2023, Vejchodská et al. 2024). The actual contribution of carsharing to sustainable mobility therefore depends significantly on the perception of carsharing as a substitute for private car ownership by (potential) car owners, and on the number of carsharing users who forgo car ownership.

Consequently, numerous studies have examined critical factors that either impede or enable the propensity to substitute carsharing for private car ownership. For example, studies have shown that concerns about the reliability of vehicle availability (Bösehans et al., 2023b; Carmen et al., 2021; Giesel & Nobis, 2016; Ikezoe, Kiriya, & Fujimura, 2020; Ye, Wang, Li, Axhausen, & Jin, 2021), extended access times and distances to shared vehicles (Czarnetzki 2023, Diana and Ceccato 2022, Kim et al. 2017, Ko et al. 2019, Namazu et al. 2018, Paundra et al. 2017), and the lack of certain car types or models in carsharing services (Zhou et al. 2020) are barriers to forgoing car ownership in favor of carsharing.

A significant yet under-researched facet pertains to the impact of having multiple carsharing memberships. In principle, being enrolled in more than one carsharing service could potentially mitigate some of the barriers to carsharing's impact on car ownership. This is because it gives carsharing members access to a greater number and variety of vehicles and pricing models. As a result, they may be able to compensate for the shortcomings of one service (e.g., the unavailability of a particular vehicle model at a desired time within an acceptable distance) by switching to another service.

The Theory of Planned Behavior (Ajzen 1991) posits that behavioral intentions and actual behavior are influenced, at least in part, by perceived behavioral control. That is, the ease or difficulty of performing a behavior is influenced by individuals' perceptions of their resources, opportunities, and experiences. The greater the perceived behavioral control, the more resources and opportunities individuals perceive they have and the fewer obstacles they expect to face (Ajzen and Madden 1986). Research in this area indicates that perceived behavioral control plays a significant role in the decision to use carsharing instead of owning a car (Derixx and van Lierop 2021, Kuhn et al. 2021, Li and Zhang 2023, Li et al. 2025, Mattia et al. 2019). Although the specific influence of having multiple carsharing memberships has not been explicitly investigated in this context, it is reasonable to assume that access to multiple carsharing services increases perceived behavioral control and thus the likelihood of perceiving and using carsharing as a substitute for car ownership.

While there is a paucity of studies that examine the use of multiple carsharing services and its impact on the perception of carsharing as a substitute for car ownership, some studies suggest that the use of multiple services of different types (e.g., free-floating and station-based round-trip carsharing) promotes the reduction of car ownership. Giesel and Nobis (2016) found an increased willingness to forgo car ownership among free-floating carsharing users in Berlin and Munich, Germany, who also used round-trip services. Similarly, Jochem et al. (2020) observed a higher reduction in car ownership among European users of a large free-floating carsharing service with memberships in other carsharing services. In a study of carsharing users in Vancouver, Canada, Namazu and Dowlatabadi (2018) found a more pronounced reduction in car ownership among those who used both one-way and round-trip carsharing services, rather than just one of these schemes. Chicco et al. (2022) reported analogous findings in major German cities, emphasizing a more substantial reduction in car ownership with the combined use of free-floating and station-based services compared to free-floating carsharing alone.

However, while there is evidence of a positive relationship between the use of multiple carsharing services and the willingness to give up car ownership, previous findings have mainly shown differences between users who only use free-floating services and those who (also) use station-based services, possibly indicating differences in the effectiveness of carsharing types rather than the influence of multiple memberships. Researchers have reached a consensus that B2C carsharing types differ in effectiveness; compared to free-floating carsharing, station-based round-trip carsharing has been found to reduce car ownership more (Becker et al. 2017, Chicco et al., 2022, Namazu and Dowlatabadi 2018), possibly due to differences in reliability and predictability of use (Glötz-Richter 2016). Research gaps persist concerning user perceptions of carsharing among individuals with multiple memberships within the same scheme. Additionally, research on the influence of perceived mobility needs and particularly perceived car dependence on the decision to enroll in single versus multiple carsharing services remains scarce.

The dearth of research on the motivations and consequences of having multiple carsharing memberships is likely attributable to the fact that carsharing is still in its early stages of diffusion in many regions. Even in Europe, where the diffusion of carsharing is relatively advanced, the simultaneous presence of multiple carsharing services is limited to a few, mostly large cities (Münzel et al. 2020, Vanheusden et al. 2022), which also limits the number of suitable study areas. However, as carsharing continues to expand, an increasing number of cities will find themselves in the situation of being the business areas of more than one carsharing company in the future. Consequently, policymakers and urban planners may benefit from an understanding of whether the presence of multiple

competing carsharing operators is conducive to sustainable urban mobility, and whether efforts should focus on individual services or on expanding carsharing options.

Therefore, this paper aims to investigate the role of multiple carsharing memberships in shaping perceptions of carsharing as an alternative to car ownership. To this end, a moderated mediation model is employed to examine the relationships between carsharing users’ perceived car dependence, perceptions of the suitability of carsharing as a replacement for car ownership, and the actual number of cars owned by carsharing users’ households. Additionally, the potential moderating effect of the number of carsharing memberships on the relationship between perceived car dependence and the perceived suitability of carsharing as a substitute for car ownership is examined. The study hypothesizes that stronger perceptions of car dependence have a negative effect on the perceived suitability of carsharing, thereby increasing the odds of car ownership, while multiple carsharing memberships mitigate the negative effects of car dependence.

The empirical data used to test these hypotheses are drawn from a survey of carsharing users in Hamburg, Germany. B2C carsharing is particularly popular in Germany (Münzel et al. 2018, Münzel et al. 2020), and Hamburg, the second largest city in Germany, offers a remarkably comprehensive range of carsharing options. In 2017, 19 % of households in Hamburg had at least one carsharing membership, with 8 % enrolled in multiple services (Follmer et al. 2020). By 2022, these figures had increased to 30 % and 15 %, respectively (Henninger et al. 2023).

The remainder of this paper is organized as follows: Section 2 describes the conceptual model for the moderated mediation analysis and related hypotheses with reference to prior research. Section 3 describes the methods used for data collection, data preparation, and model estimation. Section 4 presents the results of the data analysis. Finally, Section 5 discusses the findings in relation to existing research and implications for policy and practice.

2. Conceptual model and hypotheses

Fig. 1 illustrates the conceptual model employed for the moderated mediation analysis. In this model, perceived car dependence refers to a carsharing user’s perceived car travel needs and acts as an independent variable, as it exerts a fundamental influence on people’s preferences regarding the use of private cars or alternative modes of transportation (Metz 2023). The model hypothesizes that perceived car dependence exerts both direct and indirect effects on the number of cars owned by a carsharing user’s household. The indirect effect is assumed to be mediated by the perceived suitability of carsharing to meet a carsharing user’s car travel needs. This means that the extent to which a carsharing user perceives car travel needs will influence that person’s perception of carsharing as a suitable means of meeting those travel needs, which in turn will influence the decision to own one or more cars despite using carsharing. However, given the assumption that certain preferences regarding car ownership exist independently of views on carsharing, the model also considers a direct effect of car dependence on car ownership, unmediated by carsharing perceptions.

Furthermore, it is hypothesized that the number of carsharing memberships held by a carsharing user moderates the relationship

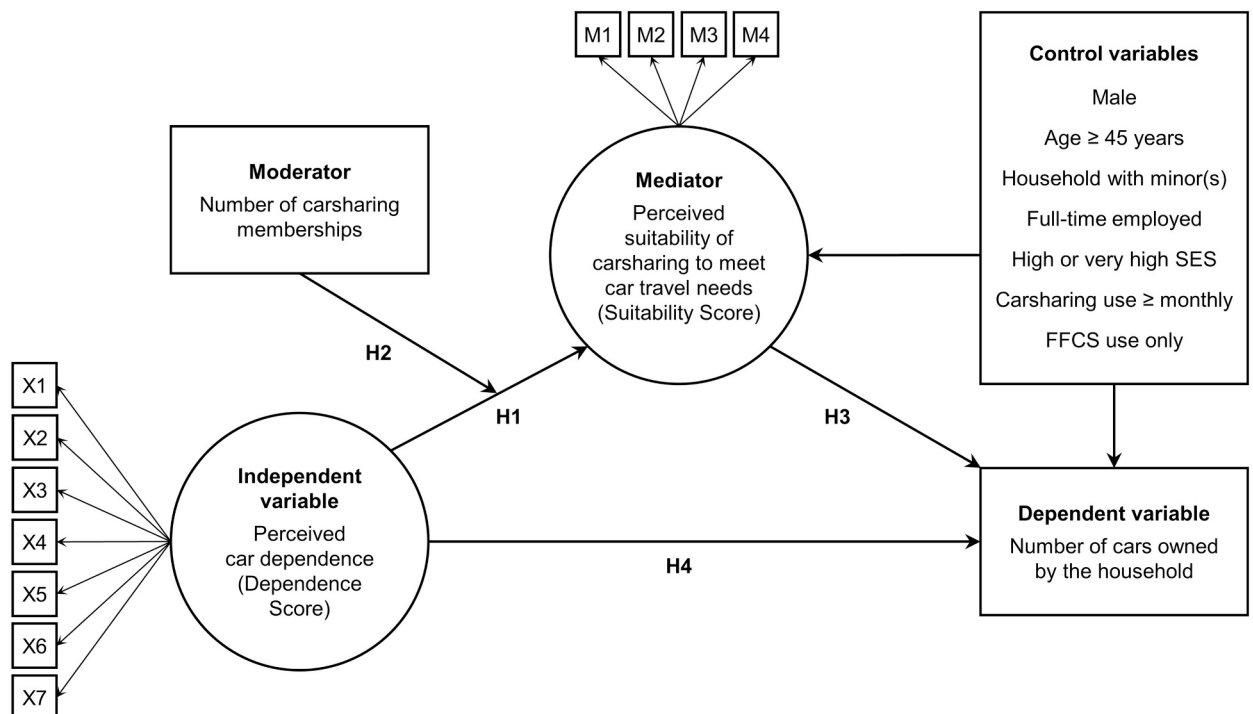


Fig. 1. The conceptual model of the moderated mediation analysis. Abbreviations: SES = socioeconomic status; FFCS = free-floating carsharing.

between that person's perceived car dependence and the perceived suitability of carsharing to meet that person's car travel needs. This is predicated on the assumption that the effect of perceived car dependence on the perceived suitability of carsharing is different for individuals with multiple memberships than for individuals enrolled in only one service. Individuals with multiple memberships have access to a broader array of carsharing options and resources, which may enable them to adequately address even relatively extensive car travel needs through carsharing.

However, the model does not examine any moderating influence of the number of carsharing memberships on the relationship between the perceived suitability of carsharing for meeting car travel needs and car ownership of carsharing users. This decision stems from the assumption that the number of memberships primarily affects whether and to what extent carsharing users perceive carsharing as a substitute for car ownership. The formation of this perception is considered a primary factor determining actual car ownership, thereby negating the need for additional moderation by the number of memberships. Perceptions of car dependence and the suitability of carsharing to meet car travel needs will be conceptualized as psychological constructs and measured through a set of psychometric indicators that will be elaborated in Section 3.

When interpreting the model and the results derived from it, it is important to consider that respondents' perceptions were surveyed at the individual level, while their car ownership was measured at the household level. This resulted in a mismatch in the unit of analysis. However, private cars in multi-person households—which constituted the majority of the sample—are often regarded as shared property, even if they are formally registered to only one member of the household. Consequently, inquiring about the number of vehicles personally owned by respondents would likely not have accurately reflected the actual situation in their households and would have potentially led to underreporting of car ownership. Moreover, all respondents in this study were adults who possessed a driver's license. Therefore, it can be assumed that they were generally able to influence their household's decisions regarding car ownership. Nevertheless, the possibility of a discrepancy between respondents' personal preferences and their household's actual car ownership status cannot be entirely discounted.

The core structure of the conceptual model (Fig. 1) represents four hypotheses to be tested. The initial hypothesis posits: *As perceived car dependence increases, the perceived suitability of carsharing to meet one's car travel needs decreases (H1).*

A multitude of studies have indicated that strong car-centric attitudes and mobility patterns have a negative impact on the propensity to replace personal car ownership with carsharing. For instance, [Haustein \(2021\)](#) identified distinct segments among carsharing users in Copenhagen, Denmark, highlighting a group characterized by high car dependence and frequent car use that did not reduce or relinquish car ownership despite using carsharing. In a similar vein, [Vejchodská et al. \(2024\)](#) observed a positive correlation between car dependence and car ownership among Czech carsharing users. [Giesel and Nobis \(2016\)](#) further noted that the propensity to relinquish car ownership among German carsharing users declined as the frequency of car use increased. Research by [Ramos and Bergstad \(2021\)](#) in Italy and Sweden demonstrated that the perceived car dependence of carsharing users had a negative impact on their intention to continue using carsharing services. These findings are not unexpected from an economic perspective, as carsharing is only cost-effective when car use is limited and actual or intended annual car mileage is relatively low ([Duncan 2011](#), [Litman 2000](#), [Prettenthaler and Steininger 1999](#)).

The negative effect of perceived car dependence on the perception of carsharing as a substitute for car ownership has therefore already been proven in earlier studies. For the present study, the examination of this relationship primarily serves to establish the foundation for the second hypothesis, which, as far as can be determined from the extant literature, has not yet been addressed in research. The second hypothesis posits the following: *The number of carsharing memberships moderates the relationship between perceived car dependence and the perceived suitability of carsharing to meet one's car travel needs. Specifically, a greater number of memberships mitigates the negative impact of car dependence on the perceived suitability of carsharing (H2).*

Higher degrees of car dependence are associated with a greater need for reliable vehicle availability, which may render carsharing inadequate in meeting this need. This notion is further substantiated by prior studies, which have demonstrated that uncertainty regarding vehicle availability can deter potential carsharing users from enrolling ([Carmen et al. 2021](#)) or hinder existing users from giving up car ownership ([Giesel and Nobis 2016](#)). In addition, inconvenient access to carsharing vehicles ([Czarnetzki 2023](#), [Diana and Ceccato 2022](#), [Kim et al. 2017](#), [Ko et al. 2019](#), [Namazu et al. 2018](#), [Paundra et al. 2017](#)) or an inadequate selection of available vehicle models ([Zhou et al. 2020](#)) can also significantly reduce the attractiveness of carsharing services as an alternative to owning a car.

However, enrollment in multiple carsharing services enables access to an expanded fleet of vehicles, which is likely to enhance the availability and ease of access to vehicles. In accordance with the Theory of Planned Behavior ([Ajzen 1991](#)), it can be posited that access to an array of carsharing options and resources through membership in multiple carsharing services serves to fortify the perceived behavioral control of using carsharing as a substitute for a personal car. In terms of adaptive decision-making strategies ([Payne et al. 1993](#)), multiple carsharing memberships could be advantageous because they allow individuals to flexibly select the most suitable option based on situational factors such as cost, availability, convenience, and specific travel needs, thereby optimizing decision outcomes in dynamic environments. While multiple memberships may not fully neutralize the negative effect of perceived car dependence on carsharing perceptions, this effect is expected to be mitigated.

The third hypothesis serves to complete the assumed indirect effect of perceived car dependence on car ownership via the perception of carsharing by stating the following: *As the perceived suitability of carsharing to meet one's travel needs increases, the odds of car ownership decrease (H3).*

A more positive perception of the suitability of carsharing as a substitute for a private car is plausibly correlated with lower levels of car ownership, although discrepancies between attitudes and actual behavior are to be expected. As demonstrated by [Chicco et al. \(2022\)](#), the perception of carsharing as a viable alternative to private car ownership is associated with a higher likelihood of car ownership reduction among German carsharing users. In a similar vein, [Giesel and Nobis \(2016\)](#) found that perceiving carsharing as equivalent to private cars significantly reduces German carsharing users' interest in purchasing private cars.

The fourth and final hypothesis is as follows: *As perceived car dependence increases, the odds of car ownership also increase (H4).*

This component of the moderated mediation model aims to discern the effects of car dependence on car ownership that are not influenced by the perception of carsharing and are not moderated by the number of carsharing memberships. Carsharing predominantly functions as a means of instrumental car use, wherein a car is used solely for transportation. However, car ownership is also known to be driven by affective and symbolic motives (Steg 2005, Gardner and Abraham 2008). While carsharing can address some of the affective and symbolic aspects of car use (Schaefers 2013), it cannot fully satisfy the non-instrumental functions of private car ownership, such as self-expression through a particular car model or the feeling of freedom and independence. The perceived car dependence measured in the present study is predominantly instrumental; however, given the correlation between instrumental and affective-symbolic motives of car use (Bergstad et al. 2011), it is plausible that carsharing users surveyed for this study may have considered aspects beyond mere transportation needs when assessing their car dependence. Consequently, it is hypothesized that the effect of perceived car dependence on actual car ownership is not fully mediated by perceptions of the suitability of carsharing to meet one's (instrumental) car travel needs, leaving a direct effect that presumably represents primarily affective and symbolic motives.

The relationship between car dependence and private car ownership and use has been extensively studied in previous research (e.g., Kenworthy and Laube 1999, Mattioli et al. 2016, Soza-Parra and Cats 2024, von Behren et al. 2018). In the present work, the primary objective of incorporating this relationship into the conceptual model is to differentiate between the effects of carsharing users' perceived car dependence and car ownership that are mediated by their perceptions of carsharing, and those effects that are not.

Beyond the relationships delineated in the four hypotheses, the model incorporates specific sociodemographic characteristics and carsharing usage patterns as control variables (Fig. 1) that may influence carsharing perceptions and car ownership. The incorporation of these variables is also intended to counteract potential self-selection bias when comparing carsharing users with single or multiple carsharing memberships. The sociodemographic control variables encompass gender, age, full-time employment, the presence of minors in the household, and high socioeconomic status.

The extant literature suggests that gender may influence the perceived importance of environmentally friendly mobility (Kawgan-Kagan 2020) and motives for car use (Steg 2005). A decline in car use and ownership has been observed in developed countries, particularly among younger demographics, as noted by Kuhnimhof et al. (2012). The presence of full-time employment and minors in the household may indicate more pronounced mobility needs. Furthermore, a higher socioeconomic status has been found to be correlated with a higher likelihood of car ownership (Nobis and Kuhnimhof 2018).

In terms of carsharing usage patterns, the model controls for whether carsharing users engage exclusively in free-floating carsharing services or whether they engage in station-based round-trip carsharing services, either exclusively or in combination with free-floating services. A substantial body of research has repeatedly demonstrated that this distinction has a significant impact on the propensity of carsharing users to forgo car ownership (Chicco et al. 2022, Giesel and Nobis 2016, Namazu and Dowlatabadi 2018). Additionally, the model considers whether carsharing users typically use carsharing at least once a month, as a number of studies have found that more frequent use of carsharing increases the likelihood of reducing car ownership (Giesel and Nobis 2016, Ko et al. 2019, Namazu and Dowlatabadi 2018).

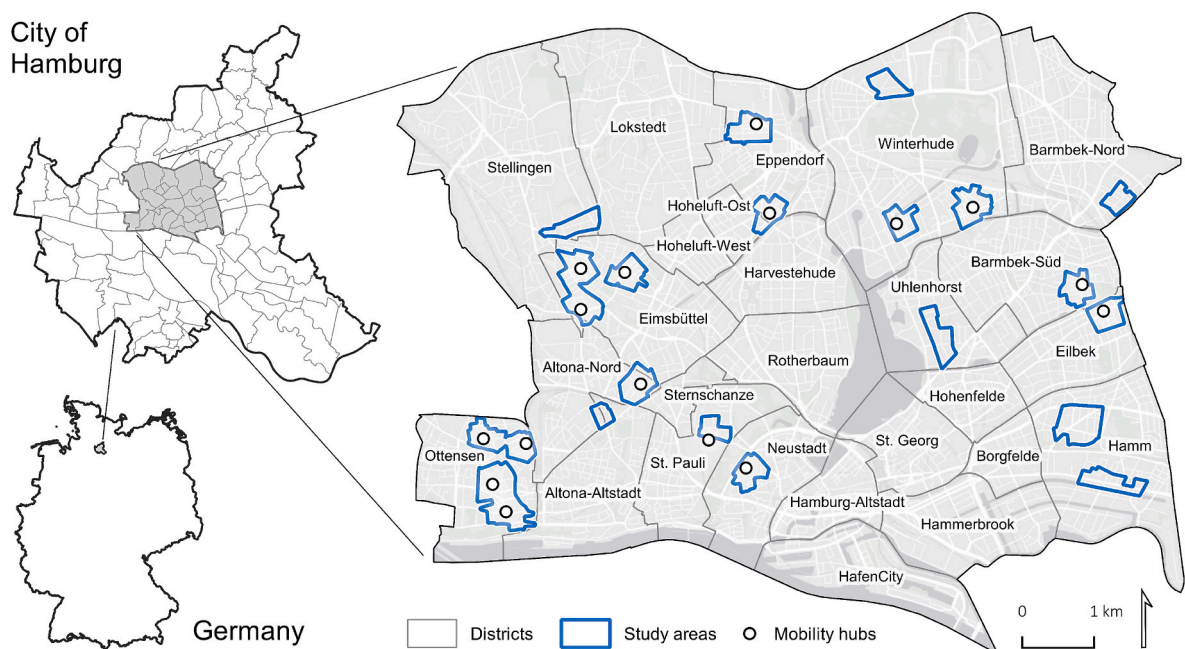


Fig. 2. Study areas in the inner city of Hamburg, Germany. (Own visualization based on OpenStreetMap and contributors).

Table 1
Sample characteristics and comparison with reference data from the national travel survey “Mobilität in Deutschland (MiD).”.

Characteristics	Study sample		Reference: MiD		Chi-square test	
	n	%	n	%	p	Cramer's V
Gender						
Female	328	41.6	163	37.7	0.206	0.04
Male	460	58.4	269	62.3		
Age group						
18–29 years	153	19.4	73	16.9	0.036	0.07
30–44 years	348	44.2	224	51.9		
45 years or older	287	36.4	135	31.3		
Household size						
One person	246	31.2	128	29.6	0.201	0.05
Two persons	332	42.1	204	47.2		
Three or more persons	210	26.6	100	23.1		
Household with minor(s)						
Yes	207	26.3	92	21.3	0.063	0.05
No	581	73.7	340	78.7		
Educational attainment						
Academic degree	604	76.6	317	73.4	0.230	0.03
Below academic degree	184	23.4	115	26.6		
Employment						
Full-time employed	585	74.2	350	81.0	0.020	0.08
Part-time employed	83	10.5	29	6.7		
Not employed/not in workforce	120	15.2	53	12.3		
Socioeconomic status *						
Low or very low	89	11.3	23	5.3	0.003	0.10
Medium	216	27.4	126	29.2		
High or very high	483	61.3	283	65.5		
Cars owned by the household						
No car	390	49.5	198	45.8	0.405	0.04
One car	312	39.6	179	41.4		
Two or more cars	86	10.9	55	12.7		
Usual frequency of B2C carsharing use						
Less frequently than monthly	303	38.5	197	45.6	0.023	0.08
One to three times per month	345	43.8	178	41.2		
At least one time per week	140	17.8	57	13.2		
Number of B2C carsharing memberships						
One membership	426	54.1	208	48.1	0.054	0.06
Two or more memberships	362	45.9	224	51.9		
Used types of B2C carsharing						
Free-floating carsharing only	548	69.5	N/A	N/A	—	—
Round-trip carsharing only	65	8.2	N/A	N/A		
Both types	175	22.2	N/A	N/A		
Sample size	788	—	432	—		

* Socioeconomic status was determined based on the size, composition, and net monthly income of the household, following the reference thresholds provided by [Nobis and Köhler \(2018\)](#).

3. Methods and data

The survey data utilized in this study were initially collected for a separate purpose, as part of a research project designed to evaluate newly implemented neighborhood mobility hubs in several densely populated residential areas of Hamburg's inner city. These hubs integrate multiple carsharing services, including both free-floating and round-trip carsharing. The objective of the hubs is to enhance the appeal of carsharing as a viable alternative to private car ownership by offering conveniently located parking spaces and vehicles within neighborhoods experiencing significant parking pressure. A thorough account of the background, methods, and outcomes of the evaluation of Hamburg's neighborhood mobility hubs has been previously documented by [Czarnetzki and Siek \(2023\)](#). Consequently, the subsequent description of the data collection is limited to the essentials. The utilization of existing data from the mobility hub evaluation offered the benefit of accessing a sample with a notably high proportion of active carsharing users, many of whom were members of multiple carsharing services. This phenomenon can be attributed to the strategic placement of the evaluated mobility hubs in areas served by all major B2C carsharing providers in Hamburg, where a significant proportion of residents were already involved in carsharing prior to the establishment of the hubs.

3.1. Study areas

Given the aforementioned context of data collection, the study areas ([Fig. 2](#)) encompassed inner-city neighborhoods in Hamburg where neighborhood mobility hubs have been operational since 2017. To determine the study areas, 16 mobility hubs were randomly selected from approximately 50 existing hubs at the time of the evaluation. From each hub, the surrounding areas were delineated

within a maximum walking distance of approximately 400 m. Additionally, seven control neighborhoods were examined, which did not yet feature any mobility hubs but were otherwise similar to the neighborhoods already equipped with mobility hubs.

At the time of data collection, eight major B2C carsharing providers were present in the study areas, including three companies offering free-floating carsharing and five companies offering station-based or homezone-based round-trip carsharing. The pervasive presence of carsharing services in Hamburg's inner city is underscored by usage statistics: in 2017, 28 % of all households in the inner city had at least one carsharing membership (Follmer et al. 2020). According to the data utilized for this study, the proportion of households with at least one carsharing membership in the designated study areas ranged from 38 % to 57 % at the time of the survey.

The study areas exhibited conducive conditions for the subscription to one or more carsharing services. In each of the study areas, multiple carsharing companies were active, most of which charged no or only low one-time fees for initial registration and no membership fees beyond that. Moreover, the city of Hamburg offers a centralized Mobility-as-a-Service application that consolidates various mobility services, including carsharing, through integrated booking and payment options. However, at the time the study was conducted, only the two largest carsharing companies in Hamburg were incorporated into this application.

3.2. Data collection and preparation

From October 2019 to February 2020, a survey was conducted in the aforementioned study areas. A postal invitation was disseminated to each household, addressed to one randomly selected adult per household, inviting them to participate in the survey. Data were collected through an online questionnaire, with each invitation containing a unique access code to prevent the same person or household from participating in the survey more than once.

Approximately 23,400 households received invitations, and 3,092 individuals accessed the questionnaire. The subsequent data

Table 2

Comparison of the subsamples of carsharing users with single versus multiple carsharing memberships.

Characteristics	Carsharing users with single membership		Carsharing users with multiple memberships		Chi-square test	
	n	%	n	%	p	Cramer's V
Gender						
Female	187	43.9	141	39.0	0.183	0.04
Male	239	56.1	221	61.0		
Age group					0.315	0.05
18–29 years	89	20.9	64	17.7		
30–44 years	191	44.8	157	43.4		
45 years or older	146	34.3	141	39.0		
Household size					0.287	0.06
One person	141	33.1	105	29.0		
Two persons	169	39.7	163	45.0		
Three or more persons	116	27.2	94	26.0		
Household with minor(s)					0.796	0.01
Yes	114	26.8	93	25.7		
No	312	73.2	269	74.3		
Educational attainment					0.090	0.06
Academic degree	316	74.2	288	79.6		
Below academic degree	110	25.8	74	20.4		
Employment					0.046	0.09
Full-time employed	304	71.4	281	77.6		
Part-time employed	55	12.9	28	7.7		
Not employed/not in workforce	67	15.7	53	14.6		
Socioeconomic status *					0.271	0.06
Low or very low	44	10.3	45	12.4		
Medium	110	25.8	106	29.3		
High or very high	272	63.8	211	58.3		
Cars owned by the household					0.036	0.09
No car	199	46.7	191	52.8		
One car	170	39.9	142	39.2		
Two or more cars	57	13.4	29	8.0		
Usual frequency of B2C carsharing use					< 0.001	0.14
Less frequently than monthly	190	44.6	113	31.2		
One to three times per month	174	40.8	171	47.2		
At least one time per week	62	14.6	78	21.5		
Used types of B2C carsharing					—	—
Free-floating carsharing only	379	89.0	169	46.7		
Round-trip carsharing only	47	11.0	18	5.0		
Both types	0	0.0	175	48.3		
Sample size	426	—	362	—		

* Socioeconomic status was determined based on the size, composition, and net monthly income of the household, following the reference thresholds provided by Nobis and Köhler (2018).

cleaning process involved the removal of questionnaires from participants who had dropped out of the survey (134 cases), questionnaires completed in an unusually short time (below the fifth percentile; 147 cases), and questionnaires with questionable or inconsistent information (94 cases). While the survey targeted the general population and included both carsharing members and non-carsharing members, the latter group (1,449 cases) was excluded from the analysis in this paper. Furthermore, carsharing members who were not actively using carsharing (480 cases) were excluded. The relatively high number of inactive carsharing members is likely due to the fact that many carsharing operators in Hamburg did not charge monthly fees, allowing inactive memberships without financial penalty. The present study's objective was to assess the actual use of carsharing as a viable alternative to car ownership; therefore, only those members who used carsharing at least occasionally were considered relevant.

Following the data cleaning and preparation phase, a sample of 788 active carsharing users remained. The sociodemographic and mobility characteristics of this sample (Table 1) are consistent with established patterns from previous research (Amirnazmifshar and Diana 2022, Becker et al. 2017, Nansubuga and Kowalkowski 2021, Wittwer and Hubrich 2018). The survey revealed that the majority of the carsharing users were male, middle-aged, and full-time employed. Notably, the majority of the users held a university degree and resided in one- or two-person households with relatively high socioeconomic status. The proportion of households without a car was as high as 50 %. The frequency of carsharing use was found to be low, with 82 % of respondents using it less than weekly and often even less than monthly, aligning with previous findings on typical usage rates (Chicco et al. 2022, Namazu and Dowlatabadi 2018, Ko et al. 2019).

While 54 % of carsharing users possessed a single membership, 30 % had two memberships, and 9 % had memberships with three services. A further 3 % had four memberships, and 4 % had five, although it should be noted that this does not imply active use of all subscribed services.

At the time of data collection, only three of the eight major B2C carsharing operators in Hamburg offered free-floating carsharing. However, 70 % of respondents were exclusively enrolled in this type of carsharing, with a further 22 % holding memberships in both free-floating and station-based services. This phenomenon can be attributed to the preeminence of free-floating carsharing services within the carsharing market of Germany's major cities (Bundesverband Carsharing 2023).

To assess the representativeness of the sample, a comparison was made with data from the Mobility in Germany survey (German: "Mobilität in Deutschland", MiD), a nationwide survey of high quality that is regularly conducted to collect representative mobility data (Nobis and Kuhnimhof 2018). The most recent MiD data available for Hamburg was from the 2017 survey wave and was provided by the city itself for the purposes of this study. To enhance the comparability of the MiD data with the survey data utilized in this study, the MiD dataset was restricted to include solely carsharing users residing within the inner city of Hamburg.

The sample utilized in this study exhibited strong agreement with the reference distributions from the MiD data, as evidenced in Table 1. Statistically significant ($p < 0.05$) or nearly significant ($p < 0.1$) differences were observed for age, employment, socioeconomic status, presence of minors in the household, frequency of carsharing use, and number of carsharing memberships. However, the consistently (very) small effect sizes of these differences (Cramér's V: 0.04–0.10) suggest negligible practical relevance. The study's sample appears to adequately represent the population of carsharing users in the inner city of Hamburg.

Additionally, the sample was segmented into two subsamples: respondents with a single carsharing membership and those with a minimum of two memberships. This segmentation was implemented to identify potential differences between these two groups (Table 2). The descriptive analyses indicated that certain characteristics typically associated with carsharing users (e.g., male gender, high level of education, being full-time employed, belonging to a two-person household) were even more prevalent among carsharing users with multiple memberships. However, the majority of these differences did not attain a statistically significant level. Conversely, respondents with multiple carsharing memberships were significantly more likely to reside in car-free households and to utilize carsharing services with greater frequency. Surprisingly, subscribing to multiple carsharing services resulted in a combination of free-floating and round-trip carsharing in only 48 % of cases, while 47 % of respondents with multiple memberships opted for exclusive use of free-floating carsharing. Conversely, a mere 5 % of respondents with multiple memberships relied exclusively on round-trip

Table 3
Construct measures and results of the confirmatory factor analysis.

Item	Statement	M	SD	λ	α	ρ	AVE
	Perceived car dependence (Dependence Score)	0.00	0.98	—	0.90	0.90	0.55
X1	I have to use a car for occupational reasons.	1.96	1.49	0.69			
X2	I have to use a car for duties of my private life.	2.04	1.32	0.85			
X3	I have to use a car for my leisure activities.	2.38	1.39	0.70			
X4	In my everyday life, I have to be very flexible and mobile.	3.22	1.26	0.70			
X5	I often have to travel to the outskirts or out of the city.	2.69	1.35	0.81			
X6	I often have to transport heavy or bulky items.	2.09	1.27	0.73			
X7	I can easily reach what I need by public transit. (–)	2.68	1.18	0.70			
	Perceived suitability of carsharing to meet car travel needs (Suitability Score)	0.00	0.98	—	0.85	0.84	0.58
M1	Carsharing is an adequate substitute for owning a car.	2.91	1.34	0.79			
M2	Carsharing allows me to organize my everyday life more flexibly and freely.	3.37	1.20	0.84			
M3	Without carsharing, important destinations would be difficult for me to reach.	2.57	1.36	0.71			
M4	Without carsharing, I would seriously consider acquiring a (or an additional) car.	1.88	1.15	0.69			

M = Mean; SD = Standard deviation; λ = Factor loading (standardized); α = Cronbach's alpha; ρ = Composite reliability; AVE = Average variance extracted. (–) marks an originally inverted item that was recoded prior to factor analysis. Note that the order of the items in the questionnaire was randomly rotated. The questionnaire was in German; the items were translated by the author for this paper.

carsharing.

3.3. Psychological constructs

As delineated in Section 2, two pivotal variables in the moderated mediation analysis were perceived car dependence and perceived suitability of carsharing to meet one's car travel needs. These variables were conceptualized as psychological constructs and measured using responses to specific psychometric items detailed in Table 3. Participants' responses were collected using a five-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"). These responses were then subjected to confirmatory factor analysis to estimate participants' factor scores, referred to in the remainder of this paper as "Dependence Scores" and "Suitability Scores", to be used in the moderated mediation analysis.

The psychometric items were adopted, with some modifications, from previous research on the psychological determinants of car use (Steg 2005) and from evaluation studies on the effects of carsharing programs in Germany (Schreier et al. 2015, Schreier et al. 2018). Furthermore, the development of these items was informed by insights gained from 21 semi-structured interviews with carsharing users and non-users conducted in April and May 2019 in Hamburg's inner city in preparation for the survey.

The construct of perceived car dependence (Dependence Score) was measured using a set of seven items. Three of these items (X1, X2, and X3) explicitly addressed the perceived need to use a car for specific purposes, such as work-related trips or leisure activities. Three other items (X4, X5, and X6) addressed more general mobility needs that might be challenging to fulfill without a car, such as transporting heavy items or traveling to remote areas on the outskirts or in the hinterland of Hamburg. The seventh item (X7) solicited respondents' ratings of the suitability of public transportation as a mobility option, operating under the assumption that this item would exhibit a negative correlation with the underlying factor.

The items designed to assess perceived car dependence were intentionally worded to capture the general need to use a car, rather than the specific need to use one's own car. This was done to ensure a link to the perceived suitability of carsharing to meet one's car travel needs. Had the items exclusively measured dependence on private cars, it would have been challenging to investigate the effect of having multiple carsharing memberships. For instance, if a carsharing user has an explicit sense of dependence on a personal vehicle, the presence of multiple carsharing memberships is unlikely to alter that person's perception of carsharing as a suitable alternative to car ownership. Conversely, if a carsharing user generally feels dependent on using a car, irrespective of its ownership status, it is more probable that access to a broader array of carsharing options will influence the perception of carsharing as a viable alternative to car ownership.

The perceived suitability of carsharing to meet one's car travel needs (Suitability Score) was measured by four items. Two of these items addressed respondents' perceptions of carsharing as a viable alternative to car ownership (M1) and its importance in maintaining their current level of mobility and flexibility (M2), while the other two items considered how the hypothetical absence of carsharing would affect people's ability to reach important destinations (M3) and the likelihood of purchasing a car (M4). The items were designed to assess the extent to which carsharing is perceived as a genuine substitute for private vehicles in meeting travel needs, rather than merely as an ancillary mobility option alongside car ownership.

3.4. Model estimation

Confirmatory factor analysis and moderated mediation analysis were conducted using R version 4.3, employing structural equation modeling with the "lavaan" package (Rosseel 2012). To ensure the reliability and validity of the estimated factors, additional assessments were performed using the "semTools" (Jorgensen et al. 2022) and "psych" (Revelle 2024) packages. The problem of missing data was minimal within the sample, with the highest rate of nonresponse (7 %) affecting the question on monthly household income. To address this, the "MICE" package (van Buuren and Groothuis-Oudshoorn 2011) was employed to estimate missing values by multiple imputation.

Certain psychometric items, as well as the number of carsharing memberships and cars owned, exhibited highly skewed distributions and were thus treated as ordinal variables in the analysis. Consequently, a robust diagonally weighted least squares (DWLS) estimator with a mean-and-variance corrected test statistic was employed in both the factor analysis and the moderated mediation model estimation. This approach aligns with prior research that has demonstrated the efficacy of DWLS estimation in addressing ordinal variables within structural equation modeling (Li 2016). Each higher level of the variables "number of carsharing

Table 4

Results of the moderated mediation analysis.

Effect	B	SE	LLCI	ULCI	p	OR
Dependence Score → Suitability Score (direct)	-0.39	0.07	-0.52	-0.25	<0.001	—
CS memberships → Suitability Score (direct)	0.10	0.04	0.03	0.16	0.007	—
Dependence Score × CS memberships → Suitability Score (interaction)	0.11	0.03	0.04	0.17	0.001	—
Suitability Score → Car ownership (direct)	-0.28	0.05	-0.37	-0.18	<0.001	0.76
Dependence Score → Car ownership (via Suitability Score)	0.11	0.03	0.05	0.16	<0.001	1.12
Dependence Score → Car ownership (direct)	0.86	0.12	0.63	1.10	<0.001	2.36
Dependence Score → Car ownership (total effect)	0.97	0.12	0.74	1.20	<0.001	2.64

B = Coefficient (unstandardized, except for the effect of the Dependence Score on the Suitability score); SE = Standard error; LLCI and ULCI = Lower and upper limit of the 95 % confidence interval for the coefficient; OR = Odds ratio.

memberships” and “number of cars owned” represented a one-unit increase in the number. For the purpose of statistical significance testing, p-values less than 0.05 were considered to be indicative of statistical significance.

4. Results

The results of the study are organized into three subsections. In the initial subsection, the outcomes of the confirmatory factor analysis are deliberated, evaluating the reliability and validity of the psychological constructs of perceived car dependence and perceived suitability of carsharing to meet car travel needs. The subsequent subsection details the results of the moderated mediation analysis, which tests the four hypotheses represented by the conceptual model (Fig. 1). Finally, the third subsection employs a simple slopes analysis to examine the role of single versus multiple carsharing memberships in the relationship between perceived car dependence and perceived suitability of carsharing to meet one’s car travel needs.

4.1. Construct reliability and validity

The reliability and validity of the psychological constructs were assessed using Cronbach’s alpha (α) and congeneric reliability (ρ). Convergent validity was assessed using average variance extracted (AVE). Table 3 presents the results of the confirmatory factor analysis.

In accordance with the guidelines proposed by Nunnally (1978) and Hair et al. (2009), internal consistency, as indicated by the two reliability coefficients, was robust for both constructs: perceived car dependence ($\alpha = 0.90$; $\rho = 0.90$) and perceived suitability of carsharing to meet car travel needs ($\alpha = 0.85$; $\rho = 0.84$). In terms of convergent validity, the AVE for both perceived car dependence (0.55) and perceived suitability of carsharing to meet car travel needs (0.58) exceeded the 0.5 threshold suggested by Fornell and Larcker (1981). Nine of the eleven items exhibited factor loadings of 0.7 or greater, signifying that more than half of the variance in these items was captured by the associated construct (MacKenzie et al. 2011). However, the factor loadings of the two remaining items (X1 and M4) were only slightly below this threshold (0.69 each), supporting the retention of these items in the model.

4.2. Moderated mediation analysis

Prior to the testing of the hypotheses, the goodness of fit of the model shown in Fig. 1 was evaluated. However, interaction terms involving latent variables have the potential to distort the chi-square goodness-of-fit test and the derived fit statistics in structural equation models (Mooijaart and Satorra 2009). Consequently, the model fit was assessed using a core model that excluded the interaction effect between perceived car dependence and the number of carsharing memberships on the perceived suitability of carsharing to meet car travel needs. Control variables were not considered at this stage, as their purpose was not to improve the model’s goodness of fit, but to ensure that the interpretation of the model’s key relationships was not biased by omitted variables. Utilizing the thresholds advocated by Hu and Bentler (1999) for interpreting fit indices in structural equation modeling, the core model exhibited good fit to the data ($\chi^2[63] = 202.24$, $p < 0.001$; CFI = 0.96; RMSEA = 0.05 [90 % CI: 0.04–0.06]; SRMR = 0.06).

Table 4 presents the main effects estimated from the full model, which incorporates the interaction effect and the control variables. In accordance with Hypothesis 1, the Dependence Score exhibited a negative and statistically significant effect on the Suitability Score ($B = -0.39$, $p < 0.001$). This finding suggests that an increase in a carsharing user’s Dependence Score by one standard deviation would result in a significant decrease in the perceived suitability of carsharing for meeting that person’s car travel needs, as indicated by a reduction in the Suitability Score by 0.39 standard deviations. However, Hypothesis 2 proposed that this relationship is moderated by the number of carsharing memberships held by a user, a hypothesis that was supported by the data ($B = 0.11$, $p = 0.001$). The positive interaction effect signifies that an elevated number of carsharing memberships mitigates the adverse relationship between the Dependence Score and the Suitability Score. A more detailed analysis of this interaction effect is provided in a subsequent subsection.

In accordance with Hypothesis 3, the Suitability Score exhibited a negative influence on the odds of car ownership ($B = -0.28$, $p < 0.001$, OR = 0.76). In practical terms, this means that a one standard deviation increase in a carsharing user’s Suitability Score increases the odds of the household owning one less car by 24 %. When considering the effects outlined in Hypotheses 1 and 3 collectively, a positive indirect effect of the Dependence Score on car ownership was observed, mediated by the Suitability Score ($B =$

Table 5
Effects of the control variables on the Suitability Score and car ownership.

Control variable	Direct effect on the Suitability Score					-	Direct effect on car ownership				
	B	SE	LLCI	ULCI	p		B	SE	LLCI	ULCI	p
Male	0.00	0.06	-0.12	0.13	0.973		0.13	0.10	-0.06	0.32	0.180
Age \geq 45 years	-0.06	0.07	-0.19	0.06	0.322		0.25	0.11	0.04	0.46	0.017
Household with minor(s)	-0.07	0.07	-0.21	0.08	0.363		0.15	0.11	-0.07	0.38	0.182
Full-time employed	0.05	0.07	-0.09	0.20	0.472		-0.09	0.12	-0.33	0.15	0.448
High or very high socioeconomic status	-0.16	0.06	-0.28	-0.03	0.014		0.30	0.10	0.10	0.51	0.003
Carsharing use \geq monthly	0.69	0.07	0.56	0.82	<0.001		-0.28	0.11	-0.49	-0.08	0.008
Use of free-floating carsharing only	-0.34	0.07	-0.48	-0.20	<0.001		0.67	0.13	0.41	0.93	<0.001

B = Coefficient (unstandardized); SE = Standard error; LLCI and ULCI = Lower and upper limit of the 95 % confidence interval for the coefficient.

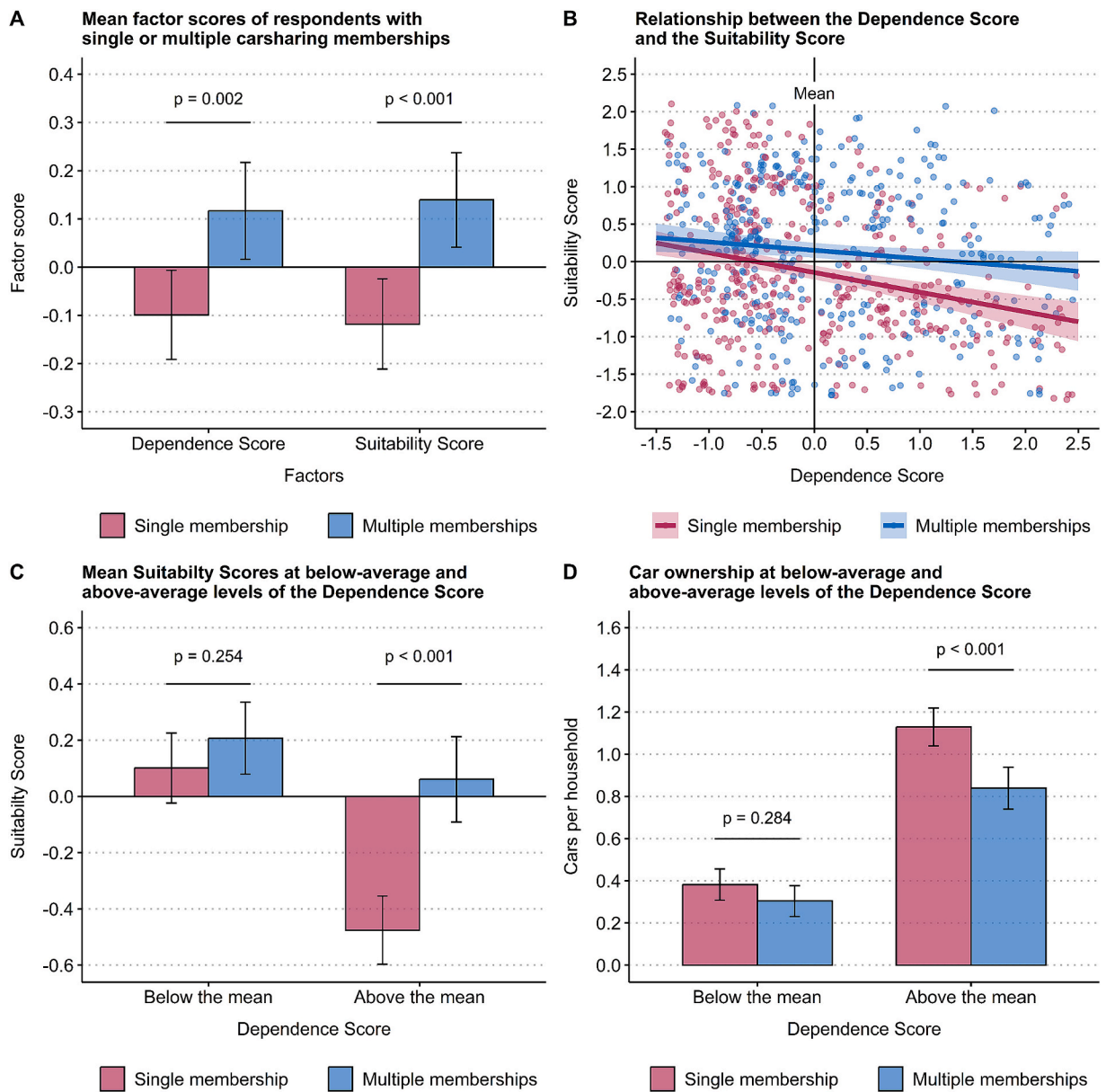


Fig. 3. Analysis of the relationships between perceived car dependence (Dependence Score), perceived suitability of carsharing to meet car travel needs (Suitability Score), and car ownership for respondents with single versus multiple carsharing memberships. Error bars (Plot A, C, and D) and shaded areas (Plot B) represent 95% confidence intervals. Statistical significance of differences in factor scores (Plot A and C) was assessed using t-tests, while statistical significance of differences in the number of cars owned (Plot D) was assessed using Mann-Whitney U tests.

Table 6

Conditional effects of the Dependence Score on the Suitability Score at different numbers of carsharing memberships.

Number of carsharing memberships	B	SE	LLCI	ULCI	p
Single membership	-0.26	0.05	-0.36	-0.17	<0.001
Multiple memberships	-0.11	0.05	-0.21	-0.01	0.030

B = Coefficient (unstandardized); SE = Standard error; LLCI and ULCI = Lower and upper limit of the 95 % confidence interval for the coefficient.

0.11, $p < 0.001$, OR = 1.12). However, the direct positive effect of the Dependence Score on car ownership, as predicted by Hypothesis 4, was substantially stronger (B = 0.86, $p < 0.001$, OR = 2.36). When both the direct and indirect effects of the Dependence Score on car ownership were aggregated into a total effect (B = 0.97, $p < 0.001$, OR = 2.64), it was determined that a one standard deviation

increase in a carsharing user's Dependence Score increased the odds of the household owning one more car by a factor of 2.64.

Furthermore, certain control variables exhibited a statistically significant impact on the perceived suitability of carsharing for meeting one's car travel needs, as well as on actual car ownership (Table 5). A statistically significant relationship between socio-demographic characteristics of carsharing users and either the Suitability Score or car ownership was not observed, with the exception of being 45 years or older, which significantly increased the odds of car ownership, and (very) high socioeconomic status, which had a negative effect on the Suitability Score and a positive effect on the odds of car ownership. On the other hand, the control variables representing carsharing usage patterns all showed statistically significant effects. The data indicate that using carsharing at least monthly is associated with a higher Suitability Score and lower odds of car ownership. Conversely, exclusive use of free-floating carsharing demonstrated a negative impact on the Suitability Score and increased the odds of car ownership.

4.3. Simple slopes analysis

The moderated mediation analysis revealed a positive interaction effect between perceived car dependence and the number of carsharing memberships on the perceived suitability of carsharing to meet one's car travel needs. To further illuminate the moderating effect of the number of carsharing memberships, the 788 surveyed carsharing users were segmented into two groups: those with a single membership ($n = 426$) and those with a minimum of two memberships ($n = 362$). This segmentation enabled the examination of the relationship between the Dependence Score and the Suitability Score separately for each group.

The comparison of the mean factor scores indicated statistically significant differences between the two groups (Fig. 3, Plot A). Carsharing users enrolled in multiple services exhibited a considerably higher Dependence Score ($p = 0.002$, Cohen's $d = 0.22$). Notably, despite the previously identified negative correlation between the Dependence Score and the Suitability Score, the Suitability Score was also significantly higher for carsharing users with multiple memberships ($p < 0.001$, Cohen's $d = 0.27$).

A subsequent simple slopes analysis of the relationship between the Dependence Score and the Suitability Score conditional on the number of carsharing memberships (Fig. 3, Plot B; Table 6) yielded further insights into the moderating effect of the number of memberships. The data indicated a statistically significant negative effect of the Dependence Score on the Suitability Score for both carsharing users with one membership and those with multiple memberships. However, for users with only one membership, this effect was of medium size ($B = -0.26$, $p < 0.001$), while for respondents with multiple memberships, the data indicated only a small effect ($B = -0.11$, $p = 0.030$).

The consequences of this difference in effect sizes became apparent when respondents' Suitability Scores were investigated not only in relation to the number of carsharing memberships, but also in relation to whether an individual's Dependence Score was above or below the sample mean (Fig. 3, Plot C). Among carsharing users with a below-average Dependence Score, the Suitability Scores for individuals with one membership and those with multiple memberships were not significantly different ($p = 0.254$). Conversely, among carsharing users with an above-average Dependence Score, the Suitability Score was significantly higher for individuals who possessed at least two carsharing memberships ($p < 0.001$, Cohen's $d = 0.60$).

A similar pattern was identified when examining car ownership among respondents with above-average or below-average Dependence Scores, depending on the number of carsharing memberships (Fig. 3, Plot D). Among carsharing users with below-average Dependence Scores, the number of cars owned did not differ significantly between those with one or multiple memberships (0.38 vs. 0.30 cars per household; $p = 0.284$). Conversely, among respondents with above-average Dependence Scores, having only one carsharing membership was associated with significantly higher car ownership (1.13 vs. 0.84 cars per household; $p < 0.001$, $r = 0.20$). Overall, respondents with only one carsharing membership owned a significantly higher number of cars (0.67 vs. 0.55 cars per household; $p = 0.030$, $r = 0.07$).

5. Discussion and conclusion

The proliferation of business-to-consumer carsharing services is indicative of a growing array of carsharing options in numerous cities and regions. This development suggests that, in the future, individuals may have increased access to multiple carsharing services in many cities. From a transportation research and planning perspective, this prompts the question of whether and to what extent a more diversified offer of carsharing services might affect users' perceptions of carsharing, particularly with regard to its suitability as a substitute for car ownership. To address this question, the present study commenced with an examination of the primary relationships between perceived car dependence, the perceived suitability of carsharing to meet car travel needs, and actual car ownership among carsharing users in the inner city of Hamburg, Germany. Subsequently, the moderating influence of the number of carsharing memberships on the relationship between perceived car dependence and the perception of carsharing was examined, along with the resulting consequences for car ownership.

The study's findings indicated that a stronger perception of car dependence among carsharing users significantly increases the odds of car ownership. This effect is partly mediated by the perceived suitability of carsharing to meet car travel needs, meaning that a higher perceived suitability of carsharing reduces the odds of car ownership. This lends further support to the notion that a strong perception of car dependence hinders carsharing users' inclination to reduce or cease car ownership, as evidenced by previous studies (Giesel and Nobis 2016, Haustein 2021, Vejchodská et al. 2024). Conversely, a more favorable perception of carsharing as a substitute for private vehicles is associated with lower car ownership levels (Giesel and Nobis 2016, Chicco et al. 2022).

However, arguably the most important contribution of this paper to the literature is the finding that simultaneous membership in multiple carsharing services significantly attenuates the negative effect of perceived car dependence on the perceived suitability of carsharing as a substitute for car ownership. Although carsharing users with multiple memberships exhibited higher levels of perceived

car dependence, they did not perceive carsharing as less suitable to meet their car travel needs. In fact, they perceived it as more suitable compared to single membership users, and ultimately owned fewer cars overall.

This phenomenon aligns with prior studies that have demonstrated a positive correlation between having more than one carsharing membership and a greater willingness to replace private cars with carsharing (Giesel and Nobis 2016, Jochem et al. 2020, Namazu and Dowlatabadi 2018, Chicco et al. 2022). However, these prior studies have typically focused on the combination of different types of carsharing, including station-based round-trip carsharing, which is generally regarded as more effective. For this reason, the analyses in this study explicitly controlled for the influence of using different types of carsharing. The results of the study suggest that having multiple carsharing memberships increases the perception of carsharing as a substitute for personal car ownership, even if these memberships are limited to free-floating carsharing.

The disparities in carsharing perception and car ownership between individuals with single versus multiple memberships were found to be significant only among those with above-average levels of car dependence. Conversely, no significant differences were observed among individuals with below-average levels of car dependence. This finding suggests that the benefits of having multiple carsharing memberships are primarily evident among carsharing users with a comparatively strong perception of car dependence, whereas individuals with low car travel needs can be adequately served by a single membership.

In summary, the results suggest that a diverse carsharing offer strengthens the role of carsharing as a substitute for the private car, especially for relatively car-dependent carsharing users who would probably not reduce their car ownership if they had fewer carsharing options to choose from. From a transport policy perspective, it therefore seems justified to encourage parallel membership in multiple carsharing services in areas with a corresponding carsharing offer. A substantial body of literature has already been published on the subject of enhancing the appeal of carsharing services. Beneficial factors include the ease of access to shared vehicles and stations (de Luca and Di Pace 2015, Rotaris et al. 2019, Silvestri et al. 2021, Wang et al. 2021), privileged on-street parking (Czarnetzki 2023, de Lorimier and El-Geneidy 2013, Dowling and Kent 2015, Glotz-Richter 2016), integration with public transport in terms of tariffs and location (Cantelmo et al. 2022, Ortega et al. 2023), and low costs, preferably without membership fees (Cantelmo et al. 2022, Litman 2000, Namazu et al. 2018).

However, it must be kept in mind that promoting multiple carsharing memberships primarily means encouraging existing carsharing members to use additional services. Carsharing members, being familiar with the service, may bring unique expectations to the table compared to individuals with no prior exposure to carsharing. Research by Wang and Song (2024) suggests that individuals with prior carsharing experience consider the quality of the carsharing infrastructure itself (such as the accessibility of stations, availability and quality of shared vehicles) to be particularly important in expanding their carsharing use.

Concurrently, it is imperative to ensure that the enrollment in multiple carsharing services does not impede the use of carsharing with a multitude of parallel (provider-specific) applications, pricing models, and terms and conditions. It will therefore be all the more important to bundle the offers of different carsharing providers—and preferably additional mobility options—on one platform, following the Mobility-as-a-Service approach (Jittrapirom et al. 2017). This objective should be pursued through two primary avenues: firstly, the digital integration of services via a centralized application, and secondly, the physical consolidation of services through the establishment of mobility hubs. Previous studies have demonstrated that the presence of such hubs can significantly enhance the appeal and efficacy of carsharing and complementary transportation modes (Bösehans, Bell, Thorpe, & Dissanayake, 2023a; Czarnetzki & Siek, 2023; Liao, Dissanayake, de Almeida, & Correia, 2024; Miramontes, Pfertner, Rayaprolu, Schreiner, & Wulfhorst, 2017).

When interpreting the results of this study, a number of methodological and contextual limitations must be taken into account. Firstly, the cross-sectional data utilized in this study precludes the establishment of reliable conclusions regarding causal directions, despite the empirical data exhibiting a strong fit with the conceptual model. Research has demonstrated that attitudes and behaviors influence each other reciprocally (Kroesen et al. 2017), thereby indicating the possibility of reverse causality in the relationships examined.

Secondly, it must be acknowledged that the perceived car dependence in this study is a relative measure based exclusively on data from carsharing users. Prior studies have demonstrated that car dependence has a negative impact on the willingness to become a carsharing member (Ramos et al. 2020, Wang and Song 2024). In addition, research by Vega-Gonzalo et al. (2024) suggests that experience with shared mobility services, such as carsharing, can further reduce perceived car dependence. Thus, when this paper refers to carsharing users with above-average levels of perceived car dependence, it does not necessarily mean that these individuals are highly car-dependent compared to the general population. The extant literature indicates that carsharing users constitute a relatively specific subset within the population in terms of sociodemographics, attitudes, lifestyles, and mobility behavior (Amirmazmiazfar and Diana 2022, Nansubuga and Kowalkowski 2021). Consequently, the findings of this study cannot be extrapolated to the general population.

Thirdly, it is crucial to note that the data were collected in a study area with an exceptionally wide and diverse range of carsharing services. At the time of data collection, respondents could choose from eight large B2C carsharing companies offering different types of carsharing. However, respondents with multiple memberships were only enrolled in an average of 2.6 carsharing services, suggesting that their choice was highly selective, depending on their specific needs. Consequently, the extent to which these results can be generalized to areas with a more limited selection of carsharing services remains uncertain.

Finally, the data available for this study did not provide insight into the reasons why carsharing users choose to enroll in more than one service and why this mitigates the negative effect of perceived car dependence on the perception of carsharing as a substitute for car ownership. With respect to sociodemographic characteristics, users who possessed multiple memberships did not demonstrate substantial deviations from users who possessed only a single membership. However, carsharing users with multiple memberships exhibited significantly higher levels of perceived car dependence, suggesting self-selection (i.e., relatively car-dependent carsharing users may be more likely to enroll in multiple services). It can be hypothesized that membership in multiple carsharing services leads to

more reliable vehicle availability and a wider choice of vehicle models, pricing schemes, carsharing stations, and service areas, which potentially improves the perceived behavioral control of carsharing users. Numerous studies have employed the Theory of Planned Behavior (Ajzen 1991) to examine carsharing usage, consistently identifying a positive association between perceived behavioral control and the adoption and impact of carsharing (Derikx and van Lierop 2021, Kuhn et al. 2021, Li and Zhang 2023, Li et al. 2025, Mattia et al. 2019). While these papers did not account for differences between having access to one carsharing service or multiple carsharing services, the present work suggests that considering the number of available carsharing services or memberships could be a useful extension of previous theories.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author used ChatGPT in order to improve readability and language. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

CRediT authorship contribution statement

Felix Czarnetzki: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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