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The uphill struggles of carsharing in the Netherlands

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The current mobility system relies heavily on privately owned cars, which results in high levels of emissions, material use, and use of scarce public space. Carsharing is a mobility innovation offering consumers on-demand, short-term access to cars. By changing consumption patterns and reducing car ownership, carsharing has great potential to contribute to a sustainability transition of the mobility system. Even so, carsharing only satisfies a small portion of today's mobility needs and has difficulties becoming mainstream. This study investigates the upscaling trajectory of carsharing in the Netherlands. We structure the analysis along the lines of the multilevel perspective and include economic, technological, sociocultural, and policy factors that shape carsharing growth. The results demonstrate how car ownership is entrenched in the social and economic fabric, and the specific barriers this poses to carsharing. Moreover, we find some forms of carsharing risk extending private car ownership rather than challenging it. The environmental outcomes of carsharing are not predetermined but depend on the trajectories key actors take during upscaling. Our analysis highlights the importance of studying innovations in the context of the consumption–production systems in which they emerge.

carsharing | sustainability transitions | transport | mobility

Significance

Carsharing is an innovation that promises environmentally friendly and affordable mobility. This study explains why it is nevertheless difficult for carsharing to grow out of niche markets and become mainstream and explains factors affecting its environmental benefits. We go beyond the existing technoeconomic analyses of carsharing and take a processual and systemic perspective to analyze its development trajectory. By including sociocultural, economic, technological, and policy factors relating to carsharing and car ownership as its main competitor, we obtain a more complete understanding of drivers and barriers to carsharing growth. For decision makers in the transport sector, our results provide a basis for developing systemic interventions, which jointly address the social and technoeconomic barriers that prevent sustainability innovations from becoming mainstream.

The current mobility system heavily relies on privately owned cars, which results in high levels of CO_2 emissions and considerable use of scarce public space. Carsharing is a mobility innovation that offers access to cars on an as-needed basis. It provides a flexible mobility alternative to consumers that meets diverse transportation needs while reducing the negative impacts of private vehicle ownership. Accordingly, it could potentially contribute to sustainable development by reducing the impact of the current mobility system on nature and providing more equitable access to mobility. Carsharing makes use of the underutilized capacity of cars, which currently stand idle 95% of the time. Current evidence shows that carsharing tends to decrease car ownership as well as distance traveled by car, reducing greenhouse gas emissions, although the impacts vary between carsharing types (1).

The first carsharing scheme dates back as early as 1948, but the practice of carsharing is still fairly uncommon in Western countries. In recent years, various macrolevel trends, such as increasing sustainability concerns and the broader rise of the access economy, have favored carsharing growth. Indeed, new carsharing schemes have been developed and higher growth rates are observed in some markets (2, 3). However, despite these developments, carsharing still only fulfills a small part of consumers' mobility needs.

This study analyzes the difficult process of the upscaling of carsharing with a focus on the Netherlands. We look at the modern-day carsharing as a radical change in consumer practices supported by technological innovation (including apps and smart locks). Understanding the development of carsharing also requires reflection on private car ownership as its main competitor, as well as on broader societal trends such as sustainability concerns and platformization. We, therefore, analyze the development trajectory of carsharing using the multilevel perspective (MLP), a "big picture" analytical framework that accommodates the multiple social and technical changes involved in sustainable innovation (4). This approach contributes to the field of sustainability science by its focus on potential sustainability solutions in the context of transitions, i.e., significant large-scale, long-term changes in consumption–production systems (5). It combines insights from different social science perspectives to analyze patterns of interaction between innovations and existing consumption–production systems (6). By identifying differences in upscaling trajectories, it can also shed some new light on the environmental impacts of innovations in terms of CO_2 reductions.

The MLP understands transitions as resulting from alignment between developments at three analytical levels: *niches, existing consumption–production systems* such as the mobility system, and exogenous "*landscape*" developments (Geels et al. Fig. 1). Niche innovations such as carsharing initially emerge in protective environments, such as particular geographical areas or market niches (7). Niche mobility innovations often have trouble

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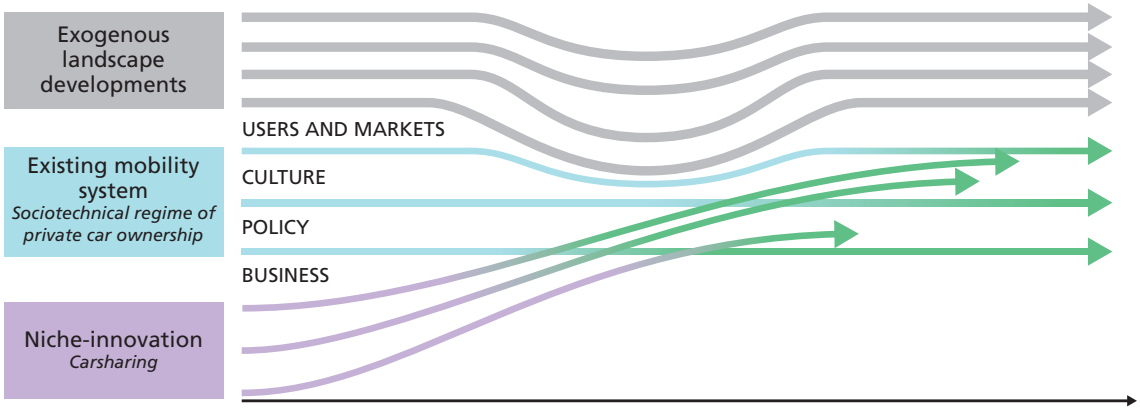

Fig. 1. Multilevel perspective (MLP) on transitions toward sustainability (Adapted from ref. 4). In this study, we analyze the dynamics of the carsharing niche and the sociotechnical regime of private car ownership.

growing, as the existing mobility system is dominated by the sociotechnical regime of private car ownership, which refers to a set of entrenched behaviors and "rules of the game" (5). These include daily commuting habits, the social status of car ownership, and the provision of free parking by municipalities (8, 9). Under the pressure of exogenous influences (at the landscape level) such as economic crises and rising sustainability concerns, can a window of opportunity open for innovations to upscale and enter the mainstream.

During the time that we focus on (2012 to 2021), carsharing in the Netherlands grew from 2,600 to 87,800 shared cars, and approximately 2% of the population used it over the 2017 to 2020 period (10, 11). The upscaling process of niche innovations is characterized by struggles over societal embedding, which can play out differently across societal domains (12, 13). Following Mylan et al. (13), we study embedding in the four different domains of users and markets, culture, policy, and business. In the remainder of this paper, we lay out how the upscaling of carsharing involves interactions between niche-innovation actors and incumbent actors and institutions across these domains, and how these interactions relate to environmental impacts.

Research Design

Carsharing has emerged as a new, organized practice among consumers in postwar Western Europe. The case study design allows researchers to address difficult "how and why" questions about phenomena over which they have little control (14). The case of carsharing in the Netherlands can be seen as a typical one, given that its carsharing adoption levels are broadly similar to those in other Western European countries (2). In terms of car ownership per capita, the Netherlands is also similar to these countries (15, 16). The Netherlands does have higher levels of cycling than other countries, which coincides with lower levels of public transport use (17). We take a longitudinal perspective and develop "analytic explanations" (18) by organizing our historical narrative of carsharing development using the concepts of the MLP. Data sources include a large-scale stated-preference survey of residents of the city of Amsterdam (N = 1,330) (19), a representative survey of the Dutch population including carsharing adopters (N = 1,835) (20), and fine-grained geographical data on shared cars available for Dutch zip codes (N = 4,048) (21) and European cities (N = 177) (2). We further build on 18 interviews and a workshop (20 participants) including industry stakeholders and policymakers (22) as well as scientific literature and sector reports on carsharing in the Netherlands.

Results

The Emergence of Carsharing. In the past 70 y, several types of carsharing schemes have been initiated (and often also terminated) worldwide. In the Netherlands, a notable carsharing experiment called "Witkar" ("white car") was launched by a cooperative in Amsterdam in 1972. In the Witkar scheme, people hired small white electric cars at charging stations in the city center, which they could take on instant, one-way trips. The project failed a few years later, mainly due to a lack of demand from consumers and limited support from the municipality (23). In the late 1980s, many more carsharing initiatives were set up by environmentally minded organizations across Western Europe (8, 24). Just like the original Witkar concept, the new carsharing schemes were *business-to-consumer (B2C)*: In the case of a carsharing B2C initiative, an organization (cooperative or firm) owns a fleet of cars, that they park inside different neighborhoods and make available for rent. Contrary to the *one-way* Witkar scheme, schemes introduced later were based on a *round-trip* system in which the cars had to be returned to the same location. During the 1990s, these B2C roundtrip schemes slowly grew, gingerly supported by governmental organizations for the environmental advantages that they promised (25). In 2011, a one-way electric carsharing service reemerged in Amsterdam, but this time as part of a *free-floating* system in which cars are rented and returned anywhere in a designated service area. This was initiated by a leading car manufacturer (Daimler) and supported by the city of Amsterdam as part of their cleaner air plans. This type of carsharing service eventually expanded to large Dutch cities. In the same year, peer-to-peer (P2P) carsharing was introduced, which allows private car owners to rent out their cars to fellow consumers (their "peers"). Owners and renters generally have to meet for a key handover with this carsharing service type as most cars do not yet have the smart locks utilized in B2C services. On the dominant P2P platform Snappcar, car owners are not allowed to offer more than three cars to prevent commercial actors from renting out cars. In the following, we analyze the subsequent development trajectories of B2C and P2P carsharing in interaction with developments at the landscape and regime levels.

Landscape–Niche Interactions. Since the early 2010s, multiple macrolevel, landscape developments have been emerging that together could create a window of opportunity for carsharing to become a widespread, mainstream mobility option. Climate concerns have gradually increased among policymakers and the general public alike. As of 2020, 62% of the Dutch population

considered climate change a major problem (26). A new climate law was introduced in 2019 aiming for a reduction in CO_2 emissions by 49% by 2030, in comparison with 1990 levels. The law was accompanied by a national climate agreement involving major societal stakeholders. Carsharing is included in the mix of solutions as part of this agreement.

The second landscape trend favoring carsharing is the development of business models that give consumers access to goods as an alternative to ownership. The access model is coming to dominate some markets (e.g., the music industry). As part of this trend, platform-enabled "stranger sharing" has become commonplace, with Airbnb being the most notable example (27). The P2P carsharing market in particular finds benefit in this development—people have become more used to renting out expensive assets to strangers via platforms that mediate trust with rating systems and microinsurance. Other access-based mobility forms have also grown in the last decade (Wells, this volume). In ridesharing, sometimes called carpooling, a person shares their empty car seat(s) with other(s) for a trip they would have made anyway. Ridesourcing or ridehailing contrastingly refers to the provision of on-demand rides. In a related cultural development, some studies indicate that cars are less of a status symbol for younger generations, who are more digitally oriented (28). This may trigger them to opt for carsharing services rather than for car ownership. However, the extent of generational differences in car use and attitudes is still a topic of considerable debate (29).

Still, other landscape factors reinforce the regime of car ownership and act as barriers to sharing cars. Continuing cultural preferences for convenience and timesaving limit the growth of carsharing, which includes hassle, e.g., related to finding and opening cars. Over the course of the 20th century, car ownership became the cultural symbol of an independent and modern lifestyle and it is still associated with individual freedom (30). A more recent relevant cultural development impeding carsharing is the search for safety and security in an increasingly unstable and unpredictable world. In automobility, this trend can be observed in the practice of "cocooning," in which the car is used as an intimate place, shielded from the outside world, and highly personalized, e.g., through customized entertainment systems (30, 31). As another macrolevel factor limiting carsharing growth, the literal landscape, i.e., the built environment, is largely a product of car ownership over decades. Abundant parking is available at homes, workplaces, and other destinations, and existing distances between home, work, retail, and leisure further entrench car ownership. In the Netherlands, this particularly holds outside the main urban areas, where accessibility to jobs and other facilities by public transport is low (32).

Finally, the COVID-19 pandemic is an external shock that had major short-term impacts on mobility, and of which the longer-term effects are starting to materialize. Some empirical studies indicate that during the pandemic, carsharing was seen as a safer travel option than public transport (33). In some European cities, the pandemic accelerated municipal initiatives to stimulate alternative modes of transport (34). Moreover, increased teleworking could reduce car ownership needs. However, given the constant amount of time that people spend traveling per day (around 1 h), the increased incidence of teleworking might also lead to migration away from workplaces toward rural areas, which tend to have higher levels of car ownership (35).

Niche-Regime Dynamics (2012 to 2021). Gradually, carsharing has grown and by 2021, 87,800 shared cars were on offer in the Netherlands, of which around 69,000 are P2P and 5,500 are B2C out of a national total of 7.6 million cars (Fig. 2)—the remaining cars are shared within businesses and private communities. The number of cars on P2P carsharing platforms has considerably increased over the past years, whereas the number of B2C cars has grown more slowly. These figures concern the supply of cars, not their use. B2C cars are used more frequently as a rule, as they are only kept in a location if demand is sufficiently high to cover costs. In terms of use, a nationally representative survey from August 2020 indicates that 1.6% of the population had used B2C carsharing in the past 3 y, whereas 1% had used P2P carsharing (11). The aggregated registration data from all

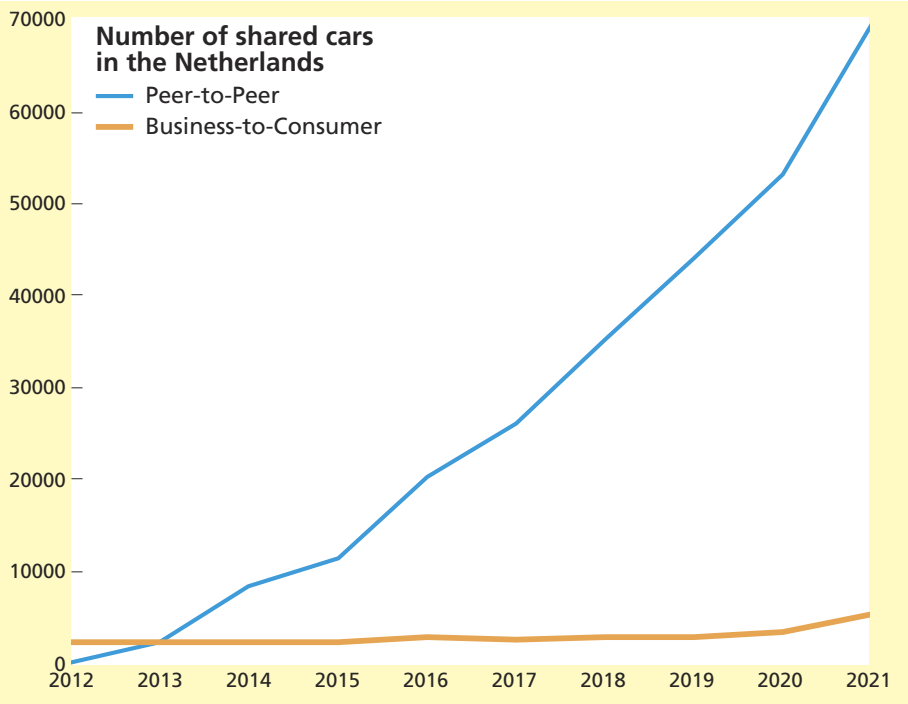

Fig. 2. The number of cars offered via B2C and P2P carsharing platforms in the Netherlands (Data: ref. 10).

carsharing organizations show that in 2021, 971,000 users were registered. This would amount to ~8.5% of Dutch inhabitants with a driving license, yet it should be noted that these figures are not corrected for double counting of people with multiple subscriptions (10).

We analyze the societal embedding of carsharing across the environments of users and markets, culture, policy, and business. Across these domains, the regime of private car ownership captures entrenched behaviors and rules of the game. Its main constituents are ownership-based mobility demand patterns (users and markets), positive social connotations of car possession (culture), ownership-friendly parking regulation and taxation (policy), and automotive incumbents' vested interests (business). In the following, we discuss the interactions between the carsharing niche and the private car ownership regime in more detail.

Users and markets. In a nationally representative survey held in 2014, it was shown that Dutch carsharing niche users display the characteristics typical of early adopters (20): They are more often highly educated (63% hold a bachelor's degree versus the 28% Dutch national average) and show higher environmental awareness (18% vote for a green party versus the 4% national average). The results further indicate that B2C and P2P carsharing attract somewhat different user groups. B2C users tend to have higher education and income levels than P2P users. Regression analysis shows that the choice for B2C over P2P carsharing can be explained by a higher income and level of education (which makes it easier to pay for the more expensive B2C carsharing type) and having a modal split that is less focused on the private car. B2C users make more frequent use of carsharing, whereas P2P carsharing is mostly used for incidental purposes. Compared to the Dutch average, carsharing users also more often live in car-free households (54% versus 28%) and have a positive attitude toward public transport (68% have a public transport subscription whereas that number is 38% nationally) and a multi-modal lifestyle in which they combine different modes.

Carsharing brings about changes to mobility patterns and user roles. In the carsharing niche, the relationship between users and suppliers differs from the regime based on private car ownership. Instead of transferring ownership of a car from supplier to user in a one-off transaction, a car is supplied by the carsharing organization for temporary but potentially repeated use. Carsharing users hence make more recurrent choices about car mobility. As a consequence, they have been found to adopt more multimodal mobility patterns and use the car less often and make more use of public and active transport (20). Additionally, P2P carsharing enables car owners to become prosumers, renting out their car to others. Indeed, from a stated preference survey held in Amsterdam (N = 1,330) in 2013, it was found that, next to environmental motivations, potential economic gains are considered relatively important in the decision to offer cars on a platform (19). We also learned that especially people already sharing their car informally are open to sharing their car on a P2P platform. Others, who are less open to sharing, are afraid of damage to their car, lack information (e.g., regarding insurance), or need their car too often themselves (20).

In the domain of users and markets, the regime of private car ownership is strong and partly strengthening. Although the Netherlands is a country well known for its high levels of bicycle use, car ownership is high, and increasing: 74% of households own at least one car (15), and the number of cars has grown rapidly in the last 20 y (from 5.6 million in 2000 to 7.9 million in 2022) (36). Increases in car ownership can lead to a "vicious circle of car dependence," in which more ownership is followed by more use, followed by infrastructure investments, followed by more car ownership, etc. (37). However, there is a clear geographical bifurcation in the development of car ownership in the Netherlands. Whereas in rural areas and small towns, car ownership is increasing, and indeed a "vicious cycle" can be observed, in the main cities, car ownership is falling (37). Hence, the regime of private car ownership is geographically differentiated (21, 38).

A clear interaction can be observed between the geographical dynamics of the regime of private car ownership and the carsharing niche. It is in urban "weak spots" in the car ownership regime where carsharing has developed and grown (2, 21). In the Netherlands, this becomes evident when looking at carsharing numbers in the largest cities compared to the rest of the country. In the largest four cities in 2020, there were on average 964 shared cars per 100,000 inhabitants, while in all other municipalities, there were only on average 222 shared cars per 100,000 inhabitants (10). Spatial regression analysis at the zip code level revealed that a higher prevalence of car ownership in a given area hampers carsharing (21). In particular, in neighborhoods with high ownership levels, often no B2C shared car was on offer. This means that people without cars must rely entirely on P2P carsharing in such neighborhoods. B2C carsharing seems to be limited to urbanized areas with a population that is highly educated and environmentally conscious. This different geographical spread of P2P and B2C carsharing can be explained by their relation to car ownership. B2C carsharing functions without private car ownership and, in this way, entails a clear break from the existing regime. P2P carsharing challenges the regime of private car ownership by allowing people to rent cars, but also extends it by allowing car owners to provide cars on platforms. The fact that people can now earn money with the cars they own further entrenches the regime by reducing the total cost of car ownership. Ironically, it is precisely because P2P carsharing makes use of the stock of owned cars, it can scale up fast in terms of supply and can more easily serve nonurban areas (Fig. 3).

Culture. Niche actors have consistently emphasized the environmental benefits of carsharing. Initial carsharing initiatives, which later turned into professional organizations (e.g., MyWheels), had strong links to green movements. Indeed, our 2013 survey demonstrated that environmental motivations are influential in the decision to use or offer cars on a platform (19), whereas a subsequent survey showed higher green party voting among carsharing users (20). At the neighborhood level, environmental organization membership positively correlates with the number of shared cars (21). In addition, P2P carsharing has some distinct cultural connotations, which niche actors employ in their framing. P2P carsharing is culturally innovative in that it entails the sharing of a private asset (the car) with strangers, tying in with the broader landscape trend of the sharing economy. Accordingly, it may foster more social capital (as strangers meet) (27). P2P carsharing also entails a cultural shift to prosumerism, giving car providers a different entrepreneurial role in the economy (39). In promotional discourses for P2P carsharing, new social and economic roles are often jointly mentioned (e.g., "earn money while also helping out your neighbors") (40).

In the meantime, social norms still strongly uphold the regime of car ownership. In a nationally representative Dutch survey held by mobility institute Kennisinstituut voor Mobiliteitsbeleid (KiM) in 2020 (41), only 13% of respondents disagreed with the statement, "it is very normal to have a car." A shift to carsharing thus implies breaking with what is considered common by friends, neighbors, and colleagues. As a general indication of car ownership convenience in the Netherlands, the majority of households can park their cars within 10 m of their homes (41). Car ownership also has an affective dimension. For example, in the

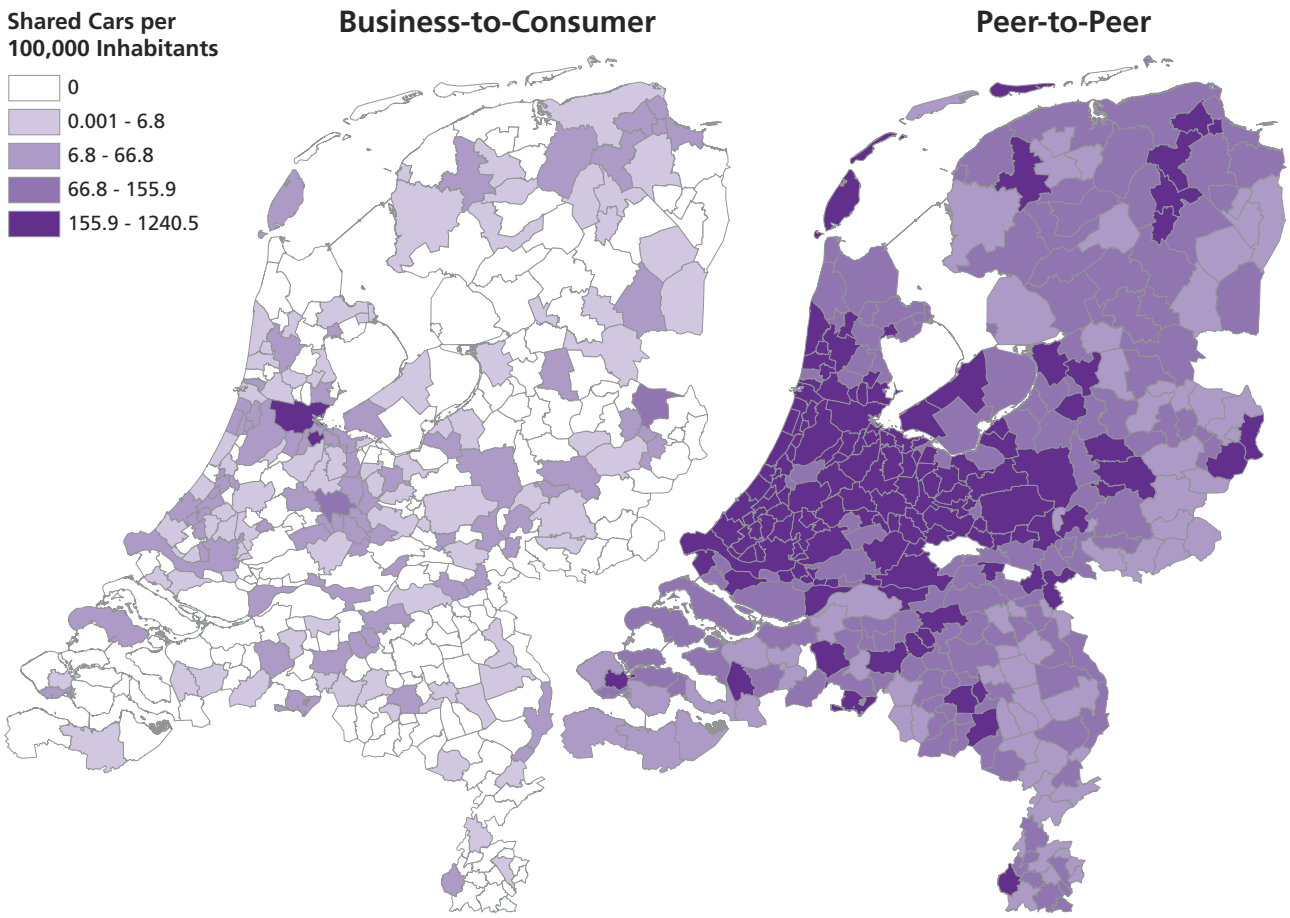

Fig. 3. The geographical array of B2C (*Left*) and P2P (*Right*) cars in the Netherlands in 2020. (Data: ref. 10).

aforementioned survey, 42% of respondents stated they loved their cars. Finally, cars are widely recognized as a symbol of social status. Because car ownership in the Netherlands is so widespread, ownership per se is not sufficient as a status symbol, but the size and type of car are used to display social position (41, 42).

In response, P2P carsharing most strongly "fits and conforms" to existing cultural conventions about cars (12). The offer on P2P platforms is much larger compared to the standard small cars on offer via B2C carsharing. P2P carsharing thus grants users the freedom to choose a "car for any occasion." Although this increases consumer options, it also boosts car culture. In this case, the privately owned car representing long-term consumer identity makes way for multiple shared cars that are a "flexible lifestyle accessory" (43). We learned for example that luxury P2P cars were popular for attending weddings in the Netherlands.

Policy. Over the past years, multiple policies supporting the carsharing niche have been implemented across the Netherlands. In general, the Dutch policy environment is favorable to sustainable mobility initiatives. Dutch cycling infrastructure is well known around the world, and extensive government support has been provided for electric cars and charging infrastructure. However, alternative transport modes are often conceived as an add-on to the regime of private car ownership, rather than as a direct challenge. To better grasp the policymaking process for carsharing in the Netherlands, in 2019, we organized a workshop with policymakers and other relevant stakeholders connected to the niche (e.g., carsharing organizations) and regime (automotive professionals, the Dutch touring club) (22). Based on a literature review, carsharing policies were identified and categorized as either niche supporting (e.g., parking spots for carsharing, start-up support, information) or regime changing (e.g., higher taxes). Broad support was found mostly for niche-supporting measures, such as information campaigns and a national knowledge-sharing hub. In line with the literature on the upscaling of niche innovations (44), stakeholders agree that developing concrete visions for the mobility system that include carsharing as an integral part, and are linked to plans for achieving environmental goals, can be impactful in scaling carsharing. Strong resistance from regime actors, such as the Dutch touring club, was observed to the idea of raising car ownership taxes, and this resistance seems largely internalized by most niche actors as well. A policy opposed by niche actors was the sharing of mobility data. It was rejected for privacy and competition reasons, although it could help scale mobility alternatives and create an integrated multimodal system.

Recent carsharing policy measures in the Netherlands have largely followed these tendencies. In 2015, a voluntary agreement labeled "Green Deal Carsharing" was concluded with stakeholders at the public, private, and nongovernmental levels with the aim of reaching 100,000 shared cars by 2018. The deal was renewed in 2018 with a target of reaching 700,000 carsharing users by 2021. Policies are mostly of the niche-supporting kind, focusing on information and coordination. Increasing car taxation still encounters broad regime resistance, e.g., from the Dutch touring club (45). Current policy proposals aim to increase the tax on car use rather than on ownership. Taxation for use aims to increase fairness ("paying for actual car use") and to compensate for the loss of income from electric vehicles, which cannot be taxed via traditional fuel tax. If a tax on car use is implemented while overall car taxation remains constant, this would reduce ownership taxes, disincentivizing carsharing.

In the domain of parking policies, changes are occurring that challenge the regime of car ownership and favor carsharing. An important policy upholding the car ownership regime is parking standards. These numbers, set by municipalities, indicate how many parking places are allocated to different areas (residential, commercial, etc.) (46), thereby facilitating private car ownership. Parking standard calculation is guided by a tool using parking history as input, hence ensuring the reproduction of the regime. Moreover, stabilizing forces interact, leading to positive feedback loops that further entrench the "system of automobility" (47). For example, through conservative parking standards that require many parking spots to be built, new developing areas need to reserve a lot of space for parking and through that become less attractive for walking and public transport, hence increasing the need for car mobility. Gradually, a more flexible and integrated approach to parking standards is emerging, mostly in urban municipalities with large progressive electorates. For instance, in 2018, the municipality of Utrecht announced a new neighborhood, Merwedekanaalzone, with a parking norm of only 0.3 parking places per dwelling. In new municipal policy guidance, a lower parking standard is allowed when developers provide a "mobility alternative" for the neighborhood, which often includes carsharing (48, 49). Nationally, a new overarching planning law "Omgevingswet" is being introduced. Under this law, fixed parking standards are giving way to a location-specific, integral mobility approach that also includes public transport and carsharing (50). Hence, in terms of formal institutions, the regime of car ownership is losing ground to mobility alternatives. Still, most municipalities struggle to reduce parking spaces due to inefficient procedures and the resistance of residents and their representatives (51). Indeed, as of 2021, local media have dubbed the low-parking neighborhood Merwedekanaalzone "a grand plan with minimal political support" (52).

Business. As explained above, the first carsharing suppliers were environmentally motivated and used a B2C round-trip business model, in which cars have to be returned to the same spot as where they are rented from. These organizations slowly professionalized while growing, and they introduced new technologies like key boxes and later keyless access. The introduction of P2P carsharing was subsequently enabled by internet-based platform technology, but is also based on a roundtrip model. An existing technical barrier for P2P carsharing is the need for a manual key swap or expensive "aftermarket" smart lock because digital ways of entering cars differ by brand and a standard access platform across brands is lacking.

In response to the initial growth of carsharing, car manufacturers have entered the market, which has led to the introduction of new business models. Car manufacturers have shown a preference to enter with their own B2C free-floating model, with cars that can be parked anywhere in a designated area. In this model, automotive incumbents benefit from their ability to provide a dedicated fleet from their assets. In the context of the climate crisis and digitalization, car manufacturers have reframed themselves as "mobility companies" (53, 54). Car manufacturers are forward integrating along the car value chain with acquisitions of leasing companies (e.g., Daimler taking over Athlon) and of carsharing organizations (e.g., Volkswagen partly taking over Greenwheels) to diversify their offerings. They have started to build their own mobility ecosystems which offer diverse mobility options (e.g., Daimler and BMWs joint venture "YourNow" includes a multimodal mobility app, charging services, ridehailing, a parking platform, and carsharing). However, carsharing is also a way for regime players to connect their brand to young urban consumers, who they hope will later on still switch to private car ownership (e.g., when raising children or relocating to smaller towns) (55).

Lease companies also play a role in the interaction between regime and carsharing niche, as different types of leasing can be seen as intermediate steps between owning and sharing cars. In the Netherlands, private car leasing (i.e., a monthly subscription to a car including services) has rapidly grown in recent years, becoming a well-established user practice. This development is connected to the carsharing market in two ways. First, the practice of leasing a car can be a transitional step for users in accessing mobility instead of owning vehicles. Second, leasing companies help to upscale carsharing supply. Their resources enable them to quickly enter the B2C market, e.g., with their own carsharing service. Through partnerships with carsharing companies, they also increase supply on P2P carsharing platforms. For example, the dominant P2P carsharing platform Snappcar created alliances with several established lease companies, which now allow and stimulate users to share their cars instead of preventing it (56). Thus, incumbent actors have identified the growing carsharing niche as a threat to their traditional business models. On the one hand, they try to keep the regime of car ownership in place through forestalling larger policy changes and, on the other hand, they try to create ways in which they can profit from the new practice of carsharing by partnering with carsharing organizations.

Environmental impacts. Empirical studies predominantly find that the environmental impacts created by carsharing are positive (1, 25), but two caveats exist that our interdisciplinary approach focused on societal embedding can help to shed more light on: 1) creation of new travel and competition with other environmental-friendly travel modes, and 2) differences in environmental impacts among the different types of carsharing. In the case of the Netherlands, taking into account changes in travel patterns and resource use (fewer cars have to be produced), Nijland and Meerkerk (2017) estimate an overall reduction of CO_2 emissions of carsharing users of between −240 and −390 kgs/year (i.e., between 13 and 18%) (25). In addition, in the capital city of Amsterdam, CO_2 emissions by passenger cars are calculated to be reduced by 1% thanks to carsharing in 2020 (and by an expected 4% in 2025) (57). A reduction in car ownership also frees up space in cities for other purposes. Various empirical studies indicate that people who use carsharing tend to travel less by car and make more use of other environmental-friendly modes (public transport, cycling), an observation reflected in our survey (20). However, the fact of being able to rent a carsharing car can also induce new car travel [15% of the car kilometers made by shared car would not have been made otherwise (25)], or replace travel that would otherwise have been made using other environmental-friendly transport modes [in the Dutch context, 41% of kilometers would have been made by train (25)]. This poses a risk in terms of the environmental impacts of carsharing, especially if the upscaling trajectory does not coincide with investments in other environmental-friendly modes of transport, and only enhances the availability of cheaper automobility. Competition with other modes also influences municipal policymakers in the Netherlands. Although there is general support for carsharing, it is sometimes seen as the "second-best" option for city centers after cycling and public transport, given that shared cars still take up parking spaces and increase congestion (58).

Importantly, the environmental impacts of B2C and P2P carsharing are different. A reduction in annual kilometers traveled by P2P users (around 15%) and B2C users (around 20%) has been observed, but a reduction in car ownership is only evident in the case of B2C carsharing (25). As discussed, P2P carsharing lowers the costs of car ownership. For owners, this thus lowers the barrier to purchasing a vehicle, because renting it out generates

additional income that covers part of the cost of ownership. The ability to share their car may also lead owners to keep old vehicles longer or even buy dedicated vehicles just for renting them out. Carsharing firm strategies codetermine environmental outcomes here. On the P2P carsharing platform we studied, the number of cars that can be rented out is currently limited to three per person to prevent commercialization. In terms of the types of cars that are shared, B2C carsharing is presently achieving greater CO_2 reductions because its share of electric vehicles is higher than the percentage overall in the Dutch fleet. In 2021, 13% of shared B2C cars were electric, while only 4% of all Dutch cars were (10). Hence, the sustainability impacts of carsharing are not a given but shaped by the different actors involved.

Summary. We can now summarize the main interactions between landscape-, regime-, and niche-level factors that shape the trajectory of carsharing in the Netherlands. Landscape factors of convenience culture and the built environment continue to stabilize the regime of private car ownership. Contrastingly, climate change and the rise of the access economy destabilize it, enabling the niche innovation of carsharing to grow. The carsharing niche interacts differently with the regime of private car ownership across societal domains. Main carsharing markets have emerged in urban areas where the private car ownership regime is weakening. Carsharing use is driven by increasing preferences for sustainable mobility. Still, car culture persists, and notably P2P carsharing conforms to the existing positive social connotations of cars. Policies have been mostly niche supporting, rather than regime challenging. Policy changes favoring carsharing are observed in the domain of parking, yet face considerable resistance. Finally, automotive incumbents have recognized the potential threat of the carsharing niche and explore new business models, yet they also aim to uphold the sociotechnical regime.

Conclusions

This study set out to analyze the uphill struggles of carsharing in the Dutch context. Carsharing today meets a growing, but small fraction of total mobility needs. The shift from car ownership to carsharing involves considerable behavioral and sociocultural change. Herewith, carsharing is different from technological innovations such as the electric vehicle, which is scaling up faster (59). Our analysis shows how car ownership has become ingrained in policymaking, spatial planning practices, business models, and social norms. This explains why current schemes that focus only on technological improvements or changing consumer behavior have failed to lead to the mainstreaming of carsharing. Instead, using a comprehensive perspective from the field of sustainability transitions (60), we can explain the development of carsharing by analyzing its embedding in different societal domains over time. For sustainability science, this approach holds relevance because it allows for the integration of insights from multiple social science perspectives. We hence respond to calls to better include real-world change processes in sustainability analyses and identify interventions for steering consumption–production systems in desirable directions (61, 62). Additionally, the developments in the mobility system we studied also influence change processes in other systems, such as those of energy and land use, for example via parking. The multilevel perspective (MLP) we used also has some limitations. It can present sociotechnical regimes as overly homogenous, paying limited attention to spatial variations including the dominance of alternative transport modes in some places. An additional limitation of the MLP, which is reflected in this study, is that it does not include an in-depth analysis of the daily mobility patterns of users. Regarding the latter, different perspectives, such as social practice theory, could be useful to compare the habitualized mobility patterns of users and nonusers of carsharing (63). Such a perspective could also shed more light on the extent to which carsharing can bring about equitable improvements in mobility patterns of different social groups.

We distill two main takeaways from our studies. First, our perspective holds that carsharing can only be successful if stakeholders take a systemic approach. This involves businesses using the most up-to-date technologies to make carsharing a convenient consumer experience. It also involves mobility system actors, rather than merely stimulating carsharing, aiming to weaken the private car ownership regime. An example in the domain of local policy in this regard would be reducing parking places for private cars. Any breaking down of the existing car ownership system will be challenged by incumbents, who may also, nevertheless, enter the carsharing services sector as a hedging strategy. What is more, higher taxes raise costs for low-income households who are car dependent, raising concerns about distribution and social justice. An example is the ongoing societal controversy around "low emission zones," which ban or tax polluting vehicles (64). As a general insight, sustainability transitions that involve significant behavioral change are very hard because existing behaviors have become entrenched in our social and economic fabric. Therefore, supporting these transitions requires not only "beginning" (supporting niche formation) but also "ending" (phasing out regime rules), a process that requires careful balancing of economic, social, and environmental impacts to ensure equitable transitions (65, 66).

As a second takeaway, multiple carsharing models coexist, each serving markets that only partially overlap. Carsharing upscaling trajectories thus remain open and may either tend toward carsharing as an "add-on" to the current regime of private car ownership or toward transformation to a multimodal system. The environmental impacts of carsharing are not predetermined but depend on the social and technical trajectories taken. P2P carsharing can be scaled up faster because car owners can offer their car at no extra cost, rendering this business model also feasible in rural areas. Additionally, P2P carsharing platforms offer a wide variety of cars, increasing consumer attractiveness. However, a larger share of P2P carsharing would entail a less transformative trajectory, as P2P carsharing relies on the existing stock of privately owned cars, and in various ways reproduces the regime of private car ownership. This also explains why P2P carsharing is found to have lower environmental benefits than B2C carsharing (25). In addition, carsharing can become highly commercialized, e.g., P2P platforms in the United States encourage providers to become entrepreneurs and offer multiple cars. This could reduce environmental benefits and increase economic disparities among those who own cars and those who do not. However, carsharing organizations can also take action to foster environmental benefits, such as encouraging the use of electric vehicles and banning old polluting cars. When policy actors tend to shy away from hard measures countering private car ownership, they stimulate carsharing as an add-on and not as a regime transformation. Alternatively, it has been found that users who adopt carsharing make use of a combination of public transit, active, and other shared modes (1). Hence, a focus by policymakers on facilitating a well-connected multimodal mobility system could convince larger groups of people to join carsharing and break the current norms of car ownership.

Ethical Statement. The study protocol was reviewed and approved by Utrecht University. Interviewees and workshop participants

were verbally informed about the purpose of the study and their consent to participation and recording was requested and obtained.

Data, Materials, and Software Availability. All study data are included in the main text.

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