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How do new mobility practices emerge? A comparative analysis of car-sharing in cities in Norway, Sweden and the Netherlands

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ABSTRACT

The hegemony of the private car is increasingly challenged as new policies and technologies affect passenger mobility. This study investigates how car-sharing is emerging and unfolding amidst established urban mobility practices. We apply a conceptual framework with seven elements based on social practice theories and transition literature to deconstruct practices in order to reveal how such (relatively) new mobility practices emerge. Our comparative study uses qualitative methods with data from 58 household interviews and three half-day workshops with stakeholders in Oslo, Norway; Malmö, Sweden; and Rotterdam, the Netherlands. The research question asks how car-sharing practices unfold differently in different places. The results indicate how elements of mobility practices change from the situation *before* and *without* car-sharing to *after* and *with* car-sharing. The analysis reveals different changes in the three areas, with greater change in Malmö because of public procurement of car-sharing and less in Rotterdam, where there was interest in urban experiments directed at phasing out car use and supporting car-free city zones. The framework highlights that new digital technologies and regulations are important, influencing business models and the social meaning of mobility towards a broader acceptance of access-based transportation. For car-sharing to contribute to environmental sustainability, the three areas need to reduce the daily use of cars so car-sharing can become a viable option for occasional use of cars. Further, policies should combine Electric Vehicles (EVs) and car-sharing, e.g. in Oslo, the focus of promoting EVs should include shared EVs, and in Rotterdam, improved charging infrastructure would be effective.

1. Introduction

Today's mobility systems are widely deemed environmentally unsustainable [1]. These mobility systems have the private car as the predominant mode of movement, leading to high fossil fuel consumption (with associated CO_2 and NO_x emissions), extensive land use for infrastructure, and the high production of vehicles. Various ways to improve the environmental sustainability of these systems have been proposed in previous decades. Technological substitutions, such as electric vehicles (EVs), have been envisaged to reduce vehicle emissions [2,3]. Moreover, studies have highlighted the need for modal shifts in personal mobility, away from motorized forms of transport and towards public transportation or more active forms of transport [4,5], such as biking and walking. Finally, other forms of car use and ownership have been proposed, most notably 'car-sharing,' to challenge the dominance of privately owned fossil fuel cars in cities, promising a reduction in kilometers driven.

This study is positioned within socio-technical perspectives on transitions, which conceptualize transport as a configuration that includes technology, policy, markets, consumer practices, infrastructure, cultural meaning, and scientific knowledge linked to various actor groups, such as firms and industries, policymakers, consumers, civil society, engineers, and researchers [6]. This perspective comes from an evolutionary system approach of innovation that does not prioritize social and technical elements but sees these as inexorably linked [7–11]. The concept of the *system of automobility* describes the continued, self-reinforcing dominance of privately owned, petroleum-powered vehicles used primarily by single occupants [12], resulting from path-dependent mobility patterns centered around the car [13].

The market for car-sharing has continued to grow steadily in North America and parts of Europe, with further expansion expected [14]. In Europe, traditional business-to-consumer (B2C) models, such as co-operatives and car-clubs, dominate car-sharing services. Recently, these

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solutions have been accompanied by peer-to-peer (P2P) business models, with people offering their private cars for rent on online platforms [15]. Shifts from product-to-service and integration of information technology into mobility, support the emergence of various forms of car-sharing, including car clubs with short-term membership-based rentals provided by not-for-profit organizations or for-profit firms [16]. New digital platforms offer opportunities for flexible shared transport, helping to overcome some barriers faced by many providers of public transport [17].

How car-sharing contributes to environmental sustainability depends on how it is used and how it is combined with or affects the use of other means of transport for personal urban mobility.

The potential for contributing to environmental sustainability through car-sharing lies mainly in the possibility of reducing the number of cars produced and the number of kilometers driven. A study from the Netherlands found that shared cars generally replace a second or third car and that kilometers driven were reduced by 15% to 20% as compared to before the commencement of car-sharing; further, there was 30% less car ownership among car-sharers [18]. However, the contribution to environmental sustainability involves other aspects as well, such as the growing presence of EVs offered by car-sharing services and how car-sharing affects the use of other modes of transport, such as cycling or public transport [19].

Several recent studies investigate the role of the user in the emergence of car-sharing, finding, for example, that outcomes associated with early adopters cannot be projected onto later adopters [20] and that different kinds of car-sharing services attract different user groups and are also used differently [21]. Other studies of the impacts of free-floating car-sharing on private-car ownership highlight that the early-stage impacts of car-sharing services may not be the same at later stages as the services mature and grow [22].

Recent empirical studies from Norway have investigated the influence of car-sharing on car ownership [23], travel patterns for new emerging car-sharing practices [24,25], and the role of context and lifestyle on car-sharing [26], finding that car-sharing relate to other mobility practices. Other studies highlight how the current dominance of private-car ownership affects adoption patterns in car-sharing [27]; that motives for sharing may be environmental or economic [28]; and that well-designed car-sharing services can provide a sustainable, flexible mobility solution for urban residents [29].

Up until now, most of this type of research on car-sharing has examined its environmental impacts, focusing on the changes in vehicle ownership and vehicle kilometers traveled [30]. However, a focus on how car-sharing impacts and relates to other mobility modes is lacking. The limited research on this suggest that car-sharing members are more intermodal and multimodal in their travel behavior and cycle more [31], suggesting that car-sharing plays a role in changing mobility beyond just affecting vehicle possession or vehicle kilometers traveled. Car-sharing relates to changes in non-car modes as well [32]. Seeking to contribute to the attention on other modes of transport besides cars, this article investigates the types of changes in mobility that occur when car-sharing is introduced.

While earlier studies help to explain important aspects of the diffusion of car-sharing, less attention has been paid to how the emergence of car-sharing is different in different places because of how it interferes with particular local, established mobility practices. In order to fill this gap, we need to understand how urban mobility practices are reconfigured as car-sharing practices emerge. This article achieves this by deconstructing car-sharing practices and mapping changes that occur in various elements when new car-sharing practices emerge.

The study applies a practice and system change approach and joins research on the role of car-sharing practices on changes in the automobility system [33–35]. In line with our conceptual framework of social practices (see Section 2), we compare car-sharing practices in Oslo, Rotterdam, and Malmö by discussing and scoring the level of changes in elements.

This article is organized into six parts: introduction, conceptual framework, methods and data collection, analysis and results, discussion, and finally, a conclusion, which outlines implications.

2. Conceptual framing: shared and actor-specific elements

This study draws on insights from social practice theories (SPTs) and transition studies. In this section, we define concepts, present research gaps, and explain the contribution made by this study and the analytical framework applied [36].

A widely used approach in SPTs is the three-element model of materials, meanings, and competencies [37]. This approach is increasingly applied in social science and energy research and has proven to be useful for policy because the studies move beyond behavior change [38–40]. In this study, we apply a conceptual framework in which practices are instead comprised of seven types of elements. This framework deviates from the existing three-element model by including shared elements and actors with actor-specific elements. We see practices as an entanglement of the performances of various actors, in the case of car-sharing: the use, the operation of the service, and the associated urban planning and regulation. Some elements are specific to these actors (i.e., knowledge and skills, financial capabilities, and values and feelings), while others are not and are instead seen as shared elements (i.e., infrastructures and artifacts, policy incentives, social norms and meanings, and business models), see Fig. 1. These elaborations on the three-element model are useful for an analysis that goes beyond consumption and the user (as do most SPTs that are central to transitions studies) to include more of the supply and regulation aspect [36].

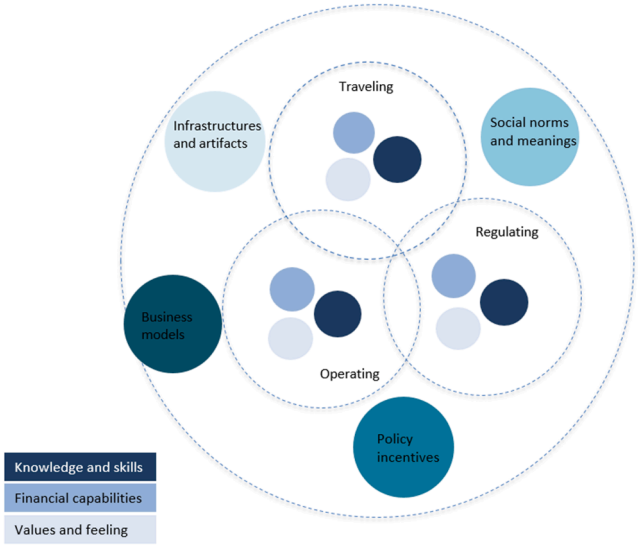

Fig. 1. Conceptual framework of car-sharing as a practice comprised of seven types of elements.

SPTs are a family of theories with some commonalities across a growing range of applications. The concept of practice comprises a 'nexus of doings and sayings' [41]: how people travel, eat, shower, heat their homes, etc. Most definitions of practices include objects and the material world as part of that nexus [42–44]. Rather than focusing on individual behavior, these approaches take practices as the unit of analysis, showing how social activity is made up of a constellation of human, material, and discursive elements [38,42].

Sustainability transitions concern changes in socio-technical systems and are defined as 'long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical

systems shift to more sustainable modes of production and consumption' [45]. Earlier studies have shown that social practice theories can be useful in transition studies by informing societal transformation [46,47] and that policies can be targeted towards changing practices in a transition towards sustainability [48].

Whereas transition studies aim at studying system change, many empirical studies are criticized either for being overly focused on 'the bigger picture' or on 'zooming in' on technological development. This study seeks to address the gap in the middle: it de-constructs practices, provides a snapshot of many ongoing changes that are either actor-specific or shared, and discusses the consequences. We take social practices as the unit of analysis, in line with other works that apply practice theories to study system change [46,48,49]. We aim to contribute with a systemic approach that is related to other system studies, which look beyond users of transport and link the social with the technical [50].

SPTs have successfully been developed to remove the division between structure and agency and to focus on practices rather than individuals and several efforts have been done to study changes in practices. For example, Watson [46] suggested three mechanisms involved when a practice changes: how the elements change, how the carriers of the practice change, and how elements and carriers relate to changes in other practices. His study indicated that system change in transitions could be explained from a practice-based perspective.

In this study, the notion of practices as 'entanglement of performances of actors' implies that durable change of practices concerns reconfigurations to intertwined, differentiated, and interlinked practices that guide both daily consumption and processes of supply and policy [51–54]. From this practice-theoretical perspective, any durable reduction in the use of cars requires changes not only related to the availability of alternatives but also to the collective know-how in terms of their use and in the social and cultural meanings attached to car mobility and the alternatives.

The framework we apply in this study includes the social context in a different way than does the three-element approach because it highlights the interrelatedness of actors in shaping practices. The seven-element framework has previously been used to address factors that hinder resource-efficient practices in the case of mobility [36]. While the previous study mapped these factors and policies by tackling the 'web of constraints,' [36] this present focus is instead on mapping enabling factors as we apply the framework to study what type of changes happen in the elements when a practice emerges amidst existing mobility practices.

In this study, we therefore do not apply the well-known three-element SPT approach [37] but instead employ the conceptual framework in which practices are comprised of seven types of elements: three *actor-specific* elements (knowledge and skills, values and feelings, and financial capabilities) and four *shared* elements (infrastructures and artifacts, business models, social meanings and norms, and regulatory incentives) [36].

The actor-specific element of knowledge and skills (or *competencies*) refers to practical know-how as well as bodily activities, similar to the three-element approach. Feelings refer to the stakeholders' specific emotions concerning the performance of the practice, and financial capabilities refer to the extent to which a stakeholder can afford the performance of the practice.

For the shared elements, the infrastructures and artifacts refer to the *materials* that enable the performance of the practice, business models refer to the way firms create value or profit from selling products or services, such as the particular offer to the customer; social norms and *meanings* are the main ways the practice is framed, and (public) policy incentives are regulations, tax incentives or subsidies, etc. that promote, constrain, or dictate (part) of the practice.

The elements are not separate but collectively shape each other (see Fig. 1). The three small blue-colored circles represent the actor-specific elements in the three dotted-lined circles (traveling, operating, and regulating), and the four outer circles in the other blue colors show the shared elements. The dotted circles surrounding the elements illustrate that the elements are interrelated, constituting the practices.

This framework enables a comparative practice analysis of three areas when describing the changes that occur in the various elements when new car-sharing practices emerge in each area. This study addresses the following research question: How does car-sharing emerge differently in different places, amid particular local, established mobility practices?

3. Methods and contexts

We combine two qualitative methods: household interviews and stakeholder workshops. Data collection was conducted in three areas: Oslo, Norway; Malmö, Sweden; and Rotterdam, the Netherlands.[1] Before describing the context of these three areas, we explain the data collection and analytical processes.

3.1. Methods

Data were collected through semi-structured household-level interviews on car-sharing and from stakeholder workshops in the three urban areas.[2] In total, 58 interviews were conducted, and three half-day workshops were organized. A general interview guide developed for the international research project, TEMPEST, was used as a starting point for the interviews in all three areas. Questions were both broad (life situation, daily travel, leisure travel) and specific (the use of car-sharing, motivations, practical elements, and implications). Interviews and workshops proved useful for obtaining data on practices, as participants talked about their experiences in revealing ways, mentioning actions they would have otherwise taken for granted [55,56].

In the Oslo urban area, members of 39 households were interviewed in their homes by TEMPEST project participants. In most interviews, the driver and other adult household members were present. Semi-structured interviews were conducted in respondents' homes during three periods: May–July 2017, October–November 2017, and January–March 2018. All households were registered with one of three car-sharing services: Nabobil (a P2P service), Hertz Bilpool (a B2C corporate service), and Bilkollektivet (a B2C cooperative). Thirty-three households used vehicles from the car-sharing services in various ways, two were members who provided cars, and four were members but non-users. Ten households mainly used P2P; 11, B2C corporate and 18 used B2C cooperative. The need for interviewees was announced through the research project on the Facebook pages of the three car-sharing suppliers. An overview of possible participants was made, and interviews were then booked with various types of households—couples or singles in families with or without children. Interviewees were informed about the research and data collection process and signed a consent form allowing the data to be used for research purposes. This part of the research project is registered with and approved by the Norwegian Centre for Research Data.

In the urban area of Malmö, members of twelve households were

[1] This study is a part of the research project, TEMPEST, with partners in Norway, Sweden, the Netherlands, and the UK. These locations were the starting point for this specific study, and the data used here are part of the larger data collection for the overarching research project. Note that this study was conducted prior to the recent municipal reform in Norway: the earlier designations of municipalities and counties are used here.

[2] Quotes in the findings in this article are accompanied by place-specific acronyms and the number of the interview, for example OHI (Oslo household interview 1–39) and OSW (Oslo stakeholder workshop),

interviewed in their homes by master's students in October 2017: six were users of Lund's Bilpool, four were users of Sunfleet, and two were non-user households. In order to create a sample with participants who used different services, the researchers began the recruitment by identifying and inviting a few participants from their own network, and then some of these initial recruits invited people they knew to join the study. In the urban area of Rotterdam, seven telephone interviews with households were conducted in March and April 2018 with current users of three different car-sharing providers: two used Greenwheels, one used Snappcar, and four used Buurauto. In this location, the researchers also identified and invited participants based on their contacts, aiming for a sample with participants who used different services. Interviews in all areas lasted between 45 min and two hours. Table 1 provides an overview of the car-sharing companies and business models in the three areas. The provision of EVs in these schemes varied, with, for example, the P2P services offering a variety of EVs that people put out for rent, Buurauto focused on EVs, and the other cooperatives offering only some limited EVs in their fleets.

Table 1
Overview of car-sharing providers and business models.

	Oslo	Malmö	Rotterdam
P2P	Nabobil		Snappcar
B2C Corporate	Hertz Bilpool	Sunfleet	Greenwheels
B2C Cooperative	Bilkollektivet	Lund Bilpool	Buurauto[1]

[1]Not organized strictly as a B2C cooperative or corporate company but with neighborhood arrangements.

Half-day stakeholder workshops that followed similar formats were arranged by project partners in the three areas as part of the TEMPEST project: on October 31, 2018 in Oslo; on January 28, 2019 in Malmö; and on October 31, 2018 in Rotterdam. Participants were representatives from car-sharing operators, the public authorities, research institutes, and mobility organizations, such as public transport companies. In Malmö, this included, for example, the Swedish Association of Green Motorists; The Swedish Transport Administration; Trivector, a company offering transport R&D and consultancy services; K2 Sweden's national center for research and education on public transport; and Mobile Heights, a non-profit ICT cluster organization and networking community. Workshops involved group work followed by plenary discussions. Questions focused on three aspects of how car-sharing relates to the existing mobility system and participants' views on a) what needs to be developed (new), b) what needs to be changed (adapted), and c) what should be stopped (phased out) for car-sharing to enter the current mobility system. In other words, their opinions on what a mobility system with car-sharing would look like, with a focus on what could be done by these stakeholders to a) build 'the new,' b) customize, and c) phase out 'the old,' were collected. Although these questions initially focused on future change, in answering them, participants also noted how mobility practices of car-sharing have changed. In Oslo, for example, three groups, as shown in Table 2, first reflected on these questions and then presented their views in a plenary session. Then the groups continued separately by discussing all ideas and how car-sharing can enter the mobility system. In the end, a summary of the main outcomes was presented and discussed in a plenary session. The Oslo workshop offers an example of how the stakeholders interacted in groups and how this generated data for the research. The photo shows the workshop in Malmö, with the participants involved in group work.

Table 2
Grouping of participants in the stakeholder workshop in Oslo.

Group 1	Group 2	Group 3
Oslo City Council, section for the urban environment	Akershus county, neighboring county to Oslo	Bærum municipality, neighboring municipality to Oslo
Bilkollektivet, car-sharing B2C cooperative	Bilkollektivet, car-sharing B2C cooperative	NSB Bybil, car-sharing from Norwegian State Railroads
Hertz Bilpool, car-sharing B2C corporate	Møller Mobility, car company	CICERO, research institute
	Ruter, public transport operator	

The analytical work was conducted in four main steps. The transcribing, coding, mapping, and comparisons were discussed among the three researchers in several sequences, leading to adjustments and annotations. First, recordings from the household interviews and stakeholder workshops were transcribed, or notes were written and organized using the computer software NVIVO.

Second, the first author coded the interviews and workshop transcriptions and notes using the seven categories of the conceptual framework. In this step, we labeled what was said about mobility practices as referring to shared elements of 'infrastructures,' 'business models,' 'social norms and meanings,' 'policy incentives' or actor-specific elements of 'financial capabilities,' 'knowledge and skills,' and 'values and feelings.' The initial coding was discussed among all three authors in face-to-face and online meetings. This led to a new round of additional coding with some adjustments.

Third, we mapped how the elements changed due to the introduction of car-sharing. The changes in each element were estimated separately in order to gain insight into what and where changes were happening. The change in each element was scored from zero to two, with 0 for 'no/little change,' 1 for 'some change,' and 2 for 'big change.' This could not have been a precise measure, but these steps offered important insights, necessitating evaluations of changes that served as a basis for further analyses and discussion. For each element, we asked a question of change—for instance, concerning the shared element of infrastructures and artifacts, we asked about the extent to which infrastructures and artifacts of the established mobility practices have been adapted (to enable car-sharing) compared to the situation before the introduction of car-sharing.

The final step involved comparative discussion on what was place- and time-specific in the three areas, where we elaborated on the discoveries behind scoring the change and investigating similarities and differences. The findings were ultimately synthesized in Excel.

The limitations of this study concern data collection and the analysis with elements and scoring the change. The data collected from the three areas involved differences, such as not including P2P in Malmö and interviewing a few informants in Rotterdam. We have tried to take this into consideration but recognize that there could be one-sidedness, for example, with regards to the participation of different providers and policymakers in the stakeholder workshops. We examined the preliminary findings together to overcome some limitations of using qualitative methods, such as the fact that the results could be influenced by personal biases and idiosyncrasies, depending on the individual skills of the researchers. This was also done in order to deal with variations in the data collection resulting from differences in conducting the interviews (telephone vs. at home), in workshop participants (variety of stakeholders), and due to the three languages involved (Norwegian, Swedish, and Dutch). Moreover, because we wanted to map any changes in elements, it was particularly important to evaluate this part of the findings with the other researchers. The comparative analysis brings greater variation but frequently also less depth since not all relevant factors can be examined [57]. Despite these shortcomings, the analysis still provides data that is rich enough to enable a comparison of what enables car-sharing practices to emerge.

3.2. Contexts

Oslo is the capital of Norway and its most populous city. Its urban area includes some parts of the surrounding county now called Viken and has approximately 1 million residents. Malmö is Sweden's third largest city; the Malmö Metropolitan Area has over 700,000 residents. Rotterdam is the second largest city in the Netherlands, and its urban area has slightly over 1 million residents.

Oslo, Malmö, and Rotterdam are all car-dependent cities dominated by the use of personal cars but also characterized by growth in public transportation and cycling. Oslo, for example, has new regulations aimed at reducing daily driving, such as higher road tolls and residential parking restrictions. Public transport is well established, and biking is becoming more widespread, supported by increased funding for bike lane construction and year-round maintenance. In the Malmö Metropolitan area, public transport is popular and well-functioning; bicycling infrastructure is extensive, with more than 500 km of bicycle lanes in Malmö alone. In Rotterdam, as throughout the Netherlands, bicycling is commonly used for daily travel. Recently, other personal mobility options have emerged in all three areas, such as car-sharing and bicycle sharing.

Although the three areas are all located in northwestern Europe, there are differences in mobility regarding policies and the use of EVs and bicycles. For example, the official policy in Norway is that, by 2025, all new cars sold should be EVs. Indeed, in Oslo, they are increasingly popular; the city is a world leader in EV growth: 60% of new cars sold in 2019 were EVs. In Rotterdam and Malmö, EV use is more limited, but the use of bicycles for personal mobility is firmly established.

Car-sharing has existed in Norway since the mid-1990s; as of 2020, there were more than 11 car-sharing service providers or platforms [26,30,58]. In Sweden, car-sharing can be traced back to the mid-1970s, rooted in the cooperative movement and local community initiatives. Before 2006, there were no commercial car-sharing companies in Malmö and only one private car club offering two vehicles. The Netherlands had approximately 41,000 shared cars and 400,000 users by early 2018, with a growth of 10,000 in the number of shared cars compared to the previous year. This increase occurred mainly in the four largest cities (Amsterdam, Rotterdam, the Hague, and Utrecht). The most rapid growth was in P2P platforms, which supply 81% of shared cars [59].

4. Results: Changes in elements of emerging car-sharing practices

Here, we compare the practices in the three areas by examining changes in the elements. In line with our conceptual framework of social practices (see Section 2), we discuss the seven elements of car-sharing practices. We score the level of changes in the four shared elements (infrastructures and artifacts, business models, policy incentives, and social norms and meanings) and in the three actor-specific elements (knowledge and skills, financial capabilities, and values and feelings). For the actor-specific elements, we score the changes for travelers, operators, and planners separately.

4.1. Shared elements

4.1.1. Infrastructures and artifacts

Car-sharing includes new technologies for accessing cars through digital platforms and integrated information technology. At the same time, many material aspects of car-sharing are similar to those in the existing mobility system, such as vehicles, roads, and parking infrastructure. The change relates more to communication than to physical artifacts and infrastructures: the main changes are in internet access, software and hardware devices with smartphones for maps, communication, keyless technologies, payment technologies, etc.

Regarding physical infrastructures, we found changes concerning parking and EVs. In Malmö, stakeholders from the municipality were involved in arranging dedicated parking in parking houses for car-sharing cars. In Rotterdam, the service Buurauto provided EVs. EVs require charging facilities, making charging infrastructure relevant for the use of EVs through car-sharing services, as put by this household informant in Rotterdam:

It's really a problem if you cannot charge the batteries. Then you've got to park somewhere else and then put it back on the spot with charging stations. When there's a shortage of charging stations, it becomes a problem for car-sharing. There's already a lot of hassle; and if,

in addition, you have to look for parking, people will drop out (RHI 5) (Table 3).

Table 3
Infrastructure and artifacts.

Infrastructure and artifacts
To what extent does car-sharing entail new infrastructures and artifacts?
Oslo and Rotterdam scored 1, 'some change,' due to the new role of EVs, smartphones, and the internet for car-sharing, without the involvement in parking infrastructure. Malmö scored 2, 'big changes' because new, dedicated parking for car-sharing has been provided in garages in addition to new devices and supporting software.
Oslo 1 Malmö 2 Rotterdam 1

4.1.2. Business models

Before the recent emergence of new business models of car-sharing services, there were some variations in car rental services and car co-operatives in all three areas. Cooperatives were non-profit organizations, where one could purchase a member share and pay monthly or yearly membership fees in addition to charges per trip or kilometer. Rental services were for-profit models with daily, weekly, or monthly deals of car use through rental offices.

Then, new car-sharing services were launched, such as the B2C corporate car rental, Hertz Bilpool, which offers self-service and shorter-term car rentals, combining, for example, monthly membership for small, medium, or large use of cars matched with driving charges and handling costs, such as insurance, fuel, and road tolls. After 2015, new P2P services, which provided platforms for people to share their privately owned cars, emerged. These new business models have led to a greater supply of cars, new locations, new opening technologies for keyless alternatives, and new payment methods in all three areas (Table 4).

Table 4
Business models.

Business models
To what extent does car-sharing entail new business models?
All three areas scored 2, 'big change', in the business model element because of the recent emergence of new services such as P2P car-sharing.
Oslo 2 Malmö 2 Rotterdam 2

4.1.3. Policy incentives

In Malmö, policy incentives have played a central role in facilitating and promoting the growth of one of the services, Sunfleet. The municipality was involved in dedicated parking for car-sharing and public procurement of their services. Civil servants attended seminars and discussed changes in regulations for housing and parking, with specific regulations for car-sharing lots replacing private cars. Through the subcontracted parking company P-Malmö, Malmö city has parking space dedicated to car-sharing in its garages. The city also temporarily assigned personnel to help introduce and implement Sunfleet there. However, the municipality was not allowed to offer dedicated or subsidized space (e.g., streets) for car-share vehicles to car-sharing companies or other public organizations. This has been an obstacle to growth and economic viability for car-sharing companies. However, other actions were taken to involve the public in Sunfleet, for example, via public procurement of their services.

In fact, the most interesting supporting move made by the city of Malmö (and adopted by other Swedish cities) was a suggestion to offer housing companies a reduced 'parking norm': the requirement to build a given number of parking lots in each newly built apartment complex. This norm can be reduced if the housing company can provide a sustainable mobility solution, such as a car-sharing scheme for residents.

One respondent expressed his thoughts on the role of policy incentives on car-sharing in Malmö:

> I think that the government and decision-makers are more pro-sharing compared to private ownership, and it's going to become more relevant. The bottom line is that if sharing is easy and cost-efficient for the users, it will continue to grow in popularity. It's partly up to the decision-makers to continue to subsidize. I don't see why sharing shouldn't become more popular in the future (MHI 2).

This was further elaborated by another household respondent, who supported changing parking regulations for housing and also highlighted the difference between accessing cars as part of housing instead of parking them randomly in the streets:

> If you buy an electric car to have in the condominium, you have it on the ground floor. Now if the state, the municipalities, had been smart, they could have reduced the parking norm requirement for the number of parking places. If they'd replaced it with carpool cars, instead of needing 20 places for a building, it would be enough to have maybe five plus two car-sharing cars or something like that. There's a big difference between having the car under a roof right there and having to walk outdoors, maybe 500 m, when it's snowing or raining … (MHI 6).

In Oslo, there are fewer direct policy incentives for car-sharing. The focus has been on support for EVs and initiatives for reduced daily car use, although there has been some (limited) political interest in car-sharing, with proposals for providing free public parking spaces for car-sharing. Ultimately, policy incentives in the Oslo area came to focus on tax exemptions for EVs; more walking, biking, and public transportation; and reduced daily driving through new parking regulations restricting free parking and the imposition of higher road-tolls during rush hours. Some stakeholders expressed their concern for the (lack of) policy incentives specifically for car-sharing because of how the uncertainty affects the competition and providers in the market. One participant from a car company commented,

> The issue of public–private collaboration keeps coming up. The big question is how to make it happen.
> For us, I also think it is important for the public to clarify its role. It's difficult for us to make big investments in an area where the government may suddenly come with a subsidized solution (OSW).

In Rotterdam, we found that the policy incentives were less directed towards cars and more towards other modes such as walking and biking. The focus was on phasing out car use in general and supporting car-free city zones, in contrast to Malmö and Oslo. Also, in Rotterdam, there was more interest in pilot projects and urban experiments, as summarized here about car-free zones from the workshop in Rotterdam:

> An emissions-free, collective-based mobility system in Rotterdam offers an attractive public space where having a car isn't necessary, but you can still go anywhere, and emissions-free mobility is always accessible and attractive for everyone.
> Further, one idea is to set up area experiments, starting in neighborhoods where there are support and initiatives, and begin to completely phase out individual ownership of fossil fueled cars (RSW) (Table 5).

Table 5
Policy incentives.

Policy incentives
To what extent does car-sharing entail new policy incentives?
Malmö scored 2, 'big change', because the municipality was involved in Sunfleet. Oslo and Rotterdam scored 0, 'no change', because policy incentives were limited to suggestions and ideas, with hardly any direct incentives actually implemented.
Oslo 0 Malmö 2 Rotterdam 0

4.1.4. Social norms and meanings

Car-sharing entails a shift in the meaning of mobility. There is a change regarding the acceptance of *accessing* cars instead of *owning* them and using transportation through subscription models and internet access. The established norm of owning cars is challenged. The change involves a direct change in the sense of the increased role of information technology in accessing the cars and indirectly due to the acceptance of the *occasional* instead of the *daily* use of cars. The greater role of ICT is not unique to car-sharing but can be seen in developments in other areas, such as the access of bikes through sharing schemes, the planning of trips and buying of tickets for public transportation, or the booking of taxi services online. In general, the threshold for using car-sharing services is lowered through the acceptance of the use of the internet to arrange for transportation. In the Oslo workshop in a discussion on how to integrate car-sharing services in apps for public transportation, one participant from a car collective said:

> It's getting easier, also for those who are new to it. Many city-people already use the Ruter [public transport] app, but very few use the car-sharing app. If it comes on the same platform, that lowers the threshold for trying it for the first time (OSW).

We also found changes in environmental concerns. In Malmö and Oslo, car-sharing is seen as a means to reduce regular car driving, facilitating the occasional use of cars. Car-sharing, we found, is seen as a sustainable option to promote less driving and private ownership. Workshop participants, both policymakers and practitioners, discussed how car-sharing contributes to environmental sustainability. There was a consensus that if car-sharing services were used in place of private cars, less driving would result. Car-sharing serves as a sustainable transportation alternative in all three areas studied because it reduces the need for the private ownership of cars. However, it is less clear whether this is seen as an element in 'sustainable urban mobility.' For example, in Rotterdam, it was noted that car-sharing also requires cars, whereas the overall objective was to reduce all cars in cities, so car-sharing was not prioritized as a sustainable solution. Car-sharing is not seen as the ultimate solution, but it can play an intermediate role in reducing and changing car ownership. Introducing car-sharing in Rotterdam should lead to a bigger change in the mobility system compared to the two other places, because here it is a step towards creating car-free zones, as expressed in a household interview in Rotterdam:

> A car is still a car; it does not change the mobility system very much. I think what really helps is that it means a shift from ownership to service. It's planting a seed for a larger step than that. If many people took up car-sharing, you'd see fewer cars in the streets. However, parking spaces are still needed everywhere and are still very dominant in the city. Maybe car-sharing would gradually help to reduce the problem (RHI 7).

We found that growing worries about daily private-car mobility (like congestion and parking restrictions) as well as a greater acceptance of car alternatives (like biking and public transport) promote norms for the acceptance of car-sharing. Transit and active travel infrastructure and culture enable the use of car-sharing. This interviewee in Rotterdam reported that bicycling and trains solved their household's daily travel needs, making car-sharing a suitable option for occasional car use, instead of private ownership:

> It's no longer necessary [to commute] by car; it's easy to get to work by train. This also means that people in the neighborhood are flexible when it comes to car use. That's a specific reason why we have started to use car-sharing (RHI 1) (Table 6)

Table 6
Social norms and meanings.

Social norms and meanings
To what extent does car-sharing entail new social norms and meanings?
Rotterdam scored 2, 'big change', because of how perceptions on the role of cars in the city have shifted towards the idea of phasing out cars. Malmö and Oslo scored 1 because the change in norms concerned reduction of daily use of cars.
Oslo 1 Malmö 1 Rotterdam 2

4.2. Actor-specific elements

4.2.1. Knowledge and skills

Users need to be able to drive different vehicles, use technology to access and find cars, and use tools to plan and pay for trips. Users need to acquire certain new skills, such as ensuring to pre-book cars for peak hours and checking the status of the cars at pick-up and delivery times. Here, the use of EVs has also played a role, as this requires specific knowledge and skills for charging and range planning, as two household interviewees in Rotterdam explained:

> There are two components: electric driving and opening and reserving (RHI 5).
>
> I'm satisfied with this system; it is amazingly easy, works 90% of the time. But you have to be able to keep pace with the technology. My wife has had a lot more trouble. The threshold is higher (…) the system didn't work, she hasn't felt like continuing, especially with electric vehicles (RHI 4).

For car-sharing operators, digital competencies play a role. The B2C car cooperatives and corporate businesses have acquired expertise in developing and sustaining their car-hub services and P2P on their online platform. We found a focus on digital competencies in all locations.

Regarding the urban (mobility) planner, the introduction of car-sharing entailed some new skills. Malmö trained civil servants through seminars on car-sharing facilities. In Rotterdam, the focus for planners and policymakers was on experiments and was not directed at car-sharing but toward achieving a car-free city. Among planners in Oslo, we found a limited focus on knowledge in car-sharing: the set-up was geared largely towards EVs and reduced parking. In fact, some new regulations concerning residential parking were criticized for not considering car-sharing, as the parking permits required ownership of the vehicles (Table 7).

Table 7
Knowledge and skills.

Knowledge and skills		
To what extent does car-sharing entail new knowledge and skills for travelers, operators, or planners? • For 'traveling' we found 'some' changes (score of 1) in all three areas, mainly with regard to planning and using smartphones in connection with transportation. These were not big changes, as users were already familiar with booking sites and applications for transportation, and these skills were applied in the use of car-sharing services. • This was similar for 'operating' with 'some' change (score of 1) in all three areas due to new combinations of existing skills and digital competencies. • On 'regulating,' Malmö scored 'big' change (2), more than Rotterdam (1) or Oslo (0). This resulted mainly from how the planners in Malmö were involved in activities that fostered learning about car-sharing and developing regulations. In Rotterdam, some change was evident because of how the planners were involved in car-sharing as part of learning from experiments for car-free cities. Oslo scored 'no change' here because we did not find a new use of knowledge or skills for car-sharing per se.		
Oslo	Malmö	Rotterdam
Traveling 1	Traveling 1	Traveling 1
Operating 1	Operating 1	Operating 1
Regulating 0	Regulating 2	Regulating 1

4.2.2. Financial capabilities

For travelers, the extent to which car-sharing was seen as an affordable alternative compared to other mobility options was relevant. The way people evaluated the cost of car-sharing varied. For some households in Oslo, the car-sharing cost per trip was closely calculated by, for example, comparing the cost of train tickets versus car-sharing for a weekend trip. Others here considered their use of car-sharing as a total cost of yearly or monthly transportation for the family, as explained by these two household interviewees in Oslo:

> We pay a monthly fixed fee to an account we have for car-sharing (OHI 9).
> It has something to do with finances. When it becomes more expensive to use the car collective than to have our own car, there's an equilibrium point as to how much we use the car. We set aside an amount every month, so we know roughly what we'll use during the course of the year (OHI 30).

In line with this, one interviewee in Rotterdam noted that the costs were a central aspect:

> What benefits are there to the use of car-sharing? Costs (RHI 6).

For the operator, financial capabilities differ in the various business models. For example, the P2P model is a business model that does not include responsibility for a car hub and consequently requires less financial resources. Common to all models is the significant financial investments and costs entailed in developing and running the digital elements of the businesses (software and ICT devices). In particular, providers in Oslo stressed their concern that the insecurity surrounding policy incentives could affect the financial position of their businesses.

For urban planners and regulators, we found involvement in the procurement of car-sharing services to be related to financial capabilities in Malmö. In Rotterdam and Oslo, however, there was hardly any direct public procurement or financial investment in car-sharing (Table 8).

Table 8
Financial capabilities.

Financial capabilities		
To what extent does car-sharing entail new financial capabilities for travelers, operators, or planners? • Concerning 'traveling,' we found 'big changes' (score 2) in Oslo and Malmö due to respondents' perceptions of financial differences between the variable costs of using car-sharing services compared to fixed costs through loans, insurance, and taxes related to owning cars, relating to the extent to which a stakeholder can afford the performance. Rotterdam scored only 'some change' (1) here, as our respondents focused more on comparing direct, variable costs for transportation, such as the use of trains or rental cars, to car-sharing. • There has been a growing assortment of 'operating' and associated business models in each of the three cities since 2015. Their expertise and concerns vary: for instance, in cooperatives, the revenues go back to the company, whereas the P2P has private providers. On the whole, we saw some change (score of 1) but acknowledged that our assignment of a score of one on this has certain limitations in revealing differences for different business models. • On 'regulating,' Malmö scored 'big change' (2); Rotterdam scored 'some change' (1), and Oslo scored 'little change' (0). In Malmö, the planners were involved in both procurement and subsidized parking. In Rotterdam, there was some change due to how financial support was directed at including car-sharing parking in certain areas to promote their efforts towards car-free cities. In Oslo, the planners were not involved in supporting car-sharing per se but focused on EVs.		
Oslo	Malmö	Rotterdam
Traveling 2	Traveling 2	Traveling 1
Operating 1	Operating 1	Operating 1
Regulating 0	Regulating 2	Regulating 1

4.2.3. Values and feelings

In Oslo and Malmö, travelers associated car-sharing with positive feelings of the freedom to drive and saw it as a solution to environmental concerns about car ownership. In all three areas, car-sharing played a role because it made it possible to use a car for specific purposes, instead of daily, as noted by this Rotterdam household interviewee:

> The main reasons are environmental considerations and that we find that it's not necessary to have a car (RHI7).

Some users in Rotterdam had seen economic concerns as being less important than environmental ones. They did not use car-sharing because of the financial aspect of saving money but because of environmental concerns:

> It's not about the cost savings but about the environment (RH1).
> It's not cheaper than your own old petrol fuel car. For me, the main point is electric driving. Electric driving is more important than car-sharing (RHI1).

For the operator, ideas and ideals associated with the sharing economy and ditto subscription models played a role. However, the type of feelings varied among the different services and business models. In B2B corporate services, there was (understandably) an entrepreneurial spirit with a certain focus on profit. Otherwise, the environmental objectives varied, some with more focus on EVs and others, less.

For the planners and regulators, car-sharing was valued differently in the three places. We found these values reflected in their involvements in car-sharing and similar to their policy incentives. It was thus valued differently, ranging from 'more change' in Malmö, due to public procurement and involvement in learning; 'some change' in Rotterdam, where we found interest in experimenting with car-sharing for reduced car use; and 'little change' in Oslo, where there was little interest from the planners on car-sharing, as it was not seen as an alternative (Table 9).

Table 9
Values and feelings.

Values and feelings		
To what extent does car-sharing entail new values and feelings for travelers, operators, or planners? • On 'traveling,' Oslo and Malmö scored 2 (big change) because of how car-sharing involved a change from the idea of using a car daily to instead, ideals of occasional, purpose-driven car use. Rotterdam only scored 1 (some change) here because of how this perception involved little change, as cars were already accepted as being used occasionally instead of daily. • On 'operating,' all three locations scored 1 (some change). Services have continued the earlier ideas for access-based car use but with some changes in values concerning their role in contributing to environmental improvements, for example, through EVs. • Concerning 'regulating,' Malmö scored 2 (big change); Rotterdam, 1 (some change), and Oslo, 0 (little change) because of how planners valued car-sharing. In Oslo, planners generally ignored car-sharing, whereas in Malmö, some planners were keen on it, and Rotterdam was in the middle because interviewees were only interested in car-sharing as a transient option towards car-free areas.		
Oslo	Malmö	Rotterdam
Traveling 2	Traveling 2	Traveling 1
Operating 1	Operating 1	Operating 1
Regulating 0	Regulating 2	Regulating 1

5. Discussion: interventions in interrelations

Scoring changes in the elements, albeit a clearly reductionist approach, offers a way of structuring the comparative analysis beyond bare qualitative descriptions—again, without any claims to quantitative precision. In the analysis, we scored changes in the shared and actor-specific elements. This is useful for further examining the interrelations between the elements and conceptualizing connections between the actor-specific and shared elements that can inform policy interventions (Fig. 2).

big change in Malmö, some in Rotterdam and little in Oslo.

We found similarities in all three areas, such as how new business models for sharing schemes were introduced, both as P2P as B2C (corporate and cooperatives). In the three locations, a new group of car-sharing users has emerged (albeit very limited in modal share) with digital skills to access cars and the necessary financial capabilities for car-sharing. The three cities show a trend of more internet and smartphone use for mobility and slightly reduced daily car driving independent of car-sharing. The new group of car-sharing users has been successfully recruited by a growing supply of car-sharing schemes/vehicles and supportive or neutral local regulations. These interactions can be understood as a collectively shaped enabling environment for car-sharing. In all three locations studied, the daily use of cars has changed for some travelers, and we note emerging new social norms of using cars, through the internet and direct payment, instead of through private garages financed with car loans. The necessary ICT technologies and associated skills related to traveling and operating are in line with the general trend of more ICT use in mobility practices as well as with the trend towards more on-demand mobility.

As the figure highlights, we also found differences in the three areas. We found that policy incentives and regulations for car-sharing varied. In Malmö, there was strong municipal engagement and support in car-sharing, while policy incentives in Oslo and Rotterdam were limited to suggestions and ideas, with hardly any direct incentives actually implemented. In Malmö, the municipality was involved in dedicated parking for car-sharing and public procurement of their services. In Rotterdam, policy incentives were primarily directed towards car alternatives such as walking and biking. These differences seem to correlate with differences in the material infrastructure for car-sharing, especially the fact that parking infrastructure is well-developed in Malmo and much scarcer in Rotterdam and Oslo.

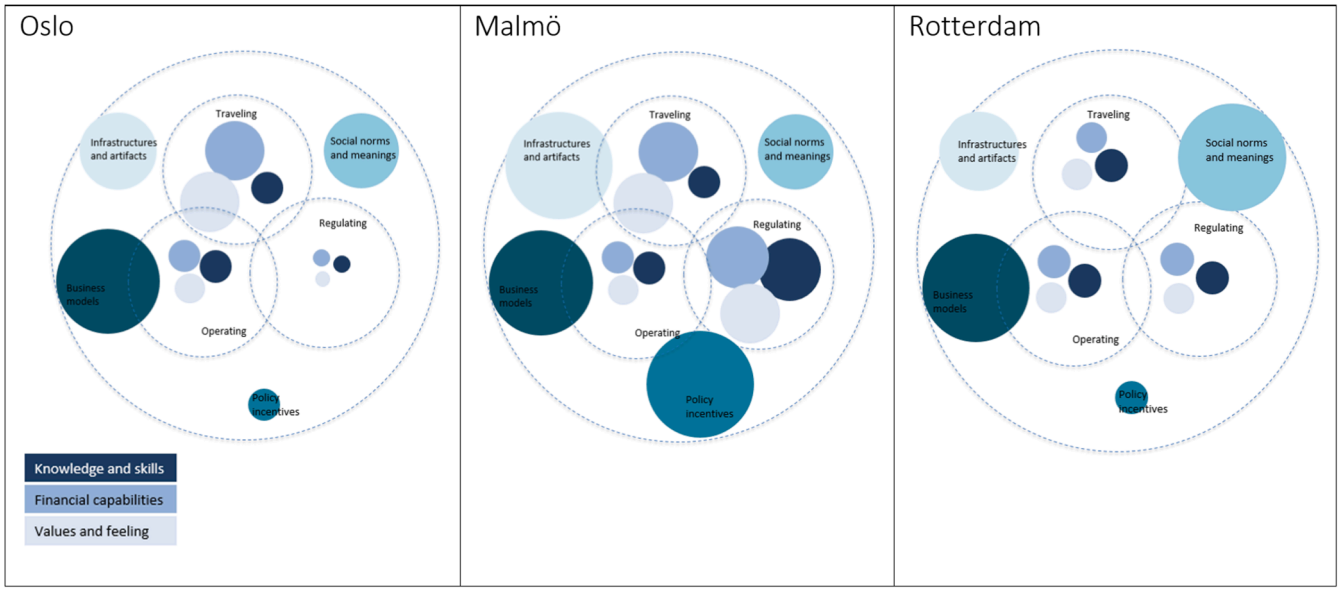

Fig. 2. Comparing the score of change in the seven elements (Figs. 4–6).

The figure is an illustration of the summary of the scoring of changes. These results emphasize that some elements are more "structural", and some are more "actional". It highlights, for example, the differences in the shared elements: the business models element represents a big change in all three areas. Social norms and meanings score some change in Oslo and Malmö and a big change in Rotterdam. For the policy incentives, there is more of a difference, with a big change in Malmö and a small one in the two other places. For the actor-specific elements the figure places interest in the differences in the changes in elements for the regulating, operating, and traveling. For example, for regulating, there is

Another key difference between the three study areas concerns the role of EVs as shaped by different national and local policies (see Section 3). In Rotterdam, some users see car-sharing as the way to access driving an EV when buying one is too expensive (or undesired). However, here some users see electric shared cars as a more complicated option compared to fossil-fueled ones, requiring additional skills (related to recharging and range planning). In Oslo, electric driving is more common.

How car-sharing has emerged in each of the three areas is also influenced by a range of 'other' non-mobility-related practices. For

instance, existing housing and working arrangements in these areas shape the timing of and demand for car use, and this also affects the development of car-sharing. However, our analysis has focused more narrowly on established mobility and car-sharing practices as though they exist in isolation from this wider urban system. Future research may take a broader scope, viewing urban mobility practices in relation to other urban practices, see Fig. 3. The figure shows car-sharing in relation to established urban mobility practices as well as, neighboring other practices, such as working and shopping. Such an analysis paves the way for a discussion on the effectiveness of policy interventions (i.e., whether the policy for sustainable mobility should be directed at mobility or at neighboring practices that trigger mobility). This relates to discussions in SPTs on what practices are *for* and where to direct interventions and, as others have noted, the fact that 'invisible energy policy' may be more significant than actual energy policy [60]. Similarly, the demand for mobility can also be studied as a derived demand driven by apparently non-mobility-related issues, such as the locations of homes and workplaces and out-of-town shopping centers.

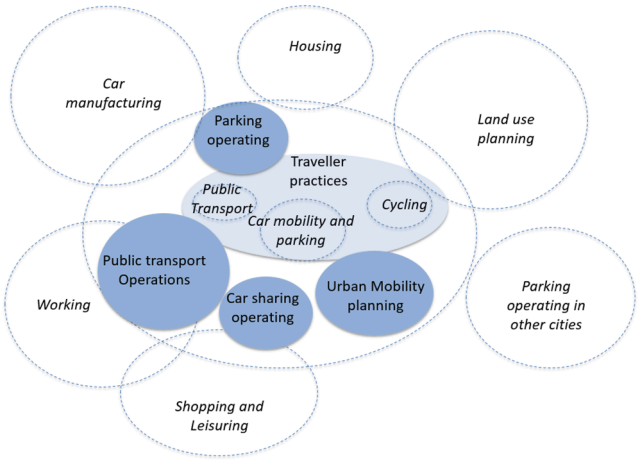

Fig. 3. Urban mobility practices in relation to neighboring urban practices.

6. Conclusions: accepting access-based transportation

This study has investigated how mobility practices are reconfigured due to the emergence of car-sharing by deconstructing a practice into its shared and actor-specific elements. First, we examined changes in four shared elements: business models, artifacts and infrastructures, policy incentives, and social norms and meaning. We then investigated changes in three actor-specific elements—knowledge and skills, financial capabilities, and values and feelings—for 'traveling,' 'operating,' and 'regulating.' The application of the theoretical framework in this empirical study shows changes in emerging practices that go beyond a mere user perspective and the carriers of the practice. The study show how social practice approaches can give more context-sensitive insights [61]. Figs. 4–6 in the appendix show the changes in each element in the three areas; larger circles illustrate big change, and smaller circles illustrate little change.

The local peculiarities mostly refer to the policy incentives and associated involvement of urban planners. Changes vary among the three study areas, with greater involvement in Malmö with regard to public procurement of car-sharing services and informing planners and policymakers about car-sharing. The focus was different in Rotterdam, where there was interest in pilot projects and urban experiments directed at phasing out car use in general and supporting car-free city zones. Car-sharing is not the objective, but a temporary instrument for a bigger change of removing cars. In Oslo, regulatory incentives were mainly focused on EVs. More local peculiarities may be highlighted in a broader analysis that includes neighboring (non-mobility) practices, such as working, shopping, and leisure practices.

New digital technologies, EVs, and parking are important in the infrastructure and artifact elements in all three areas; and they affect the other shared elements (business models and social norms and meanings) in terms of the acceptance of access-based transportation. Changes in these three shared elements, together with regulations aimed at reducing daily car driving, can explain the reconfiguration in mobility practices that support the emergence of car-sharing.

For car-sharing to contribute to environmental sustainability in personal urban mobility, the three urban areas all need to work on different ways of reducing the daily use of cars, so that car-sharing can become a viable option for occasional use of cars. In all areas measures to reduce the daily use of cars involve support for public transportation and biking to become viable options for daily transport. This can imply new or increased support for bikes for transport of people/children and goods, possibly with (electrical) cargo bikes, and opportunities to combine biking and public transport, and bike parking in transport stations, housing, workplaces, and shopping areas.

On the one hand, in Oslo, the prominent focus on EVs has led to the continued use of these types of cars for daily travel. Thus, Oslo could instead focus beyond EVs for daily travels and could benefit from changing the focus from EVs to car-free alternatives. In Rotterdam, on the other hand, providers and policymakers should focus on EVs for car-sharing as EVs and associated charging infrastructure were pointed out to be desired but absent.

Dedicated parking for car-sharing is connected to the shared elements of infrastructures, business models, and regulations, and the actor-specific elements and different support for car-sharing parking will therefore have ripple effects. For example, changes in parking norms to also include car-sharing parking in housing will affect the business models providing car-sharing in such buildings.

In the three locations, *specific* actions targeted *indirectly* at car-sharing would be valuable to further promote the development of car-sharing practices. Changing existing mobility practices to further the occasional use of cars, meaning, for example, increased walking, biking, public transport, home deliveries, or work-from-home solutions, would pave the way for acceptance of access-based models by travelers, operators, and planners. This implies that interventions should thus not only be directed at car-sharing per se, rather it should be on urban mobility in general with associated infrastructure, business models, and social norms towards changing the daily use of cars.

This study has implications for transition studies and social practice theories because it demonstrates how an elemental approach of shared and actor-specific elements is useful for showing how changes in emerging practices relate to existing systems. The approach can be useful to map how actors react to changes in regulations, business models, or social norms and values. Future research should develop the framework further, examining connections to neighboring practices and applying them to other empirical topics, such as EVs or other areas involving relations between technology and policy and interventions dealing with interconnections between the shared and actor-specific elements.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Disclosure statement

The authors report no potential conflict of interest.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

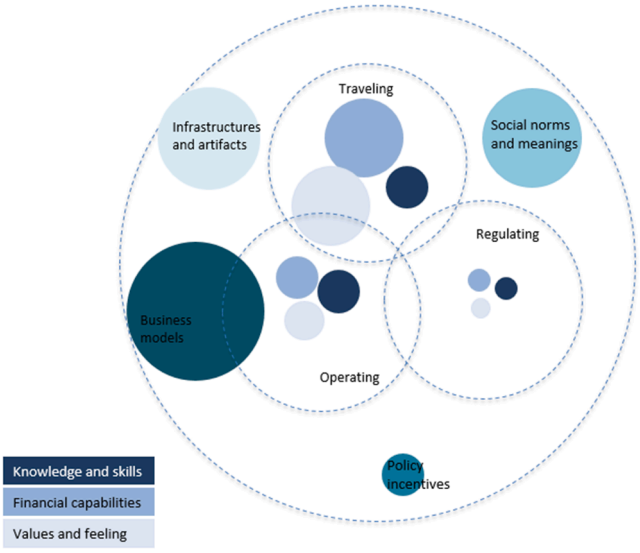

Fig. 4. Changes in elements Oslo.

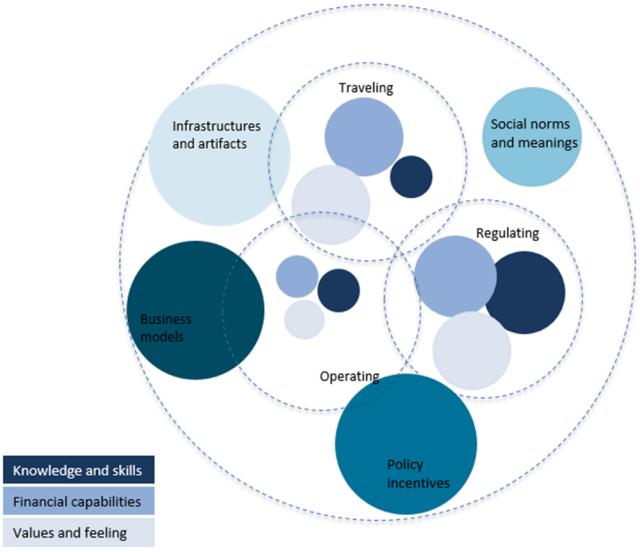

Fig. 5. Changes in elements Malmö.

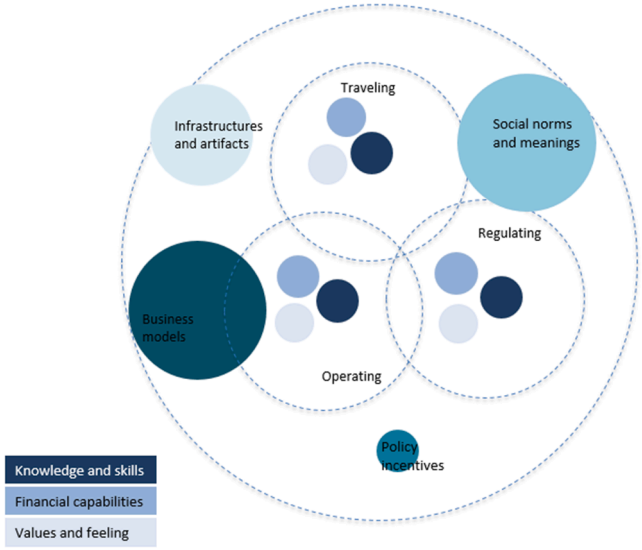

Fig. 6. Changes in elements Rotterdam.

Shared elements

	Business models	Infrastructure and artifacts	Policy incentives	Social norms and meanings
Oslo	2	1	0	1
Malmö	2	2	2	1
Rotterdam	2	1	0	2

Summary of scores in shared elements

Actor-specific elements

	Knowledge and skills	Financial capabilities	Values and feelings
Oslo: traveling	1	2	2
Oslo: operating	1	1	1
Oslo: regulating	0	0	0
Malmö: traveling	1	2	2
Malmö: operating	1	1	1
Malmö: regulating	2	2	2
Rotterdam: traveling	1	1	1
Rotterdam: operating	1	1	1
Rotterdam: regulating	1	1	1

Summary of scores in actor-specific elements

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