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TOPICAL REVIEW

The sharing economy is not always greener: a review and consolidation of empirical evidence

Tamar Meshulam[1,2,*], Sarah Goldberg[2], Diana Ivanova[3] and Tamar Makov[1,2,*]

[1] Guilford Glazer Faculty of Business and Management, Ben Gurion University of the Negev, Beer Sheva, Israel
[2] The Goldman Sonnenfeld School of Sustainability and Climate Change, Ben Gurion University of the Negev, Beer Sheva, Israel
[3] School of Earth and Environment, University of Leeds, Leeds, United Kingdom
[*] Authors to whom any correspondence should be addressed.

E-mail: mtamar@post.bgu.ac.il and makovt@bgu.ac.il

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Abstract

The digital sharing economy is commonly seen as a promising circular consumption model that could potentially deliver environmental benefits through more efficient use of existing product stocks. Yet whether sharing is indeed more environmentally benign than prevalent consumption models and what features shape platforms' sustainability remains unclear. To address this knowledge gap, we conduct a systematic literature review of empirical peer reviewed and conference proceeding publications. We screen over 2200 papers and compile a dataset of 155 empirical papers, and consolidate reported results on the environmental impacts of the sharing economy. We find that sharing is not inherently better from an environmental perspective. The type of resource shared, logistic operations, and the ways in which sharing influences users' consumption more broadly affect environmental outcomes. Sharing goods is generally associated with better environmental outcomes compared to shared accommodations or mobility. Within mobility, shared scooters and ride-hailing emerge as particularly prone to negative environmental outcomes. Contrary to previous suggestions, peer-to-peer sharing (vs. centralized ownership) does not seem to be a good proxy for environmental performance. As sharing becomes intertwined with urbanization, efforts to steer digital sharing towards environmental sustainability should consider system levels effects and take into account platform operations as well as potential changes in consumer behavior.

1. Introduction

Swift innovation and broad adoption of information and communication technologies have facilitated the emergence and expansion of a digital sharing economy in which individuals can become suppliers in multisided markets and share their underutilized assets with peers (Botsman and Rogers 2011, Sundararajan 2017, Schor 2021, Schor and Vallas 2021). Though sharing of underutilized assets is not new, the internet has allowed sharing to expand beyond existing social networks of friends and family and turn into a market phenomenon (Belk 2014, Schor 2014, Einav *et al* 2016, Richards and Hamilton 2018, Curtis and Mont 2020, Makov *et al* 2023). The digital sharing economy has grown significantly from $15 billion in 2014 to $113 billion in 2021, and is expected to reach $600 billion by 2027 (Statista 2023). Digital sharing platforms have proliferated into almost every domain of consumption.

The digital sharing economy (sharing economy hereafter) is a broad and somewhat ambiguous concept encompassing a wide variety of activities and domains under the circular economy. Frenken and Schor (2017), define the sharing economy as consumers granting each other temporary access to underutilized physical assets, while Hamari *et al* (2016) focus on how technology simplifies the act of sharing physical and non-physical assets. While these definitions suggest that sharing is a predominantly peer-to-peer (P2P) activity, others also include product service systems (PSSs: Tukker 2015) under sharing's definition (Acquier *et al* 2017). Aiming to understand the environmental impacts of the social phenomena which is the sharing economy we adopt Acquier's definition and focus on digital sharing of physical assets. From that perspective the sharing economy lies at the intersection of three foundational ideas: the ***access economy***, which optimizes the use of underutilized assets; the ***platform economy***, which supports decentralized exchange between peers through digital platforms; and the ***community-based economy***, which facilitates non-hierarchical and non-monetized exchange.

From its outset, the sharing economy was expected to disrupt traditional consumption and production systems, by severing the link between ownership and access (Heinrichs 2013, Sundararajan 2017). Similar to PSS, the sharing economy is commonly thought to deliver environmental benefits through better utilization of existing product stocks (Botsman and Rogers 2011, Heinrichs 2013, Nijland and van Meerkerk 2017, Makov *et al* 2020). As a wedding dress is typically used only once, by increasing its use intensity and allowing it to serve more than one bride, we expect demand for new dresses to decline. Equally, the average passenger vehicle is parked 95% of the time (Shoup 2021). Using a shared vehicle could cut down idle time and increase its use intensity. As a result, a single car could potentially fulfill the travel needs of several families, which would then reduce the need to produce more cars (Liimatainen *et al* 2018, Pauliuk *et al* 2021).

But while intuition suggests that sharing is inherently more environmental, research implies this is not necessarily the case. First, consumer adoption may have unexpected consequences. For example, sharing might not displace the product it is expected to, but rather undercut more environmentally friendly options. For example, when someone who usually walks to work instead takes a shared electric scooter, GHG emissions would increase rather than decrease (Buehler *et al* 2021). In addition, the cost savings offered by sharing platforms can affect users' general consumption patterns (a phenomenon often referred to as rebound effect). For instance, when Airbnb is cheaper and more convenient than a hotel, people can afford longer, more frequent trips (Tussyadiah and Pesonen 2015).

Second, additional products and services may be required to support the operations of sharing platforms. Shared wedding dresses need to be transported and cleaned between users. So, while the production of dresses may in theory decline, demand for cleaning services and transport would increase, eroding some or even all of the environmental benefits of avoided dress production (Zamani *et al* 2017). Finally, economic incentives to participate in the sharing economy may raise demand for durable products and subsequently reduce their use intensity. To illustrate, when a residential apartment is converted into a full-time vacation unit instead of being leased out via Airbnb only when its owner is away on a planned trip, use intensity would decline rather than increase. As these examples illustrate, the potential environmental implications of sharing may not be straightforward.

In an attempt to resolve some of these tensions Curtis and Mont (2020) suggest that the following platform features increase the likelihood that platforms would have beneficial environmental impacts: (1) operating as a two-sided, P2P market; (2) sharing idle resources or existing stocks; (3) promoting access over ownership; and (4) minimizing economic incentives that could increase consumption. Beyond platforms features, several have noted that research design features, including the system boundaries and inclusion of higher order effects such as displacement and the need for supportive platform operations could also meaningfully influence assessments of platform sustainability (Frenken and Schor 2017, Iran and Schrader 2017, Zink and Geyer 2017, Sun and Ertz 2021b).

While several reviews examine the sharing economy, most touch on the subject of sustainability very briefly if at all and a few reviews specifically mention the evaluation of environmental impact as a gap (Laurenti *et al* 2019, Mukendi *et al* 2020, Sun and Ertz 2021b). Domain specific reviews in fashion (Mukendi *et al* 2020, Henninger *et al* 2021), micro-mobility (Zheng and Li 2020, Orozco-Fontalvo *et al* 2023), and ride-hailing (Tirachini 2020, McKane and Hess 2023) are important sources of knowledge, but they do not break the domain silo, nor do they address the mechanisms that drive and affect environmental outcome of sharing.

Further complicating the situation is the wide range of consumption domains, disciplines, and methods used to study sharing, from environmental science through management and business models, to mobility, fashion and tourism, make it extremely challenging to integrate findings and gain meaningful insights. For example, some papers report changes in consumer behavior (e.g. what type of transport mode bike sharing replaces or how vacation patterns change due to Airbnb), while others report results in terms of GHG emissions or even a full set of life cycle analysis (LCA) environmental indicators. Furthermore, even within LCA studies there is great variation in functional unit and system boundaries such that one study examines the impacts of lifelong use of child strollers, another explores the impacts of renting clothes and a third examines emissions per km driven.

In sum, evidence on the environmental impacts of sharing is currently fragmented and a better understanding of the features which shape the environmental performance of sharing platforms is needed. Building on existing literature, we examine the evidence base on the environmental performance of the digital sharing economy and identify the key features which shape environmental outcomes. To this end, we conduct a systematic literature review, screening over 2200 papers and synthesizing the results of 155 empirical studies that specifically assess environmental impacts of digital sharing. To the best of our knowledge this work presents the first attempt at an organized consolidated synthesis of published empirical findings on the environmental impacts of the sharing economy.

2. Methods

To assess the environmental performance of the sharing economy and identify the features and conditions under which sharing is environmentally preferable to prevalent consumption modes (e.g. private ownership), we performed a systematic literature review. After searching for relevant papers (see section 2.1), results were screened following predetermined inclusion and exclusion criteria (see section 2.2), we compiled a dataset of 155 relevant empirical papers which report findings in terms of environmental impact (e.g. GHG emissions, water depletion) or behavioral changes from which environmental impacts can be directly derived (e.g. a shift from walking to shared scooter rides).

Since the papers included in our dataset reported environmental outcomes using different measures and impact categories (e.g. behavior change, kg CO_2eq) we first had to convert the reported results into a uniform index of environmental impact. Our research team examined the full text of all papers and manually assigned each an environmental impact score: negative, mixed or positive. We then classified papers based on platform related and research related features (see section 2.3 and table 3), and examined whether these features affected environmental impact scores using ordinal probit regression and descriptive analyses (see section 2.4). The full dataset is available in the supporting information (SI).

2.1. Paper search

Papers for this review were retrieved from Web of Science (WoS) and Scopus. The basic search string was constructed based on previous sharing economy reviews, and limited to peer-reviewed studies and conference proceedings in English, published between 2004 and 2022. The basic search string was refined in an iterative process to specifically target papers on environmental performance and digital sharing platforms using titles, keywords and abstracts (see table 1). The final string was composed of four sub-strings which covered sharing economy and sharing economy platforms across different consumption domains (search sub-strings A, B, C, and D), and one sub-string honing in on environmental impacts. The search string can be expressed with Boolean Operators as:

((A or B or C or D) and E).

2.2. Paper screening, inclusion and exclusion criteria

Finding 1659 papers in WoS and 1858 in Scopus, we downloaded the results as reference files. Duplicates were removed using Python code, which left 2255 papers. We then screened papers first by their title and abstract, and then by reading the full text ($N = 460$). Removing any remaining duplicates, we compiled the final dataset which included 149 relevant papers as well as 6 additional papers that were highly cited by others, yet did not come up in the search (see figure 1).

The PICO framework helps to define the inclusion criteria used in this review. The study population (P) includes platforms catering to consumers and private households. The intervention (I) includes any physical consumption mediated by the digital sharing economy. To clarify, activities such as knowledge transfer are excluded. Eligible studies must compare (C) the sharing economy to prevalent consumption modes and report outcomes (O) in terms of environmental impacts or behavioral changes from which environmental impacts can be easily derived. We include both qualitative and quantitative studies, as long as they include an empirical analysis. Table 2 provides a detailed explanation of inclusion and exclusion criteria.

2.3. Data preparation for analysis

Data perpetration for analysis included two main stages: assignment of environmental impact scores and classification by features related to the platforms' studied or papers' research design.

The papers in our final dataset included work from a wide range of disciplines, and thus reported results using different measures (e.g. number of people not buying a car, or kg of CO_2eq per km of bike ride). To consolidate the empirical body of knowledge and assess the environmental impacts of the sharing economy enable an analysis of all papers, the research team therefore examined the full text and manually assigned each paper an environmental impact score, ranging from negative, through mixed to positive. Note that we did not evaluate the scientific quality of the papers nor their methods. Thus, the environmental impact scores reflect the reported results as written up by each paper's original authors.

Table 1. Sub-queries used in screening.

Name	Used to identify	Query
A	Sharing economy and domain specific sharing economy terms	'sharing economy' OR 'shared economy' OR 'collaborative consumption' OR 'collaborative economy' OR 'gig economy' OR 'access based consumption' OR 'access economy' OR 'peer to peer consumption' OR 'community based economy' OR 'rental economy' OR 'on demand economy' OR 'platform economy' OR 'p2p economy' OR 'peer* economy' OR 'car sharing' OR 'carsharing' OR 'ride sourcing' OR 'ridesourcing' OR 'ride sharing' OR 'ridesharing' OR 'ride hailing' OR 'ridehailing' OR 'mobility sharing' OR 'shared mobility' OR 'mutualized mobility' OR 'mutualised mobility' OR 'vehicle sharing' OR 'bike sharing' OR 'bicycle sharing' OR 'scooter sharing' OR 'shared e-scooters' OR 'collaborative fashion' OR 'clothes sharing' OR 'food sharing' OR 'meal sharing' OR 'tool sharing' OR 'space sharing' OR 'accommodation sharing' OR 'P2P accommodation' OR 'peer* accommodation' OR 'home sharing' OR 'goods sharing' OR 'item sharing' OR 'library of things'
B	Mobility sharing economy platforms	Uber OR Lyft OR Didi OR BlaBlacCar OR Ola
C	Accommodation sharing economy platforms	Airbnb OR HomeAway OR XiaoZhu OR Couchsurfing
D	Goods sharing platforms	RentMyWardrobe OR DesignerShare OR 'Rent the Runway' OR Olio
E	Environmental impacts	('environmental impact*' OR 'environmental benefit*' OR 'carbon emissions' OR 'greenhousegas*' OR 'greenhouse gas*' OR GHG* OR 'sustainability' OR 'rebound effect*' OR 'Life cycle assessment' OR LCA OR 'carbon footprint' OR 'climate change mitigation' OR 'co2 emission*' OR 'emission* reduction*')

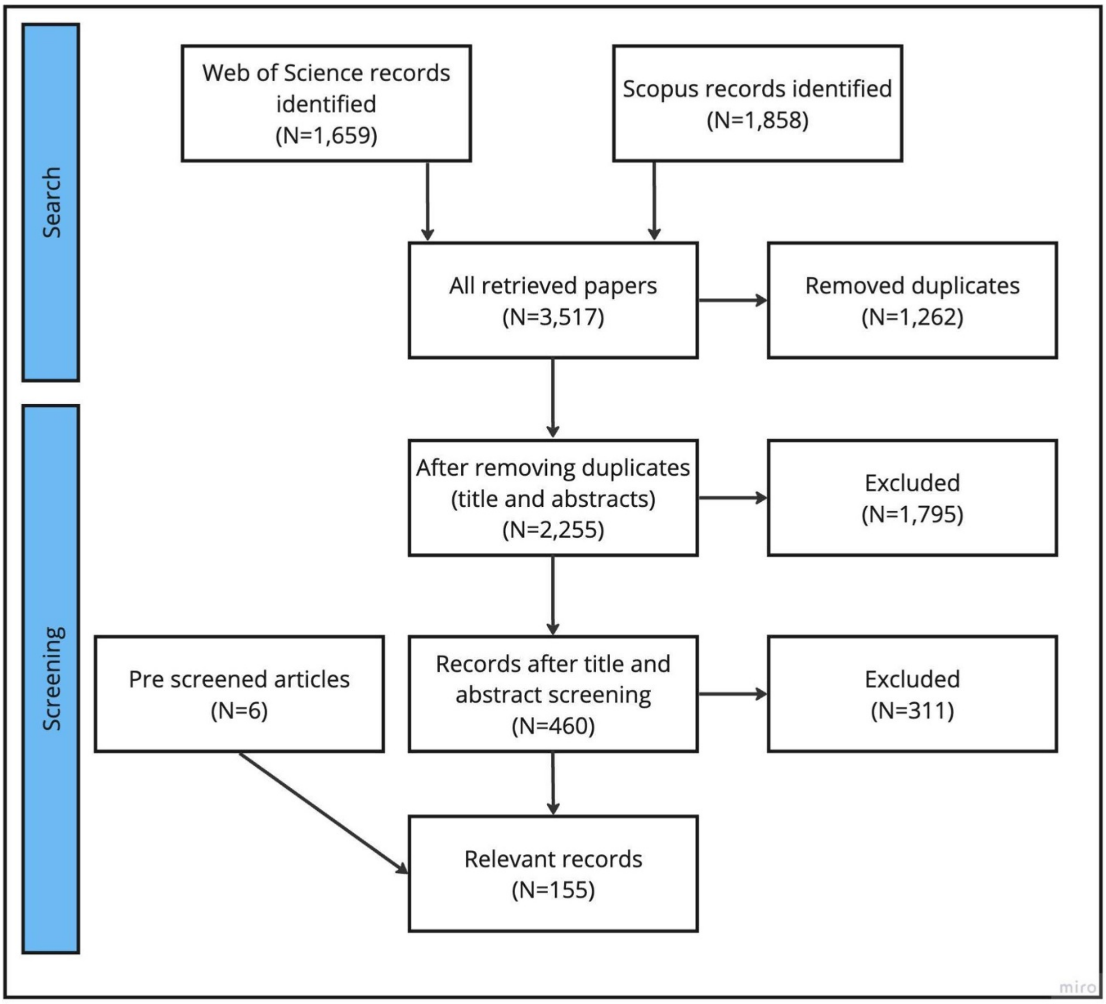

Figure 1. Flow diagram: the number of papers included in each stage is presented in parenthesis.

Table 2. Eligibility PICO used as screening criteria for studies.

Screening criteria	Inclusion criteria	Exclusion criteria
Population (P)	Sharing economy platforms catering to the consumers, be it individuals or households.	Sharing economy implemented between businesses and enterprises (Grondys 2019).
Intervention (I)	Digitally facilitated sharing of durable goods (e.g. shared scooters, fashion sharing)	Non-digital forms of sharing such as sharing within households (Ala-Mantila *et al* 2016) Non-physical forms of sharing, such as knowledge and time sharing (Pang *et al* 2020)
Comparator (C)	Compare the sharing economy to prevailing consumption patterns (i.e. ownership based).	Sharing economy of emerging technologies (e.g. autonomous vehicles (Liao *et al* 2021)) Comparing pooled ride-hailing to regular ride-hailing (Cai *et al* 2019) or to taxis (Sui *et al* 2019) Improving sharing platform algorithms (Luo *et al* 2020, Zhang *et al* 2020). Effect of COVID on the sharing economy (Hossain 2021)
Outcome (O)	Studies report environmental impacts or behavioral changes from which environmental impacts can be derived.	Studies report perception of the sustainability of the sharing economy (Puspita and Chae 2021, Laukkanen and Tura 2022). Studies report user characteristics or motivation for participation in the sharing economy (Böcker and Meelen 2017, Kostorz *et al* 2021, Nguyen-Phuoc *et al* 2022).

Next, papers were classified based on different features which could potentially affect environmental outcomes. These include platform related features such as the type of product shared (i.e. sharing domain), sharing model, and product ownership structure, as well as research design features such as the type of impact examined (environmental impacts or consumption changes with relevance for environmental outcomes), the scope of the analysis (i.e. product level or sector level analyses), and whether added platform operations or displacement were considered. Added operations refer to activities required to support platform operations. Within shared fashion this would be added transport and cleaning services, while in mobility operations may include Uber trips with no passengers (also known as 'dead-head' miles), or rebalancing bike stocks between different locations. Displacement refers to studies that examined the specific consumption pattern that sharing displaced, for example, determining the transport mode one would use if car-sharing were not available (also known as modal shift).

Table 3 presents a detailed description of all features considered in our analysis. A list of all papers included in our review, their classifications and their assigned environmental scores is available in the SI.

2.4. Analyses

Common guidelines for synthesizing papers which report environmental impacts suggest statistically examining heterogeneity in reported results (Collaboration for Environmental Evidence Synthesis Assessment Tool, see Woodcock *et al* 2014). This includes statistically evaluating potential reasons for heterogeneity in the reported environmental outcomes. Similar to prior studies (e.g. Ivanova *et al* 2020 Galante *et al* 2023) we examined potential sources of heterogeneity such as platform or study design features (i.e. effect modifiers) which could potentially affect reported results of the sharing economy's environmental performance in comparison to prevailing consumption patterns.

In our analysis, we used an ordinal probit regression model to examine whether features significantly affected reported results as well as the direction of this effect. Reported results (the dependent variable) were coded as negative (1), mixed (2) or positive (3) according to the environmental impact score they were assigned. The features examined (the independent variables) were entered into the regression based on data availability and theory. Specifically, we gave preference to features which theory suggests would affect the environmental performance of sharing, including the sharing domain, region, the ownership model, the studies' system boundaries, and the inclusion (or lack thereof) of added operations and displacement. Other features, although of interest, were excluded due to small sample sizes (e.g. there were only 3 not-for-pay platforms in our dataset). All categorical predictors were entered as dummy variables into the regression. Across all regression models, we differentiated between shared transport types, while keeping accommodations and good sharing as

Table 3. Features examined for empirical papers. Features are organized by those related to the platform and its operations, and those related to the research design.

Feature related to	Feature	Description and categories
Platform	Domain	The type of product shared: shared accommodation; goods sharing and different shared mobility variants. In shared mobility, papers are split between bike sharing, scooter sharing and different car sharing schemes. One important distinction is between car sharing, which allows users to gain access to a vehicle (e.g. car2go, Zipcar), and different modes which allows users to travel to their destination in a car with a driver. Ride-hailing is the most common form of on-demand transportation services (e.g. Uber, Lyft, which can be for one client or pooled between several clients). Ride-sharing is for drivers and passengers with similar origin-destination pairs. For further discussion on the different shared mobility types see Zhu *et al* (2023). **Note:** Papers could be assigned to more than one domain depending on their content, as a result total N is larger than total number of papers.
	Region	Region or regions of the platforms studied (Asia, Europe, North America and others) **Note**: Papers could be assigned to more than one region.
	Sharing model	For pay, For free
	Resource ownership structure	Who owns the stock: centralized ownership—Business to consumer (B2C, also referred to as product service systems) or decentralized—Peer-to-Peer (P2P, also referred to as Consumer to Consumer)
	Platform size	Defined according to market valuation. Small (under \$1 million), Medium (above \$1 million, bellow \$1 billion), Large (over \$1 billion)
Research design	Data source	Platform data—provided by sharing platforms Platform users' data—provided by sharing platforms' users Public data existing platforms—using public data (e.g. national surveys) Public data theoretical platforms—using public data (e.g. national surveys)
	System boundaries	Product—how a shared item compares to a prevalent consumption item. (e.g. shared dress vs. owning a dress); Sector—how a shared item affects the entire sector (e.g. using ride-hailing affects transportation choices including public transport and walking); Entire economy—how a shared item affects several/all sectors
	Type of impact examined	Change in consumer behavior—research reports behavioral change and environmental impacts can be assumed by readers; GHG emissions—research reports expected change in GHG emissions; Environmental impact—research reports GHG as well as other impact categories such as water depletion, land use etc.
	Added operations	Whether methods took added platform operations (e.g. rebalancing and charging for bikes and scooters, dead-head miles/km for cars, added transport and cleaning for fashion) into account, explicitly including it within the system boundaries.
	Displacement	Whether methods took displacement (e.g. modal shift in mobility, comparison to hotels in accommodation) into account, explicitly including it within the system boundaries.

separate groups given their smaller sample size. In Models 1–5, Goods served as the base category for comparison between subdomains, while in Model 6 which focused solely on shared transport, shared bikes served as the base category. To verify that our main findings were robust to the regression specifications, we repeated the analysis using alternative regression models (see SI).

Finally, in some cases the sample size limited our ability to test for interaction effects between different features (e.g. subdomain and region). Therefore, to dig in deeper and tease out underlying trends we also conducted a descriptive analysis of environmental impact scores. Of particular interest were potential differences between sharing domains which we thus further explored.

3. Results

We find that research into the environmental impacts of the digital sharing economy has grown substantially over the past few years. The geographical location of platforms studied is split between Europe, Asia, and Northern America, with China and the United States of America as most popular origins on a country level (see figure 2). While mobility is widely studied ($N = 148$), papers on goods and accommodation sharing remain scarce ($N = 15$, $N = 8$). Goods

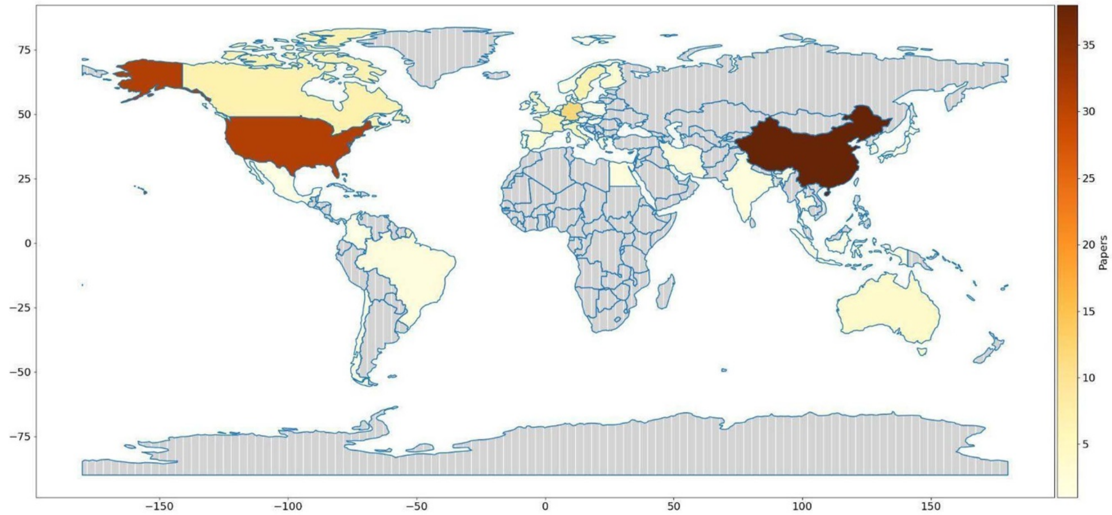

Figure 2. Geographical distribution of platforms: Europe 59; Asia: 46 papers; North America: 40; South America: 4; Australia: 3; Middle East: 3.
Note: Some papers could be assigned to more than one region depending on their content.

sharing covers a wide range of resources including food, apparel, electronics, and tool libraries, while research on accommodation sharing is predominantly focused on Airbnb ($N = 6$ out of 8 papers). In shared mobility, passenger vehicles are the most well studied ($N = 83$: car sharing $N = 40$, ride-hailing $N = 28$, and ride-sharing $N = 15$), followed by bikes ($N = 48$) and scooters ($N = 17$).

A descriptive analysis of environmental impact scores across all papers revealed conflicting results—while about half of the papers reported that sharing is environmentally preferable to prevalent consumption modes (50%), over a third reported the opposite (34%), and the remaining reported mixed results (16%). Placing these results on a chronological axis reveals that the share of negative and mixed results increased over time (figure 3(a) and table SI-6).

3.1. Platform and research related features

Results and specifications for the different regression models are presented in table 4. Descriptive statistics are available in tables SI-6 through SI-18. We find significant differences in environmental performance of sharing platforms across subdomains across all regression models. Specifically, studies on ride hailing and scooter sharing (Models 1–5, $p < .001$), along with papers on accommodations (Models 1–3, and 5) were more likely to report negative environmental impacts compared with studies on goods sharing ($p < .001$). Differences between subdomains are also evident in the descriptive analysis (see figure 3(b), table SI-8, and a more detailed overview in section 3.2 below).

Despite theoretical predictions, platform location and ownership model (P2P vs. B2C) did not significantly affect the likelihood to be assigned a specific environmental impact score (see regression Models 1 and 2 respectively). Descriptive analysis of these features did not present interesting results for platform region, but did reveal that papers on decentralized platforms where peers share with other peers are more likely to report negative outcomes (57% negative for P2P vs. 33% in B2C platforms, see figure 3(d) and table SI-9). Interestingly, 62% of papers on larger platforms reported negative results compared to only 21% of papers on smaller or medium platforms (figure 3(c) and table SI-11). Since, however, only 64 papers could be assessed in terms of platform size the sample size precluded a regression analysis.

To understand if and how research design choices affect reported results, we also examined different features related to study design. Contrary to our expectations, system boundaries, whether papers looked at the level of product, sector, or entire economy, did not significantly affect the likelihood that a paper would report positive or negative findings (see reg. Model 3). In contrast, accounting for platform operations emerged as statistically significant across all relevant models (Models 4–6, $p < .001$) and increased the likelihood that papers would report negative findings (53% negative when accounting for operations vs. 25% without, see figure 3(e) and SI table SI-16). Choice of data source displayed more negative results for public data on existing platforms (50%) compared to public data on theoretical platforms (13%, see figure 3(f) and table SI-12), though here too sample size was too small to support a regression given the 4 different source types.

When examining papers from all sharing domains, accounting for displacement did not significantly affect results. Yet we did find a main effect of displacement when including an interaction between displacement and the mobility sub domain (Model 6, $p = 0.019$). However, these results were sensitive to

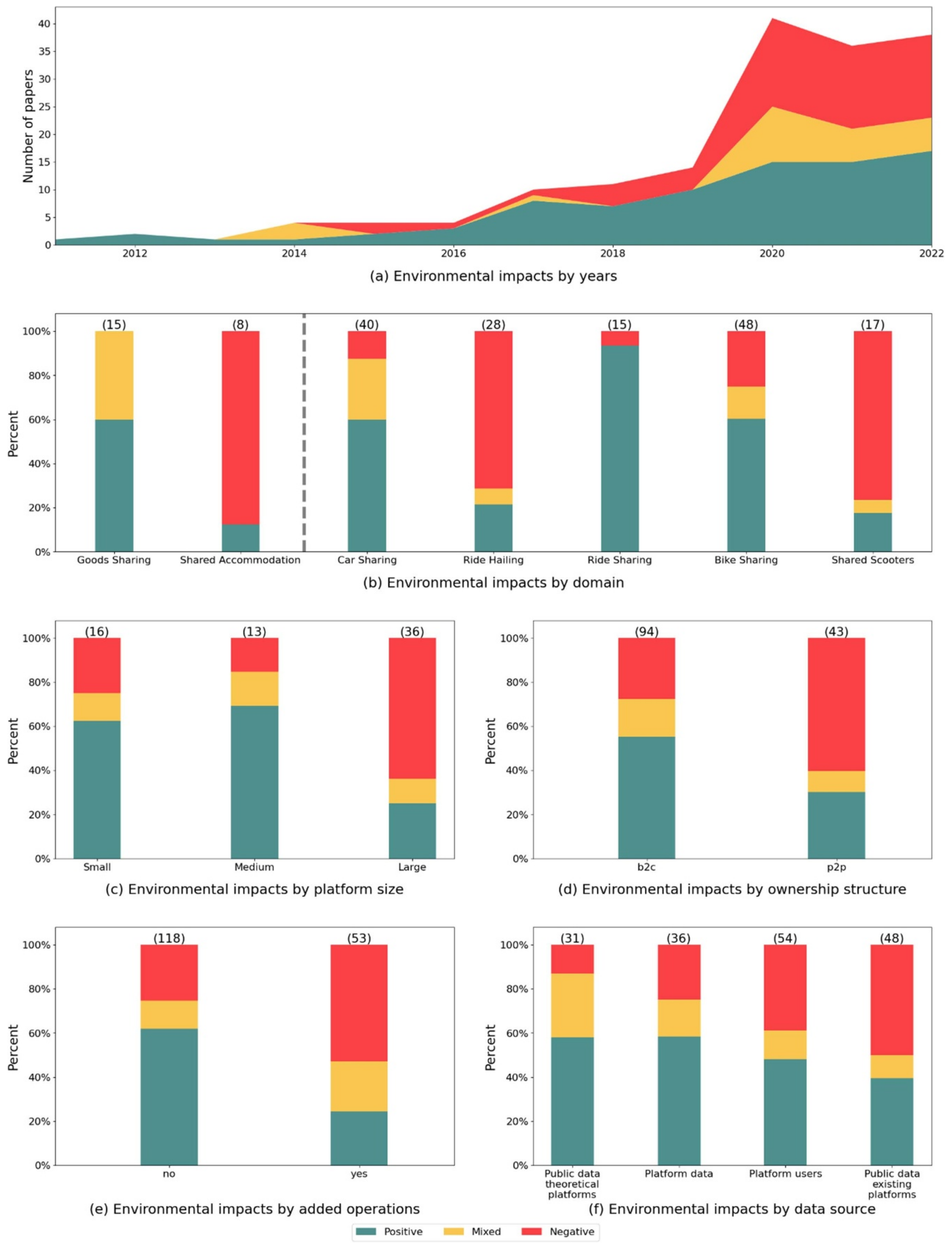

Figure 3. Environmental Impact score frequency by feature. (a) Absolute numbers over the years (b)–(f) Relative values of selected platform and research features. Numbers in brackets over the columns refer to the absolute number of studies within the specific category. See SI for tabular representation.

the choice of baseline category and should therefore not be seen as robust. A descriptive analysis of displacement suggests that there are differences between subdomains (see table SI-17). Negative results were more common in ride hailing papers that included displacement vs. those that did not, as many platform users substituted walking and public transportation for ride-hailing (Rayle *et al* 2016, Clewlow and Mishra 2017, Alemi *et al* 2018, Afroj *et al* 2019, Gehrke *et al* 2019, Lee *et al* 2019, Tirachini *et al* 2020, Schaller 2021). In contrast, within bike sharing displacement seemed to positively affect reported results, as some of the shared bike rides would displace more carbon intensive transport modes. Within car sharing, displacement had mixed results, depending on user profiles. For car dependent users, participating in

Table 4. Environmental impact score by platform and research related features.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6 (Transport only)
Sub domain						
Goods	*Baseline*	*Baseline*	*Baseline*	*Baseline*	*Baseline*	—
Accommodations	−2.322***	−6.080	−2.106***	−3.349***	−3.337***	
Bike sharing	−0.298	−0.902	−0.420	−0.931*	−0.953**	*Baseline*
Scooter sharing	−1.692***	−2.263***	−1.906***	−2.308***	−2.331***	−4.377 (2.933)
Car sharing	−0.201	−0.775	−0.238	−1.319**	−1.321***	0.825 (−1.563)*
Ride sharing	0.898	0.278	0.799	−0.001	−0.003	6.504 (−6.395)
Ride hailing	−1.714***	−1.864***	−1.618***	−2.722***	−2.721***	−1.071 (−0.673)
Region						
Asia	*Baseline*		—			—
North America	0.021					
Europe	−0.125					
Other	0.539					
Multiple	−0.653					
P2P vs. B2C		−0.525	—	—	—	—
System boundaries		—	0.192	—	—	—
Added operations (Included vs. not)		—	—	−1.532***	−1.518***	−1.451***
Displacement (Included vs. not)		—	—	—	0.062	1.105*
Observations	$N = 167$	$N = 137$	$N = 170$	$N = 171$	$N = 171$	$N = 148$
LR chi^2	63.84	56.63	61.78	95.89	95.96	87.84
Prob > chi^2	.0000	0000	.0000	.0000	.0000	.0000
Pseudo R^2	0.1912	0.2062	0.1819	0.2793	0.2795	0.3008

$^*p < 0.05$; ** $p < 0.01$; *** $p < .001$; In parenthesis we report the beta coefficients of the interaction between displacement and the domain.
Table presents coefficient and significance of features' effect on environmental impacts score (the dependent variable) for ordinal regression models 1–6.

car sharing lowered emissions but for car free users, car sharing increased emissions (Arbeláez Vélez and Plepys 2021, Martin and Shaheen 2008, Wang *et al* 2022).

3.2. Environmental impact score by domain and sub-domain

Research on goods sharing mostly reports environmental benefits from increased use intensity of underutilized products (Martin *et al* 2019, Schneider *et al* 2019, Makov *et al* 2020, Wasserbaur *et al* 2020, Kerdlap *et al* 2021), though some of these may be eroded as more intensive use may shorten product lifespan (Retamal 2017, Zamani *et al* 2017, Schneider *et al* 2019). In addition, as evident from the regression results, some of these benefits can also be eroded as goods sharing often requires supportive logistic operations which may increase demand in other sectors, such as transportation and cleaning leading to problem shifting (Amasawa *et al* 2020, Behrend 2020, Makov *et al* 2020, Johnson and Plepys 2021, Kerdlap *et al* 2021).

While shared accommodation research is very limited ($N = 8$), two key findings emerge. First, leasing an entire apartment is more common than the more environmentally benign option of leasing a room in an otherwise occupied dwelling, with Airbnb consisting over 5% of housing stock in the cities reviewed (DiNatale *et al* 2018, Stergiou and Farmaki 2020, Muschter *et al* 2022). Second, Airbnb and shared accommodations might not displace hotel stays and instead may induce additional travel as lower prices allow users to take more frequent and longer vacations (Tussyadiah and Pesonen 2015, Farronato and Fradkin 2018, Sainaghi and Baggio 2020). Taken together, reports of reduced use intensity, and induced consumption suggest that shared accommodation increases rather than reduces environmental impacts.

Bike sharing papers ($N = 48$) report mostly positive results. Contrary to intuition, shared bikes are less efficient compared to private bikes, to a great degree because of an increase in bicycle stocks, but also because of platform operations (Ma *et al* 2018, Luo *et al* 2019, Chen *et al* 2020, Sun and Ertz 2021a, Wang and Sun 2022). In bikes, environmental benefits can also stem from bikes displacing private cars and results are predominantly positive in papers reporting bike displacement to cars (according to surveys around 20%: Lu *et al* 2017, Chen *et al* 2020, Lai *et al* 2021, Suchanek *et al* 2021, Cheng *et al* 2022), though these benefits are sensitive to the assumed displacement patterns (Kou *et al* 2020, Li *et al* 2020, Zhi *et al* 2022). However, when added operations (i.e. bike rebalancing) are accounted for, results shift becoming more negative (Sun and Ertz 2021a, Reck et al 2022, Wang and Sun 2022). Accounting for added operations, Li et al (2020) pinpoint the displacement tipping point at which bike sharing reduces emissions suggesting that at least 30% of shared bike rides should displace car rides. So, while bike sharing has potential to reduce environmental impacts, current papers which do not take platform added operations into account might overestimate the benefits.

In shared scooters, 13 out of the 17 papers report negative results mostly due to scooter's short lifespan and the high environmental costs associated with their production, as well as the emissions associated with their rebalancing and charging (Hollingsworth et al 2019, Moreau et al 2020, Severengiz et al 2020).

Most papers on car sharing ($N = 40$) report positive findings (60% positive vs. 13% negative), arising from modal shift (Lane 2005, Amatuni et al 2020) and reduced car ownership (Firnkorn and Müller 2011, Clewlow 2016, Nijland and van Meerkerk 2017, Becker et al 2018, Mishra et al 2019, Chapman et al 2020). However, in many papers the improvements are not directly related to sharing but rather related to newer or smaller cars (Cervero and Tsai 2004, Namazu and Dowlatabadi 2015), moving to electrical cars (Chicco and Diana 2021) or both (Fernando et al 2020, Migliore et al 2020).

Ride-hailing papers ($N = 28$) tend to report negative results, mainly due to users displacing low emissions modes of transport such as walking and public transportation (Rayle et al 2016, Tirachini et al 2020, Schaller 2021, Shi et al 2021), induced travel (Rayle et al 2016, Gehrke et al 2019) and added operations in the form of dead-head miles, where drivers drive around to pick up passengers potentially doubling the distance traveled (Oviedo et al 2020, Tirachini et al 2020, Schaller 2021). In contrast, ride-sharing papers ($N = 15$) predominantly report positive outcomes, mostly stemming from increased car occupancy (Ding et al 2019, Realini et al 2021, Sun and Ertz 2021a).

4. Discussion and conclusion

Despite widespread adoption of sharing platforms, high market valuation, and controversies over emerging regulation (Sell 2021), empirical evidence on the environmental impacts of sharing remains limited. Our extensive review and consolidation of the existing body of work suggests that the common assertion that the digital sharing economy is more environmentally benign by nature is not sufficiently grounded in empirical evidence. Synthesizing findings reported in the existing literature we see that different features, including added platform operations and the way sharing affects consumer behavior, play a pivotal role in shaping the realized environmental effects of sharing platforms.

4.1. Sharing, use intensity, and environmental impacts

The expectation that sharing would relieve environmental burdens weighs heavily on the notion that sharing, like other access-based economy models (Tukker 2015), increases use intensity and enables the provision of a fixed amount of utility with smaller product stocks. Yet despite intuition, sharing does not necessarily reduce stocks (e.g. fleet size or the number of vehicles used overall), as illustrated by research on ride-hailing (Gong et al 2017, Zhang and Zhang 2018, Paundra et al 2020, Wadud and Namala 2022), and bike sharing (Ma et al 2018, Luo et al 2019, Chen et al 2020, Wang and Sun 2022). Furthermore, while sharing can potentially increase use intensity (Zhang and Mi 2018, Martin et al 2019, Schneider et al 2019, Amatuni et al 2020, Makov et al 2020, Wasserbaur et al 2020, Kerdlap et al 2021), it can also reduce use intensity, when for example, shared bikes and scooters are used less frequently than privately owned ones (Reck et al 2022) or when residential dwellings are converted into Airbnb vacation apartments (DiNatale et al 2018, Stergiou and Farmaki 2020).

Critically, measures of use intensity often reflect idle time which does not necessarily correlate with environmental impacts. Within mobility for example, 90% of GHG emissions are associated with the use phase rather than production (Allwood et al 2012). This means that GHG emissions are more a function of the passenger-km driven (Schäfer and Yeh 2020) than the number of cars on the road at any given time (i.e. fleet size). As such, reducing the number of cars should be coupled with increased passenger occupancy for it to effectively reduce environmental impacts (Amasawa et al 2020, Sun and Ertz 2021a).

4.2. Added platform operations

Yet even when sharing increases use intensity and reduces stocks, it might not deliver the expected reduction in environmental burdens. Added platform operations can offset some or even most of the expected benefits of increased use intensity. Kerdlap et al (2021) suggests that the added transport and cleaning services required in stroller sharing offset a large portion of the environmental benefits. Similarly, managing shared scooter and bike stock locations and moving them from one place to the other to meet users' demand in free floating systems can have substantial environmental impacts (Hollingsworth et al 2019, Li et al 2020).

Platform operation might also be related to platform size and help explain why larger platforms are generally associated with more negative environmental impacts where smaller ones do not. As platforms expand so does their geographic reach. Uber drivers might have to drive more dead-head miles between passengers or trucks rebalancing bikes will drive further. Relatedly, as platforms scale the economic incentive to participate might increase, and as a result sharing ceases to be a marginal activity of owners monetizing unused stocks and becomes closer to conventional markets instead. Recent work by Cansoy and Schor (2023), reveals that as Airbnb became more popular, frequently rented listings (essentially vacation apartments) started making up a larger share of its total listing supply.

These examples demonstrate how crucial it is for researchers to take a full system's perspective and incorporate platform operations in environmental assessments. Failing to go beyond simplistic single product comparisons may often result in a biased result which does not capture the full extent of environmental impacts.

4.3. Displacement and rebound effects

Changes in consumer behavior or in consumption patterns more broadly should also be taken into account as they can affect the environmental performance of sharing. First, sharing may not displace the products and services it is assumed to replace. For example, the literature on ride-hailing suggests that 21%–61% of trips did not displace car rides but more environmental modes of transport such as walking and public transportation (Rayle *et al* 2016, Clewlow and Mishra 2017, Alemi *et al* 2018, Afroj *et al* 2019, Gehrke *et al* 2019, Lee *et al* 2019, Tirachini *et al* 2020, Schaller 2021). Moreover, sharing may trigger added demand increasing overall environmental burdens rather than decreasing them. For example, Rayle *et al* (2016) reported that 8% of ride-hailing users surveyed would have otherwise stayed home, while Farronato and Fradkin (2018) reported that 42%–63% of nights booked on Airbnb would not have resulted in a hotel booking in the absence of Airbnb.

Second, sharing often saves users money which they then typically re-spend on additional products and services, a phenomenon referred to as re-spending or indirect rebound effect (Meshulam *et al* 2023). The rebound effect can occur when platform users save money (by collecting free food for example) and then use these savings to buy other things (Druckman *et al* 2011, Makov and Font Vivanco 2018, Sorrell *et al* 2020). Alternatively, rebound can emerge when owners in P2P (decentralized) platforms earn money by sharing their apartments (Cheng *et al* 2020) or when yacht owners spend only a portion of their money on maintaining yachts (Warmington-Lundström and Laurenti 2020). While research on sharing economy rebound effects remains scarce, the existing evidence from accommodations and goods sharing suggests that added consumption (or rebound effects) may negate a substantial part of the expected environmental benefits of sharing (Cheng *et al* 2020, Warmington-Lundström and Laurenti 2020, Meshulam *et al* 2023).

4.4. Limitations and future research

This review is limited to English papers only, and might be missing relevant non English papers. Moreover, given that our findings stem from extant literature, we can only draw conclusions on features widely researched. Consequently, our ability to draw insights on goods and accommodation sharing is limited due to the small number of papers. Similarly, while we did not find evidence that P2P platforms which operate as a two-sided market are necessarily better than platforms where resources are centrally owned (B2C platforms; Curtis and Lehner 2019, Curtis and Mont 2020), these results might be affected by research availability and confounded with other platform features such as domain and size, given the large number of papers on Uber and Airbnb. More work is needed to better understand the relationship between platform ownership and environmental impacts across a wider range of platforms and domains.

Future research should extend our findings and dive deeper into optimizing the sustainability benefits of the sharing economy. This is particularly important in light of growing interest in sharing among policy makers at the national and local level as well. Cities, in particular, have emerged as hubs for sharing. Past work has highlighted the major role that urban areas play in the growing popularity of the sharing economy. Davidson and Infranca (2016), for example, poise that 'platforms and networks that make up the sharing economy fundamentally rely for their value proposition on distinctly urban conditions'. Relatedly, Mont *et al* (2020) state that sharing in cities is 'particularly promising' from a sustainability standpoint. Indeed, urban features including high concentrations of economic activity, human population, consumption, and existing infrastructure, are thought to make urban areas exceptionally 'fertile breeding grounds' for sharing initiatives and innovations (Palm *et al* 2019, Mont *et al* 2020). Yet despite much interest in sharing as an urban phenomenon, as evident by the growing body of work focusing on urban governess of sharing activities (Davidson and Infranca 2016, Bernardi and Diamantini 2018, Akande *et al* 2020) the ways in which urban form affects sharing networks and the subsequent environmental impacts of sharing needs further exploration.

In a broader context, future research should also take into account rebound effects, growth imperatives, power imbalances, and the limitations imposed by capitalism, which hinder the potential for sharing, along with the commonly discussed concerns regarding greenwashing (Ivanova and Buchs 2023).

4.5. Conclusions

The sharing economy, along with the digital technologies it relies on, is a growing phenomenon, increasing its presence in everyday lives. Although our findings suggest that the sharing economy does not reduce environmental impacts by default, it is critical to note that it is not inherently negative either, and both platforms and their users could help make sharing more environmentally benign. Platforms can optimize their operations for minimal environmental impact (rather than costs alone). For example, platforms can optimize their stock rebalancing practices or place more emphasis on extending the lifespan of shared products through proper maintenance (Luo *et al* 2020, Severengiz *et al* 2020). In addition, platforms can strive to target specific consumer segments whose current consumption patterns are more environmentally intensive compared to sharing. Similarly, users can actively opt for more environmentally benign options such as waiting for shared carpooling (e.g. Uber pool) rather than single occupancy ride-hailing, forgoing dry cleaning of shared strollers, or deciding to collect free shared food only if it is within walking distance (Cai *et al* 2019, Makov *et al* 2020, Kerdlap *et al* 2021). Given growing interest in sharing as a sustainable consumption model, policy makers and sustainability advocates should push for more comprehensive analyses of sharing and how it can be optimized not only to reduce idle stock or scale up economically, but also on how sharing can be designed at the system level to minimize environmental impacts.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

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ORCID iDs

Tamar Meshulam https://orcid.org/0000-0002-4642-0655
Diana Ivanova https://orcid.org/0000-0002-3890-481X
Tamar Makov https://orcid.org/0000-0001-7345-5864

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