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Policy Paper

Making Smart Mobility Sustainable

How to Leverage the Potential of Smart and Shared Mobility to Mitigate Climate Change

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Beyond Carbon: Shaping the Transition to a Low-Carbon Economy
Perspectives from Israel and Germany

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Making Smart Mobility Sustainable

How to Leverage the Potential of Smart and Shared Mobility to Mitigate Climate Change

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Executive Summary

Smart and shared mobility are among the new mobility options entering the scene, often heralded as deliverers of sustainability and climate-change benefits. While supporters of these new technologies present them as aligning green consciousness with convenient mobility and new business opportunities, skeptical voices increasingly stress that these alternatives will place even larger greenhouse gas (GHG) outputs in the sector. This analysis aims to provide a comprehensive assessment of shared mobility options, by estimating marginal CO_2 emissions of various shared mobility modes and considering the factors that account for the wide range in their respective emissions. Findings reveal that high systemic energy efficiency in the form of proper and proportional use of all transportation modalities, in combination with high vehicle occupancy in usage are key determinants of making urban transport low-carbon. Moreover, the consideration of wider systemic effects, presented in this paper, proved to be crucial to identifying the overall climate change mitigation contributions (or potential damage). Only if shared mobility is effectively designed and focused on replacing private car trips and complementing rather than substituting public transport, can it contribute to achieving low-carbon mobility.

When combining these footprint investigations with an economic perspective, including profitability challenges faced by shared mobility companies, the findings indicate that the evaluated shared mobility models have little future in providing low-carbon sustainable mobility in the current array. Nevertheless, reason for optimism remains when focusing on traditional stationary carsharing and incorporating improved conditions and regulations. Results indicate that by these means, private car traffic and emissions can be reduced dramatically while also yielding positive side benefits such as more space for urban life.

A combination of private bicycle use and shared pooled mobility can make urban transport low-carbon. Nevertheless, effective implementation depends on regulatory agencies creating further incentives for both mobility participants and service providers, and taking bold measures to institute new norms and regulations for use of street space, with the ultimate aim of banning cars entirely from city centers.

1. Introduction

As climate change mandates drastic changes to the way our economies function, and as congestion and crowded parking continue to be major issues for quality of life, new emerging mobility options such as smart and shared mobility enter the scene, promising to align green consciousness with convenient mobility and new business opportunity. As organizers of Israel's Smart Mobility Summit 2019 framed it: "The time is ripe for a revolution in transportation, for a world free of oil, populated by clean, accessible and efficient means of transportation." [1] And it's true: fossil-fuel-based transport is rapidly becoming history, and new digital technologies make novel mobility modes and usage frictionless and attractive. In particular, countries like Israel, not hampered by a domestic car industry, but motivated by having the most congested streets of all OECD countries, would profit from redesigning mobility systems.

Yet, the digitalization of urban transport does not automatically translate into social and environmental sustainability.[2] Pedestrians complain about e-scooters on sidewalks. Uber services present unwelcome competition for taxi drivers. And though shared mobility options are increasingly entering into service, streets remain crowded as ever. Nor is there a sign that GHG emissions in the transport sector are declining. It is time to revisit the promise of smart and shared mobility and investigate how it can be steered in order to realize its potential.

The unfortunate starting point of this policy paper is a confusion of meaning – too often smart mobility is equated with sustainable mobility. A survey among Israel-based stakeholders reveals that smart mobility entrepreneurs are mostly concerned about commercial opportunities and lack a deeper understanding of what is necessary to transition to sustainable mobility.[3] Noy and Givoni state that "the belief amongst those entrepreneurs, it emerges, is that technological developments alone, specifically with respect to autonomous and connected vehicles, can lead to sustainable transport. This should be a real concern if those same actors are the ones who lead and pave the way forward for transport planning."[4] Hence, it's time to address this confusion and work out which smart or shared mobility options contribute to goals like climate change mitigation and which do not, as well as to clarify the conditions of environmental and social success.

This policy paper converses with an earlier policy paper by this author, on the feasibility and rationale of an integrated data platform to manage smart and shared mobility.[5] It first identifies the specific CO_2-emissions of different shared mobility options, demonstrating a wide range of emissions between respective venues. Second, it highlights the specific role of vehicle occupancy as key variable. Third, it calculates larger system-wide effects, and fourth, it projects the economics of shared mobility. Armed with this information, this paper will conclude with policy recommendations.

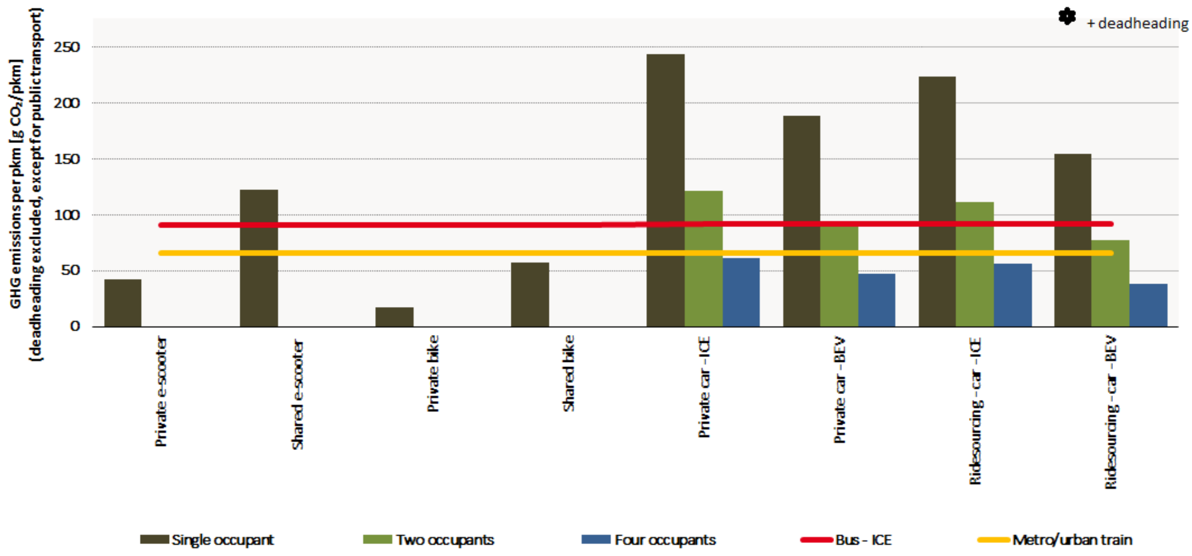
2. Assessing Marginal CO_2 Emissions of Shared Mobility Modes

There are four different modes of carsharing.[6] First, micromobility involves bike sharing and e-scooter platforms, like Tier and Lime, and similar modes. They are commonly used in cities and for shorter distances. Second, is carsharing, involving regular car driving but with cars that can be accessed by a common customer base. Carsharing refers both to stationary format with fixed pick-up and return points, and free-floating versions that allow for more flexibility, but usually at higher costs. Third, there are ridesourcing services like Uber and Lyft, essentially unregulated taxi services (that are now becoming increasingly regulated). And fourth, there is shared pooled mobility, like Bubble (ViaVan), which picks up and delivers several passengers along flexible routes. We will evaluate these modes in turn, but leave out carsharing for the moment, as marginal emissions are essentially the same as for normal car driving. Shared mobility's essential promise is that it changes consumer behavior in the long run "by shifting personal transportation choices from ownership to demand-fulfilment."[7]

A first step towards evaluating the climate effects of different shared mobility modes is to calculate marginal CO_2-emissions for each kilometer a person travels. This can be done by attributional life cycle analysis (ALCA), commonly performed in academic studies. The International Transport Forum released a complete data set of LCA values for a range of modes, and ran data through them for different assumption sets.[8] Figure 1 presents a selection of modes as reported by the International Transport Forum. The modes portrayed in the figure are micromobility (bike sharing and e-scooters) and ridesourcing.

Figure 1.

Comparison of Attributional Life-Cycle Emissions of Different Shared and Non-Shared Modes[9]



ICE is referring to internal combustion engine and BEV is an abbreviation of battery electric vehicle. If deadheading (cruising without passengers) is included (see top right side of the figure), ridesourcing becomes more CO_2-intensive than using a private car.

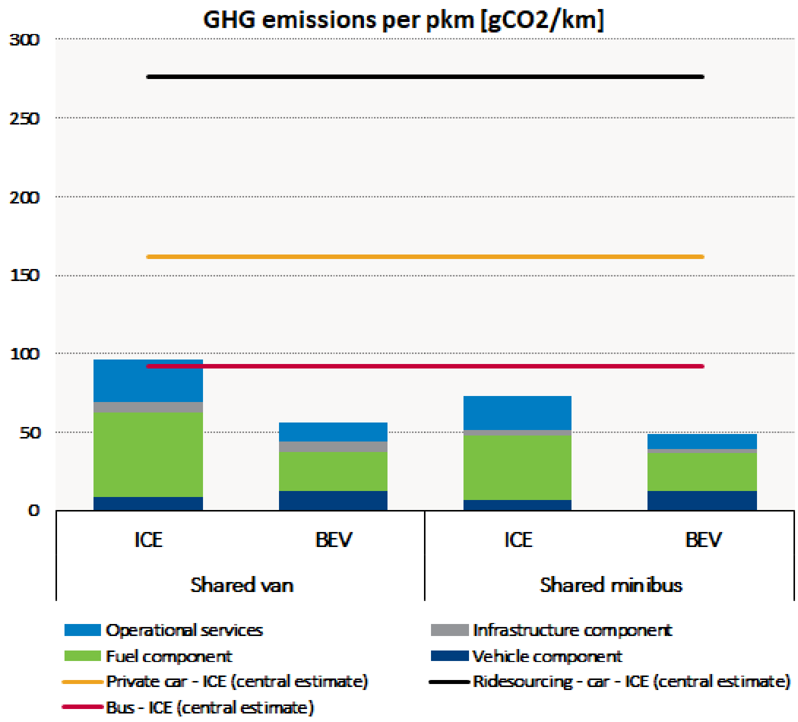
The data reveals the following key messages: First, two wheelers are more climate friendly than four wheelers. Both e-scooters and bikes considerably outperform any sort of car transport. For example, a private bicycle is 15 times more CO_2-efficient than an average car with an internal combustion engine. The main reason is that two wheelers are much lighter than cars, and thus total energy expended required for travel, proportional to mass, is concurrently lower. Less dominant but also relevant: lifecycle emissions of vehicle production are also much lower for the smaller vehicles.

Second, there is a clear technological hierarchy. Non-motorized means of transport (bikes) are most CO_2-efficient, followed by electric mobility (e-scooters and battery electric vehicles). Conventional fossil fuel cars perform worst. Importantly, electric vehicles are powered by electricity that is partially sourced from coal or gas power plants, and hence are not carbon neutral. Nonetheless, from a climate perspective, electric mobility clearly is an improvement compared to combustion engines.

Third, occupancy makes all the difference for car use. While cars with a single driver perform considerably worse than conventional public transit, marginal passenger-km CO_2-efficiency increases with every passenger, and with four passengers, cars perform similar to e-scooters and shared bikes. Occupancy is in fact the major factor driving efficient mobility. A recent study finds that occupancy accounts for about 70-90% of observed GHG emission intensities, while only the remaining 10-30% is explained by differences in trip distances, technology and operating conditions.[10]

There is one final issue to consider in this accounting: deadheading. Deadheading refers to empty trips traveled by public or shared mobility vehicles. Commonly, buses drive empty for 1-25% of their travel time. Cities and countries with high modal split in bus transit (e.g. Bangalore, India) have usually little deadheading, while cities and countries with low modal split in public transport (e.g. Brisbane, Australia) have high deadheading. Ridesourcing is a mode with high deadheading shares, typically with deadheading shares of 42-81%.[11] These are high values and must be considered in calculating the marginal emissions per passenger-km. When passenger-km emissions are taken into account, ridesourcing's GHG emissions are considerably higher than that of private vehicle transport (Figure 1).

Figure 2.
Comparison of Different Shared Pooled Mobility Modes with Bus, Private Vehicle and Ridesourcing (with Deadheading)[12]



Vans are assumed to have eight seats, with a utilization rate of 70% as observed for New York City (4.5 seats occupied in average), and deadheading of 150%. Minibuses have a 20-seat capacity and average occupancy of 10 seats.

Next, let us consider shared pooled mobility. Our occupancy analysis above suggests that shared pooled mobility have an advantage, because it transports more passengers per vehicle-kilometer travelled. Indeed, attributional lifecycle analysis reveals that shared pooled mobility outperforms not only ridesourcing and conventional ICEs but also bus transport in terms of marginal CO_2 emissions (Figure 2). This is an impressive feat and should draw our attention, as it implies that there is a win-win situation in the dimensions of convenience and CO_2-efficiency when switching from bus to shared pooled mobility (though the latter is usually more expensive). When combined with electric propulsion, shared pooled mobility becomes similarly efficient to e-scooters.

As an intermediate summary, we can hence observe that micromobility services and shared pooled mobility with high occupancy make a difference from the perspective of climate change mitigation, but ridesourcing does not.

3. Systematic Effects: A Clouded Landscape

Until now, we have discussed marginal GHG emissions of shared mobility modes. However, as is commonly known in sustainability science, the choice of boundaries of analysis is crucial.[13] Specifically, it is important to also consider wider system effects. The most important such effect is the question of which transport mode is replaced by novel shared mobility options. If they replace cycling or walking, overall GHG emissions will rise. If some of the better options replace private vehicles, systemic effects will be beneficial.

The ITF study summarizes observed replacement effects.[14] It finds that ridesourcing outfits such as Uber, already implicated with the worst CO_2 footprint of all modes, replace public transport in a third of trips. Also the replacement of car and taxi travel in about 40% of all ridesourcing trips, otherwise plausibly beneficial, actually increased GHG emissions, according to the study. Finally, the convenience of ridesourcing gives rise to an effect known as "induced travel," whereby in 8% of ridesourcing trips patrons would have stayed home otherwise. This mode of transport therefore leads to the most overall additional GHG emissions per trip. A highly regarded study, however, found that ridesourcing complements rather than substitutes for public transit in the United States.[15] A study of Didi, the main Chinese ridesourcing service, reveals that ridesourcing is more CO_2 efficient than taxis, because Didi drivers wait at the drop-off location for new passengers rather than returning to fixed stations.[16]

Carsharing, so far not considered, has marginal beneficial effects. It replaces, in some cases, private car ownership and inasmuch as it substitutes normal car travel, it does not have any effect on GHG emissions. However, it does lead to a reduction of overall (car) trips, essentially cancelling out unnecessary travel, thus reducing GHG emissions. For example, an early study of San Francisco carsharing demonstrated a saving of nearly half a ton of CO_2 per carsharing user due to replacement of private car usage, corresponding to about 16-18% of previous GHG emissions.[17] Similar effects were also observed in the Netherlands and in Calgary, but at a somewhat lower magnitude.[18]

Micromobility has ambiguous effects. It replaces some car trips (in about 5-15% of trips), which reduces overall GHG emissions. However, it also replaces numerous walking and cycling trips – nearly half of all trips with e-scooters would have been walked otherwise. This induced motorized travel increases GHG emissions. However, the example of dockless bikesharing in Shanghai demonstrates that bike sharing replaces a high number of car trips, especially during the evening peak hour and in the inner city, and reduces CO_2 emissions by more than 25,000 tons.[19] A case study of motorcycle sharing in Jakarta demonstrates that beneficial effects of car substitutions are canceled out by public transit replacement and deadheading, thus improving mobility but not sustainability.[20]

Table 1.

Systemic Modal Substitution Effects of Shared Mobility[21]

Mode	Country	Modal Substitution Effect					
		Taxi	Public Transport	Cars	Walking	Cycling	Induced Travel
Ridesourcing	United States	-39%	-33%	-6%			8%
	France	-27% to -32%	-38% to -45%	-5%			9%
Carsharing	United States		Slight reduction	-10%			-10%
	France		Slight increase	-10%			-10%
Micromobility	United States	-15%	-10%	-15%	-37%	-9%	8%
	France	-4% to -5%	-29%	-4% to -5%	-47%	-12%	3%
	Brazil	-26%	-20%	-14%	-52%		

In summary, substitution assessment and case study observation demonstrate that the evaluation of systemic effects in shared mobility is crucial for identifying the overall climate change mitigation contribution (or additional damage). If shared mobility is efficiently designed and replaces private car trips, it can contribute to marginally reducing GHG emissions.

4. The Economics of Shared Mobility

While some shared mobility modes entered urban markets only recently, carsharing is a much older concept. It is therefore important to take stock of the decades-old development. The insight is clear: while carsharing has been established in niche markets, it has not made a dent in overall rates of car ownership and has failed to change mobility patterns in cities. Analysis demonstrates that new free-floating carsharing models, marketed aggressively, have also failed to make a difference.[22] It is true that companies like ShareNow (formerly Car2Go and DriveNow) are popular and brought in a reasonable customer base. However, the numbers remain too low to change overall car ownership and mobility in cities. Carsharing and similar offers are chosen for convenience and their economics complement rather than substitute the use of private cars, at least at aggregate scale.

A key additional challenge is the economics of density. Economics of density here means that shared mobility companies require sufficient ridership and sufficiently frequent use of their vehicle stock to remain economically viable. Shared mobility modes are economically competitive where populations are concentrated, i.e. in dense cities. One report, considering the German case, suggests that only the areas with the highest population density in Germany, which account for only 5% of the population, are attractive for carsharing companies.[23] This needs to be contrasted with the observations that urbanites in city centers are the people least dependent on cars to start with. Areas with low-to-medium population density including suburbs, where there is most potential for transitioning from individual to pooled car use, are meanwhile not targeted by private companies fearing insufficient revenues to cover operation costs. This analysis, together with the footprint investigations of the first part of this paper, suggest that shared mobility has little future in providing low-carbon sustainable mobility in the current market system.

However, there are two rays of light. First, the above analysis was focused on free-floating shared mobility. More traditional stationary carsharing (i.e. car rental), in contrast, is more often used for longer trips outside the city and is more strongly related to replacement of private car ownership and overall mileage, thus effectively reducing emissions.[24]

Second, modelling studies from the International Transport Forum suggest that under different conditions and regulation, shared mobility could make a difference. The International Transport Forum modeled shared mobility potentials for Dublin, Lisbon and Helsinki.[25] Their results demonstrate that replacing private car traffic with pooled van and minibus services in urban areas dramatically reduces the number of vehicles required, lower GHG emissions, and makes current parking space available for urban life – while maintaining door-to-door accessibility for all inhabitants. For example, with minibuses, today's automobile traffic in Helsinki would be replaced by just 4% of the current number of private vehicles, realizing the following benefits: 1. GHG emissions from cars would fall by a third; 2. Congestion would be reduced by more than a third; 3. Parking spaces could be freed for public life; 4. Fewer transfers, less waiting, and shorter travel times would provide an advantage over traditional public transport. Given these benefits, even current habitual car users would be attracted to this new mobile freedom.

This leaves the question of what kind of steps could be taken to realize these fantastic benefits. The last section will investigate this conundrum.

5. Policy Recommendations

Our analysis suggests that smart and shared mobility can indeed contribute to climate change mitigation and other sustainability and efficiency goals, such as reduced congestion and more livable cities. However, the analysis also reveals that in its current state, with its focus on ridesourcing and micromobility, shared mobility not only contributes little to climate change mitigation but also produces undesirable effects, such as partially increasing GHG emissions and reducing active mobility by providing a convenient motorized option that leads people to forego the effort of walking or biking, which can have a negative effect on public health. A central question hence concerns the choice of policy instruments that can help shared mobility realize its potential.

The key policy recommendations presented in this paper are motivated by the observation that occupancy is what makes shared mobility CO_2-efficient. Higher occupancy shared taxis, minivans or minibuses can be strategically incentivized. A starting point is preserved boarding space in attractive locations, e.g., in front of office complexes, opera houses, and football stadiums, for shared pooled mobility but excluding ridesourcing and taxi services. Urban parking space can be discounted for shared mobility modes.

A more radical approach calls for the exclusion of private cars from city centers altogether. This approach is justified by the understanding that private car use is a "tragedy of the commons," where individual benefit – the convenience of having one's own mode of transport always accessible – deteriorates quality of life for everyone else (public space occupation, congestion, air pollution, climate change, resource depletion, etc.). In fact, benefits lost are offset by some gained by the prohibition of the private car, namely better mobility as congestion is reduced, alleviating the stresses of travel and potentially reducing the time it takes. Freeing up parking spaces also contributes to a fair allocation of street space:[26] From a space distribution perspective, the use of space for non-moving vehicles is much more problematic than the use of streets for moving cars. Shared mobility optimizes this situation by having fewer cars, which move more.

Another recommendation is that municipal governments should proactively engage with shared mobility providers and offer lenient regulation, which can even be leveraged as an incentive in exchange for data sharing and trusted urban data governance.[27] Preferential regulation should inter alia allow for free parking, especially in areas insufficiently covered by public transit, thus increasing the likelihood of complementing rather than substituting for public transit use.

Furthermore, reporting standards for shared mobility providers should be created, especially with regard to environmental and CO_2-footprint data. Measuring total lifecycle GHG emissions of shared mobility vehicles provides not only transparency but also changes the mindset of providers to actively consider opportunities to make mode use more efficient and thus reduce overall GHG emissions. A crucial dimension is the lifetime of vehicles, also to be reported, which can be improved by corporate policies, probably without increasing costs. Federal jurisdictions and cities can make licensing subject to reporting and minimum CO_2-footprint standards.

A last policy recommendation relates to the lack of incentive for mobility service providers to consider actual GHG emission reductions as part of their business plans. This begins with an understanding that shared mobility is embedded into an overarching economy-wide strategy to reduce GHG emissions, complying with the goals of the Paris Agreement, and achieving a low-carbon society. Such an orientation would give rise to policies such as economy-wide carbon pricing that puts a price on pollution, from GHG emissions not only due to vehicle use, but also from vehicle construction. This would trickle down to mobility service providers, who would then be motivated to comply with the wider environmental and planetary interest.

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