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Corporate ownership of automated vehicles: Discussing potential negative externalities

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Abstract

This paper proposes a new angle on the relationship between ownership models of automated vehicles and implications for travel. Specifically, the paper speculates on the potential negative externalities of corporate ownership. It argues that corporate ownership may have an incentive to prolong trips in order to maximize returns on capital and to take advantage of passengers' in-vehicle attention. Corporate owners are expected to generate revenue from providing passengers with personalized content, by providing car-immersive entertainment services and prolonging trips. The paper argues that corporate owners will have important stakes in the 'attention economy': a fast-growing industry with an explicit interest in harvesting persons' attention through digital content, and repurposing it for financial gain. One of the consequences of corporate ownership introducing such incentives into transport schemes is that congestion may worsen, because the corporate owner can generate potential revenue from prolonging travel time. This would work against the goals of reducing travel time for passengers and engendering more sustainable transport.

In addition, there may be other negative externalities from corporate ownership with stakes in the attention economy: a reduction in positive utility due to reduction in the ability to convert travel time to productive time; a reduction in human well-being, and exacerbating social injustice. Given that the attention economy is in the business of capturing persons' attention, this will make it difficult to convert travel time into productive time, since it will become harder for the passenger to disengage from tailored digital targeting. In addition, in-vehicle experience, combined with the hold that the attention economy will have on passengers, reduces the potential of developing and exercising our human capacities, which is crucial for well-being. Finally, subscription plans that will offer the ability to opt-out from personalized targeting may create social injustice insofar as some people will be able to afford opting-out, while others will not. The upshot is that corporate interests need to be taken into account in assessing the implications of automated vehicles on travel, and regulatory mechanisms to anticipate and correct for these externalities are timely.

The introduction and potential proliferation of automated vehicles present the classic challenge of balancing the freedom of private manufacturers to innovate with government's responsibility to promote social goals. Automated vehicles (AVs) raise concerns about unsustainable urban growth patterns and the risk to more sustainable and healthier travel modes like public transport, walking and cycling (Fleetwood, 2017; Gruel & Stanford, 2016; Milakis, Kroesen, & van Wee, 2018).

This paper focuses on concerns regarding AV ownership regimes and their implications for travel (van den Berg & Verhoef, 2016). This is motivated by the worry that large corporations are exerting significant influence in the era of 'smart' in pursuit of goals that may not strongly align with social and environmental sustainability goals as well as economic prosperity (Lyons, 2018).

Milakis, van Arem, & van Wee (2017) propose that the effects of the introduction of AVs can be analysed as ripple effect of first, second and third order of impact, with possible feedbacks between these levels of impact. The first-order impact of automated driving are implications on traffic, travel cost, and travel choices; the second-order impact is the implications of AVs with respect to ownership, location choices and land use, and transport infrastructure; the third-order impact contains the wider societal implications in energy consumption, air pollution, safety, social equity, economy, and public health (Milakis et al., 2017, p. 326). Within this conceptual framework, I examine how ownership paradigms (second-order impact) create first-order impacts for congestion, travel time and travel choices, and reflect on various interactions between the first, second and third order of impact, as follows.

First, the incentive of mobility providers is to generate as much mobility as possible, whether trips or driven kilometres, in order to maximize return on capital (Docherty, Marsden, & Anable, 2018). Second, travellers seem to be more sensitive to out-of-vehicle travel time than in-vehicle travel time (Bhat, 1998). Therefore, when free from the need to drive, passengers may not mind a marginally prolonged journey. Mobility providers may capitalize on this lower sensitivity to in-vehicle time, and instead of minimizing travel time, will rather prolong journeys to generate more revenue. It is therefore important to identify the incentives that mobility providers may have, and to create corresponding regulatory mechanisms to ensure that the social goals of smart mobility are not jeopardized.

The paper proceeds as follows. I begin by reflecting on corporate interests in the context of the 'attention economy'. The attention economy (Kessous, 2015) is a fast growing industry with an explicit interest in harvesting attention by penetrating the internet-ready car, as this is a lucrative source of revenue (Lyons, 2018). The following section presents three scenarios of AV ownership and operation models: corporate ownership, corporate ownership with customized payment options, and private ownership. Each scenario represents different manifestations of the attention economy's foothold in determining AV travel. The subsequent section reflects on four potential types of negative externalities that corporate ownership may impose: congestion; limited potential of positive utility; decrease in well-being and social injustice. The closing sections discuss possible government regulation and directions for further research.

Before continuing, a note on terminology. The literature classifies AV ownership paradigms into private or shared ownership. However, I argue that calling non-private ownership 'shared' is a misnomer and as such it is normatively misleading. This is because "When "sharing" is market-mediated—when a company is an intermediary between consumers who don't know each other—it is no longer sharing at all. Rather, consumers are paying to access someone else's goods or services" (Eckhardt & Bardhi, 2015). In a non-private AV system, there is no mutuality in the relationships between travellers, or between the traveller and the company. Thus, from a conceptual point of view, it is more appropriate to address non-private for-profit operators as corporate-owned. The reason for insisting on calling a non-private operator a corporate owner is that it helps to make explicit that corporate owners are going to have incentives that are distinct from, indeed might be opposite to, the social or sustainability goals of mobility.

1. The attention economy

In-vehicle experience may have a significant impact on route choice and trip length. In a mobility

system where persons no longer have to drive, riders may use travel time to do other things. At first glance, this seems either innocuous or even a good thing. Without the need to concentrate on driving, passengers could make more productive use of their time: read, listen to music, watch videos, socialize, hold meetings or shop. Yet a closer look reveals that freeing attention from driving may be 'hijacked' by corporate interests. This may have negative externalities for the transportation system and for social justice. The following unravels this argument in detail.

According to the Digital Humanities Institute at the University of Sheffield, "Entertainment is likely to be one of the chief activities that takes place in autonomous vehicles… the UK's creative economy should begin developing the partnerships, thought leadership, creative designs, and business models that will help secure it as a future world leader for in-car immersive services that focus on entertainment creativity and consumption". It is worth pausing to ask: is the enthusiastic adoption of car-immersive services something to look forward to? Is it good to be immersed in entertainment consumption? Who is going to benefit from selling immersion and entertainment services, and is it going to create a more or rather less just society?

In the broader context, the car-immersive environment is part of the 'attention economy'. The game of harvesting human attention and reselling it to advertisers has become a major part of our economy. The major stakeholder in this game—'attention merchants'—have realized that the winning strategy in this game is gathering chunks and subsequently slivers of our unharvested awareness (Wu, 2017), reselling it to other parties who can make a profit from persons' re-purposed attention.

Importantly, the attention economy shapes individual behaviour. Not only do attention merchants sell the audience's attention; the collected information is used to target ads for each individual user so that the ads hit home pertaining to user needs, interests, and stances. Users are being monitored to the end of making economic profit by selling information about users along with their attention to third parties. Furthermore, surveillance provides information about the surveilled that may be (mis)used to persuade, trick, and manipulate more effectively (Hendricks & Vestergaard, 2016).

One of the biggest studies on the effectiveness of tailored marketing, using three field experiments that reached over 3.5 million individuals with psychologically tailored advertising, found that matching the content of persuasive appeals to individuals' psychological characteristics significantly altered their behaviour. Persuasive appeals that were matched to people's extraversion or openness-to-experience level resulted in up to 40% more clicks and up to 50% more purchases than their mismatching or unpersonalized counterparts (Matz, Kosinski, Nave, & Stillwell, 2017).

Attention and cognition are the foundation on which all our capacities depend—our ability to think, to concentrate, to solve problems, and be present with each other. Yet according to Tristan Harris, former Design Ethicist at Google, technology's constant interruptions and precisely-targeted distractions, which have been designed to keep us more engaged with tech products, are taking a major toll on these critical functions (Centre for Humane Technology, 2018).

To the extent that the attention economy is becoming a major part of our economy, it is likely that 'attention merchants' will seek to capitalize on the advertising platforms offered by new technologies. One such platform is the interior of the driverless car. Google, for example, has already recognized that the most valuable advertising space in history will be the inside of automated vehicles, because the vehicle knows who the passenger is, the car provider has their credit card information, and the passenger is captive in a space that will be covered in screens (Tumlin, 2016). A report by McKinsey (Cornet, Mohr, Weig, Zerlin, & Hein, 2012) speculates that on average every AV passenger will spend 50 minutes in their car per day. If even 5 minutes of this 50 minutes can be

acquired by the 'attention economy' then this could amount to 25 billion euros of revenue generation per year (Cornet et al., 2012, p. 12). One illustration of this revenue generating scheme appeared recently in Forbes magazine:

> ''Cross-channel advertising opportunities in this fully immersive environment could combine the offline mediums, where commercial ads would sponsor your video content or streaming TV series; an outdoor/billboard type of environment where a product placement or still ad billboard could pop up before any article or organically flash across your screen as you geolocate near a particular store or brand, and radio spots could be micro-targeted for your demographic and sponsor podcasts and music channels. And of course, there would be digital banners and pay-per-click (PPC) targeting on your computer and mobile devices.
> While it may seem like it could be a further invasion of personal space, the in-vehicle experience will actually be more customized with personalized content based on past likes and online activities and histories. Imagine restaurant or activity recommendations made on the fly. The vehicle might even be programmed to take passengers directly to recommended destinations upon opt-in from the passenger. Eventually, the vehicle might even be able to be commanded to suggest a customized day, curated entirely by the autonomous vehicle.
> So, what do brands need to consider when they begin to add in-vehicle advertising and marketing to their media mix? The new self-driving vehicles will begin to not only shift the way people look at transportation but also change the way people behave within those vehicles. It will mean a whole new level of personalization to the brand experience where, if an advertisement comes into your car, you could click on the ad and the vehicle could physically take you to where you can personally experience the brand or the offering'' (Hawthorne-Castro, 2018).

Beyond the explicit interests that corporates will have in altering individual behaviour, as expressed in the passage above, one of the ripple effects that the attention economy may create is the unnecessary prolongation of trips. To the extent that the attention economy is interested in harvesting as much attention as possible, it could impose longer AV trips in order to create the material and mental space for passengers to engage with the attention economy during the trip. Recall that psychological targeting can alter a person's behaviour, by making them purchase more goods and services compared to unpersonalized marketing. Combined with the analysis above that if the attention economy can capture the attention of the passenger for even 5 minutes thereby generating 25 billion euros of revenue per year, it is plausible that the attention merchants may try to prolong AV trips, in order to generate more revenue from each additional in-vehicle minute. This might be especially relevant in the case of short trips.

Vehicle providers—corporate owners of the vehicle themselves—are expected to play an important role in the attention economy. Since mobility providers' intent is to generate as much mobility as possible in order to maximize return on capital (Docherty et al., 2018), it makes sense, for mobility providers, to either provide content themselves, or to cooperate with content providers, to create the environment that generates as much revenue as possible from in-vehicle marketing.[1] The upshot is that to assess the impact of AVs, ownership paradigms, owners' incentives and potential externalities need to be accounted for. The following reviews three possible scenarios regarding AV ownership in this context.

[1] Such cooperation could hypothetically be modelled after the business model of companies like Alphabet Inc., with its subsidiaries Google, Waymo (self-driving technology development company) and Sidewalk Labs, the latter building a smart urban quarter in Toronto.

1.1 AV Ownership scenarios

Scenario 1: corporate ownership

In this scenario, corporate owners include the players in the attention economy with stakes in the AV operation scheme. For example, mobility providers (e.g. Ford) renting the vehicle interior to 'attention merchants' (e.g. Facebook). Alternatively, in this scenario, one corporate player (e.g. Waymo, a subsidiary of Alphabet Inc., Google's parent company) includes both functions—providing both the infrastructure and the content.

The attention economy has a vested interest in growing the market for driverless vehicles *for single passengers*, because this way it can target each passenger most effectively, by creating ads that are tailored to their personal characteristics. High-occupancy vehicles cannot provide the platform for tailored advertising, since there are multiple passengers with diverse tastes and habits, which make it impossible to target particular individuals. The type of behavior that marketing companies seek to engender, as captured by the Forbes article above, is impossible in a high-occupancy vehicle where routes are more or less fixed. Since marketing companies see lucrative financial potential in creating a personalized environment, low occupancy/single-rider pods are more effective, from a business-model point of view. In this scenario, therefore, corporate ownership implies that the industry will lobby for single-occupancy vehicles, which may exacerbate congestion compared to a system oriented towards public-transport.

When AVs are corporate-owned, and the corporate owner wants to capitalize on the passenger's attention, it is plausible that the owner will try to optimize the following criteria:

1. Minimize operation costs by choosing the most efficient route and shortest travel time;
2. Maximize the passenger's exposure time to tailored content.

When minimizing operation costs (criterion 1), the operator chooses the most efficient route, which will contribute (all else being equal) to sustainability and congestion reduction. However, the corporate's interest in maximizing exposure to in-vehicle personalized content means that in in order to optimize for criterion 1 with criterion 2, the route-finding algorithm can be designed to prolong trips by either taking a longer route, or by decreasing speed (or a combination of both).[2]

Table 1 presents one possible manifestation of the negative externalities (i.e. added trip time) caused by the implementation of criterion 2. As already stated, the corporate operator is interested in maximum efficiency on the one hand (criterion 1 in column 1). At the same time, the

[2] Optimizing for both criteria is not necessarily providing false claims about what the corporate offers to consumers (which is already regulated in many countries). The AV industry is currently framing their mobility solutions in terms such as safety; speed; reliability; comfort and convenience. Therefore, if corporates continue to use these terms to market their product rather than explicitly promising shortest travel time, optimizing for the two criteria may not count as false or misleading advertising. Furthermore, the route-finding algorithm is based on AI, which is a "black box" to both consumers and the government. This obscures the extent to which corporates actually manipulate the route-finding algorithm for their own interests, making it harder to prove that corporates are using misleading tactics. I discuss the need to regulate against the risk of "black box" AI in section 3.1.2 below.

corporate owner is interested in prolonging trips in such a way that is both difficult for the passenger to detect, but is long enough to guarantee revenue from exposure to personalized content (criterion 2, column 2). The estimates in column 2 are speculative, yet based on the assumption that for shorter trips, if the corporate prolongs the trip too much by taking a conspicuously longer route or by slowing down significantly, this will be detected by the passenger. Therefore, for trips under 10 minutes, I assume an addition of 30 seconds. On short trips an addition of 30 seconds prolongs the trip by 10%, which, when aggregated across the whole system, may have significant effects on congestion. For longer trips the logic is similar: prolonging the trip such that it does not add more than 10% to what would have been the optimal travel time.

Table 1: Potential implications (marginal disutility) of prolonging in-vehicle travel time

Optimization for maximum efficiency (criterion 1)	Added trip time by implementing criterion 2	Optimization for criterion 1 and criterion 2	Marginal disutility of implementing criterion 2 (%)
5 min.	0.5 min.	5.5 min	10%
10 min.	0.5 min.	10.5 min	5%
20 min.	1.5 min.	21.5 min	7.5%
60 min.	4 min.	64 min.	6.7%
90 min.	4.5 min.	94.5 min.	5%

Hensher (2018) warns that for a mobility system to fulfils its intended goals and objectives (reduced travel time, greater access, less pollution, less externalities), all transport providers will have to collaborate transparently. In a corporate-owned AV paradigm it is likely that prolonging trips may be difficult to detect. Since travel times will be dynamic, and influenced by all the other vehicles that happen to be using the system at that particular time, it will be impossible for the passenger to tell whether their particular trip is taking longer than would otherwise take, since there are no fixed routes or schedules that one could compare to. It is plausible, therefore, that absent regulation that requires transparency about route-finding, a corporate-owned AV fleet will contribute to congestion and other negative externalities, as discussed in greater detail in section 2.

Scenario 2. Corporate ownership with opt-out option

In scenario 2, AVs are corporate-owned, and the passenger is given a choice between three options:

> **Option A**: pay a standard fee per trip, with exposure to in-vehicle advertising;
> **Option B**: pay a higher fee per trip for an ad-free in-vehicle environment;
> **Option C**: buy a subscription to an ad-free service for all trips included in the subscription.

In this scenario, if passengers choose Option B or Option C, the mobility provider optimizes criterion 1 only (minimize operation costs), since the corporate owner has no incentive to unnecessarily prolong the trip. Regarding Option A, however, corporate owners do have an incentive to prolong trips. The overall effect on VMT, travel time and congestion is expected to be lower compared to scenario 1, because only some AV trips will be prolonged. It is unclear, however, whether the improvement compared to scenario 1 will be significant. This will depend on the share of users choosing Option A compared to the other options.

Scenario 3. AV private ownership

In this scenario, vehicles are owned privately. Since the vehicles are not corporately owned, the attention economy has less of a foothold in determining the length of the trip, as it cannot insert its criteria into the route calculation algorithms. This is in contrast to Scenario 1, where the attention economy can insert its own criteria to the route calculation algorithms by negotiating with the corporate fleet owner. In scenario 3, therefore, the risk of system-wide additions to travel time in order to create more personalized content exposure is lower compared to Scenario 1 and Scenario 2.

According to Hensher (2018), without a significant switch to the sharing economy and relinquishing of private car ownership, congestion is not expected to decrease. Yet the discussion so far complicates this picture. When we consider the interests that corporates have in manipulating routes and travel time to their own advantage, it becomes less clear whether and by how much corporate ownership will provide more benefits compared to private ownership. The following develops some of the potential implications of corporate ownership.

2. Implications of AV corporate ownership

Given the possibility that corporate ownership may create ripple effects on travel, the following sections discuss four potential types of negative externalities that may occur at the first-order level (e.g. congestion) and the third-order level (e.g. societal implications).

2.1 Congestion

One of the potential advantages of the AV is that it is expected to reduce congestion due to improved efficiency, yet forecasts and simulations provide mixed results on the likelihood of the AV to reduce congestion. The AV is expected to generate induced demand (Fagnant & Kockelman, 2015) which could be as high as 50% (Medina-Tapia & Robusté, 2019). Since AVs will likely encourage more travel by previously less-mobile populations, reduced congestion may induce additional demand, and travel by empty vehicles may negate some congestion benefits. Further, having empty vehicles relocate to parking facilities outside of the city centre is likely to cause significant levels of localized congestion (Kloostra & Roorda, 2019). Simulations in the San Francisco Bay Area show that assuming zero time cost for traveling in an AV, the increase of VMT would be 14.5% (Gucwa, 2014). If we take into account the implications of scenarios 1 or 2 in the previous section, in which travel time is prolonged due to corporate interests, it follows that congestion may become even worse.

Furthermore, Harper, Hendrickson, Mangones, & Samaras (2016) estimate up to 14% VMT increase in the US from additional travel demand of non-driving populations like the elderly or people with travel-restrictive medical conditions. Their study focuses on adults 19 and older, so it is plausible to assume that if unaccompanied children also become users, VMT will rise even further, especially if household location is more dispersed because of the greater location flexibility allowed by the AV (Soteropoulos, Berger, & Ciari, 2019). Future studies on AV and congestion, therefore, could benefit from accounting for corporate interests in prolonging trips in order to estimate the

extent to which an unregulated corporate paradigm may reduce the social optimum in terms of travel time.

2.2 Trip utility: attention and willpower

One of the popular narratives regarding the AV is that it will convert wasted time into productive or fun time. The AV is described in industry reports and marketing efforts as a revolutionary technology, in that it will allow the passenger to work, read books, watch movies or sleep during the commute. Yet there is reason to be sceptical regarding the 'positive utility' (Mokhtarian & Salomon, 2001) derived from AV mobility. If indeed positive utility is overestimated (as discussed below) then corporate owners may benefit from the discrepancy between expected positive utility and actual positive utility, by diverting passengers' attention away from productive or enjoyable activities. The following develops this argument.

On the face of it, being free of the need to drive brings up new possibilities to spend time during the ride. Pudāne et al. (2019) report that some possible new activities envisioned by participants in a focus group include the ability to work (write emails, participate in a work meeting), do business (beauty salon in car), sleep, prepare dinner, wash oneself, brush teeth, attend to children, do administration, exercise, sing karaoke, play board games or computer games, sew, watch movies, spend time with friends, video call or use a massage chair.

Nevertheless, Singleton (2019a) speculates that positive utility is overrated: most of it will derive from relief from drive-related stress and the ability to transition mentally. Conversion of travel time to more productive time, however, is less likely. First, the AV travel experience will likely resemble today's car ride more than a train ride in which it is possible to work or read, for several reasons. Motion sickness is more prevalent in the car than in the train; passengers tend to feel less comfortable at lower acceleration levels than do car drivers; safety mechanisms might restrict movement or flexibility within the vehicle, further limiting the potential of multitasking (Singleton, 2019a). In addition, in short-duration trips it is even less plausible to use trip time productively (Singleton, 2019a, p. 56).

Second, it is likely that activities that are usually undertaken while driving or riding a train such as gazing, conversing, or listening to music would continue to be important when riding an automated vehicle, and would not be converted into work instead (Cyganski, Fraedrich, & Lenz, 2015). In their study, Cyganski et al. also report that respondents explicitly state that one of the advantages of the AV is that they could use the time to connect socially, including on social media (Cyganski et al., 2015, p. 11). Moreover, many instances of travel-based multitasking for transit passengers may be more about coping with a burdensome or boring commute (Singleton, 2019b), rather than wanting to work.

In addition, the narrative of converting unproductive time to work time ignores segments of the population who do not work, such as minors. It is also worth mentioning that if predictions about job automation are correct, we should expect a radical decrease in the need to work. This strengthens the scepticism towards both the potential of converting driving to productive work time, and the extent to which positive utility will be derived from work in the car.

Finally, if the AV is designed such that it both limits movement and is covered in screens, the prospects for positive utility may be even lower than in the optimistic predictions. First, being surrounded by screens may have a negative effect on mental well-being. Studies show that the presence of a smartphone, even when off, can reduce cognitive capacity by taxing the attentional resources that reside at the core of both working memory capacity and fluid intelligence (Ward, Duke, Gneezy, & Bos, 2017). Furthermore, there is evidence that social media may be harmful for well-being (Dhir, Yossatorn, Kaur, & Chen, 2018; O'Reilly et al., 2018). It is therefore plausible that

being enclosed in a vehicle covered with screens is going to have similar, if not heightened effects in the same direction, lowering the passenger's well-being.

The difference between a privately-owned AV and a corporate-owned AV in this context is that in a private AV the passenger has, in principle, the choice not to engage with social media or other distracting media during the ride, and instead engage with new and meaningful activities (e.g. read a book or rest). In a corporate-owned AV, on the other hand, the corporate controls the screens and the content, making it almost impossible for the passenger to redirect their attention to those new and meaningful activities, thereby reducing the level of trip utility compared to the utility in a private AV. Furthermore, in a corporate-owned vehicle, if trips are prolonged to accommodate corporate interests (as discussed in section 2.1), passengers will endure lower levels of trip utility for longer spans of time, thereby reducing trip utility even further.

What is more, while the popular narrative is that AV travel will enable the passenger to engage in new and meaningful activities, it is unclear to what extent passengers will *actually* engage in these activities. Persons tend to overestimate their willpower in general (Loewenstein & Schkade, 1999) and their willpower to resist temptation in particular (Hesmat, 2012). The implication is that while persons may imagine or even fully intend to spend AV travel time productively, in reality they may be tempted away from engaging in activities that require willpower. Taking into account that the attention economy is precisely in the business of taking advantage of the difficulty to resist temptations, it is plausible that while persons speculate or report that they will prefer to spend their time engaged in worthwhile activities during an AV trip, in reality the all-too-human weakness of will may be exploited by the attention economy, diminishing the prospects of positive utility even further.

2.3 Trip utility: human capacities

Mobility is valuable in two distinct ways: it has instrumental value and it has intrinsic value (Sager, 2006). Instrumental value is value that is derived from achieving an external end. For example, mobility is important because it enables access to opportunities that are necessary for living a well-rounded life, opportunities to jobs, education, leisure and culture. Intrinsic value, on the other hand, is value that is not dependent on external goals, it is valuable in itself (Ferdman, 2018, p. 666). Mobility has intrinsic value when it is good in itself. When mobility is inherently interesting, enjoyable or desirable, it reflects an end in itself, whence the motivation for travel is *autotelic*. The existence of autotelic motivations for travel, including curiosity, adventure-seeking, independence, status, therapy, escape, information-seeking and exercise, means that their *fulfillment* increases well-being (Mokhtarian, 2019).

One explanation for the intrinsic value of mobility is that given the right conditions, we are able to develop and exercise our human capacities in meaningful ways when on the move. As humans, we have diverse capacities: to know, understand, innovate, form friendships, love, achieve, play, move our bodies. We live well-rounded lives when we engage these capacities in things that are intrinsically valuable, like love, friendship, knowledge, beauty and physical achievements (Bradford, 2017). In walking or cycling, we engage our capacities to generate new knowledge about the world around us, or to develop our affective and social capacities interacting with others occupying the same space as us (Krizek, 2019). In these instances, mobility itself is of intrinsic value. Mobility is therefore an important part of the background conditions against which persons in a society may develop and exercise their human capacities, in order to live meaningful, well-rounded lives.

Just as mobility creates value, it can also create disvalue. The potential instrumental disvalue of the AV includes congestion (as discussed in previous sections), unsustainable urban growth patterns (Soteropoulos et al., 2019), and infrastructure deterioration (Milakis et al., 2017). Yet even if these externalities are resolved, there is still reason to be sceptical about the *intrinsic* disvalue (badness) of low-occupancy AVs.

Intrinsic value—value in itself—is generated when we develop and exercise our human capacities. When we are blocked from developing or exercising our human capacities, this is not merely a lack of value, but a disvalue, a 'bad' in itself. Although a driverless vehicle frees up cognitive resources by removing the need to focus on driving, it is not necessarily the case that instead the passenger will develop and exercise their capacities in well-rounded ways. For example, in order to develop our social capacities, to get a sense of the social 'we' as a separate entity from the 'I', humans need to occupy a *material* space together with other people (Koch & Denike, 2001; Maniscalco, 2015; Yeh, 2012). In a single-rider environment, the conditions for developing and exercising our social capacities are limited, compared to walking and cycling, in which persons have to share space with others and in this way develop social capacities to negotiation co-habiting the same space.

Regarding cognitive capacities, when pedestrian environments are attractive and interesting, they enable the pedestrian to acquire new types of knowledge, by integrating embodied knowledge, gained through the human senses, with cognitive knowledge gained through our rational capacities (Anderson, 2004; Bairner, 2011; Middleton, 2010; Wunderlich, 2008). Riding in an enclosed vehicle does not offer the same opportunities to develop and exercise these capacities, because the environment inside the AV is poorer, in terms of exposure to things that trigger our human capacities, compared to a lively, urban environment.

In the previous section I argued that people may not utilize their travel time as productively as portrayed by the industry's popular narrative. This section argues further that even if persons are highly motivated to use their in-vehicle time productively, the design and operation of the in-vehicle environment contribute to an environment which inhibits the development and exercise of our human capacities. The argument here is that absent regulation on the vehicles' design and operation model, the attention economy will likely design smaller vehicles such that will capitalize on a market of single-ridership, in order to capture passengers' attention more effectively, yet in a way that is disruptive to the development and exercise of our human capacities.

It is worth noting that the diminished human environment embodied by the single-occupancy vehicle is especially relevant for children's development. The development and exercise of capacities requires exposure to things that trigger those capacities. Long rides to school or afterschool activities in an enclosed vehicle surrounded by screens is likely to work against the development and exercise of children's' capacities, compared to walking or cycling. One explanation for this is that there are two types of experience that determine early childhood development. The first is 'primary experience', in which the child can directly use her five senses: sight, sound, touch, smell and taste. The second is 'indirect experience', which is mediated, passive and employs only sight and sound, providing an impoverished experience of the world (Reed, 1996). Engaging with screens is an indirect experience involving only sight and sound, and is disadvantageous for the development and exercise of the child's capacities.

While the discussion on capacity development so far is relevant for any type of AV ownership, it is nevertheless the case that the possibility of longer trips, caused by corporate interests, is likely to diminish capacity development even further, since persons will have even less time, and therefore less opportunities, to develop and exercise their human capacities.

In addition, there are ethical aspects of offering tailored content and advertising for minors when they are alone in an AV. While parents may have some control over the content that their children have on their personal screens, in a corporate-owned AV parents are likely to have less

control, unless the corporate voluntarily regulates itself, or unless regulations on content are imposed by the government. The upshot is that in an AV dependent mobility system, coupled with corporate ownership interests designed to hijack our attention for profit, the prospects for meaningful development and exercise of our human capacities is diminished, compared to a mobility paradigm which promotes non-motorized modes like walking or cycling.

2.4 Social justice

The fourth negative externality that may be caused by corporate ownership is that corporate ownership may widen social injustice. Cohen and Cavoli (2019) have already noted that non-regulated penetration of the AV is likely to widen inequality gaps. This section strengthens this worry. In Scenario 2 I describe an operation model whereby the passenger has an 'opt-out' option, in which they can pay for blocking ads or other tailored content. While at first glance this seems like a broadening of individual choice, on further reflection, introducing the possibility to purchase a content-free environment within the mobility system may contribute to inequality in the following sense: those who have the resources to opt out will be immune from personalized content and targeting, and those who do not have the resources will be not be immune from personalized targeting. Furthermore, those who can afford to, will not only be able to enjoy an ad-free environment, but they will also enjoy shorter trips, because in their case the corporate owner will only apply criterion 1 (maximum trip efficiency). Those who are less well-off, on the other hand, are not only going to be more vulnerable to personalized content, but will be further penalized by longer trips, because in their case, the corporate owner will optimize criterion 1 (efficiency) with criterion 2 (prolonged trip).

The harm that the attention economy is imposing has not gone unnoticed by many principals of the tech industry. Many tech leaders do not allow their own children to use the products they build—which implies they are aware that their products pose risks, especially for young users (Centre for Humane Technology, 2018). Some parents in Silicon Valley worry about the ubiquity of tech and social media, and are severely restricting technology use at home (Weller, 2018). In Toronto, residents and local activists are urging Toronto to abandon Google's Sidewalk Labs smart city project, raising concerns that companies such as Google cannot be trusted to safely manage the data they collect on residents (Cecco, 2019). While these instances of resistance are localized and not widespread, they indicate that as a society, we do not need to be defeatist about the attention economy's power to determine the rules of the game. To the extent that personalized content within the AV decreases the potential for developing and exercising our capacities (as previous sections suggest), the ability to occupy ad-free environments should not remain the prerogative of the privileged who can pay to opt out.

3. Governance

The role of government in the pre-AV era cannot be underestimated, and should focus on transport policy and land use policy (Thomopoulos & Givoni, 2015). Together with the worry that growth in corporate ownership is expected to come at the expense of public transport (Pakusch, Stevens, Boden, & Bossauer, 2018), one policy implication is that more emphasis should be placed in making public transport and non-motorized modes more attractive if sustainable mobility is to be developed. Government interventions that aim to promote collective transport and discourage

single-occupancy car-use (e.g. Cohen and Cavoli 2019, 140; Hensher 2018, A5–6) are relevant as a means to respond to the negative externalities envisioned in this paper, since they aim to reduce low-occupancy AVs, regardless of ownership. However, in the following, I propose several potential interventions in regulation and pricing that governments could exercise specifically in response to the worry raised in this paper, namely interventions to minizine the possibility that corporate operators might prolong trips in order to generate revenue.

3.1 Regulation

3.1.1. Regulating AV operation

Tackling the negative externalities of AVs requires banning particularly disadvantageous aspects of AV operations (for example, the banning of empty running cars as a means to reduce congestion, Cohen and Cavoli 2019, 139). In line with this justification, governments may regulate the vehicle's interior in order to discourage corporate operators from prolonging trips. The worry raised in this paper is that corporate owners might be motivated to exploit passengers' vulnerability to tailored content by prolonging trips. To the extent that passengers are more likely to be vulnerable in immersive environments (e.g. built-in screens, VR in the vehicle) governments may be justified in prohibiting in-vehicle screens or limiting their size.[3]

3.1.2 "Black box" regulation

One of the implications of unregulated corporate ownership is that corporates could manipulate the route-finding algorithm in order to prolong trips. As discussed above, since traffic will be dynamic, the route-finding algorithm is a "black box" to both the passenger and the government. Neither passenger not the government will be capable of detecting whether corporates in fact prolong a trip, or by how much. In order to tackle this risk, governments need to insist on algorithmic transparency (Brauneis & Goodman, 2018). Corporations need to try to increase the technical transparency of the system, so that outside experts can understand how the AI system has been put together (Select Committee on Artificial Intelligence, 2018, p. 38).

However, corporations will most likely be reluctant to comply with algorithmic transparency, on account of protecting trade secrets. Nevertheless, AI experts insist that anyone procuring AI technologies for use in the public sector should demand that vendors waive trade secrecy claims before entering into any agreements with the government (Whittaker et al., 2018, pp. 4–5). The justification for accountability and transparency rests on the "right to explanation": AI developers and operators are required to provide meaningful information about the logic of processing (Edwards & Veale, 2017; Goodman & Flaxman, 2017). Among the mechanisms for transparency and oversight are rank-and-file employee representation on the board of directors, external ethics advisory boards, and the implementation of independent monitoring and transparency efforts. Companies need to ensure that their AI infrastructures can be understood from "nose to tail," including their ultimate application and use. Importantly, third party experts should be able to audit and publish about key systems (Jobin, Ienca, & Vayena, 2019; Whittaker et al., 2018, p. 4). By making the route-finding algorithm transparent and explainable, governments could thereby detect

[3] If indeed future research establishes the connection between in-vehicle design and passengers' attention and behaviour.

whether the operator is manipulating the route-finding algorithm in their own interest and against the common good.

3.1.3 Regulating subscription plans

A further worry this paper raises is that corporates may offer subscriptions plans that include the offer to receive tailored content, thereby allowing the operator to prolong trips, disproportionately targeting disadvantaged populations, as discussed in section 2.4. In order to guard against social injustice, governments may be justified in regulating payment schemes that target vulnerable and disadvantaged populations.

3.1.4 Protecting minors

So long as unaccompanied minors become frequent users of AVs, governments have a duty to protect them from targeted advertising, for example by limiting the advertisers' ability to provide tailored content during the ride. Regulation of content is already in place, for example in the UK, where advertising of products high in fat, salt or sugar is prohibited before 9pm (Department for Digital, Culture, Media & Sport & Home Department, 2019). Such regulation could be expanded to include rules against targeted ads when a minor is occupying an AV.

3.2 Economic instruments

Smart pricing has been suggested as a means to promote AV use as a first/last kilometre solution for encouraging high vehicle occupancy (Cohen & Cavoli, 2019, p. 141). Similarly, smart pricing could be used, when corporations enter into a contract with the government, to encourage shorter single-occupant AV trips, and in this way to offset some of the potential revenue that corporates would otherwise generate from prolonging trips.

4. Future research

As this paper is speculative, future research is necessary in order to verify its intuitions. This paper offered several hypotheses, which future research could examine, in the quest to ascertain whether and to what extent an unregulated AV corporate-ownership regime will contribute to negative externalities. I propose two main research directions.

4.1 Trip forecasts

The first hypothesis worth examining is whether unregulated corporate ownership will increase congestion by prolonging trips. One way to test this hypothesis is to compare travel forecasts for two scenarios within a single metropolitan area: a regulated scenario, in which maximum efficiency is sought (i.e. shortest travel time), and an unregulated scenario, in which corporate owner are free to prolong trips. Since the goal is to compare the differences in overall congestion, a 4-step model

may be appropriate for the task. The advantage of the 4-step model is that it is already designed to optimize for shortest travel time (similar to criterion 1 in section 1.1 above), and therefore can represent the regulated scenario without modifications. In the unregulated scenario, the 4-step model will need to be adjusted so that it optimizes both travel time and the maximization of passengers' exposure time to tailored content (see criterion 2 in section 1.1 above). A comparison of the two travel forecasts could shed more light on how corporate interests might increase congestion at the metropolitan level.

Another hypothesis raised in this paper is that corporate owners may increase marginal addition to travel time as trip length grows, thus worsening congestion (e.g. a shorter trip incurs an additional 0.5 minute whereas a longer trip incurs an additional 4 minutes, see Table 1). Sprawled environments generate longer trips to begin with, and lengthening travel time in an unregulated AV market might make congestion worse. Testing this hypothesis could be carried out by replicating the methodology above of comparing the regulated/unregulated travel forecasts, across different city sizes and city densities. This methodology may help detect the extent to which low-density areas will be prone to longer trips and more congestion in an unregulated AV market, compared to a regulated market.

4.2 Passenger behavior

Another avenue for further research is the effect of the in-vehicle environment on passenger behavior, both during the ride and in structuring daily travel choices. With respect to in-vehicle behavior, a third hypothesis raised in this paper is that passengers will accept small additions to travel time when they are engaged with social media or immersive technologies during the trip. There are actually two variations to this hypothesis: first, that passengers will be willing to accept small additions to travel time because they will be distracted by social media or immersive technologies. Second, that because traffic will be dynamic, it will be difficult (or impossible) for passengers to detect when a trip is unnecessarily prolonged. Future simulations could test these hypotheses by modelling various AV operational scenarios that examine in-vehicle behaviour, specifically single-riders' engagement with social media and immersive technologies. This would provide a better understanding of the extent to which the attention economy may exploit the passenger's distraction and prolong the trip. Simulations could also model various AV interior designs, such as immersive technologies or built-in screens, to determine the extent to which immersive environments amplify the attention economy's hold over the passenger (compared to handhelds for example).

With respect to daily travel choices, a fourth hypothesis raised in this paper is that disadvantaged populations may suffer longer travel times disproportionately, since they will be unable to purchase ad-free subscription plans. Testing this hypothesis may combine revealed preference studies on vulnerability to tailored content with stated choice experiments about willingness to purchase ad-free travel subscriptions that guarantee shorter trips. Additionally, an activity based model, which is sensitive to socio-economic circumstances, can be designed to represent situations in which disadvantaged populations involuntarily accept tailored content and longer trips, whereas well-off populations purchase ad-free subscriptions and therefore enjoy shorter trips. This may shed more light on how different payment regimes that target different socio-economic groups affect metropolitan travel patterns.

5. Conclusions

Ownership paradigms of automated vehicles may have negative implications for congestion, travel

time, well-being and social justice. Specifically, this paper argues that to the extent that corporate owners will be free to capitalize on the potential of AV interiors and on their ability to exploit passengers' attention, this could generate negative externalities that have been unaccounted for in previous studies. It could be argued that the negative externalities discussed in section 2, especially those negative externalities pertaining to well-being and social injustice, are relevant not just for corporate ownership but rather to any type of AV travel, whether corporate or privately owned. The point, I think, of discussing these negative externalities in the context of corporate ownership is that this type of ownership may exacerbate these externalities compared to private ownership. First, corporate interests may lead to longer trips, thereby contributing to more congestion and less well-being compared to private ownership of AVs. Second, corporates may exploit disadvantaged populations' vulnerability to targeted advertising through unfavourable payment schemes, leading to widening social gaps.

In closing, the insights of this paper strengthen the urgent need for public sector governance to define the institutional setting within which smart mobility can deliver sustainability mobility options (Hensher, 2018; Lyons, 2018). Yet governments in most instances avoid stringent measures in order to promote AV developments and the majority of responses are non-binding and focus on creating councils or working groups to better explore AV implications (Taeihagh & Lim, 2019). This paper adds to the growing concerns regarding the lack of comprehensive regulation, by urging the need to develop regulatory mechanisms to ensure that the goals of sustainability, well-being and social justice are not jeopardized in future automated mobility paradigms.

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