Electric vehicles in ridehailing applications: Insights from a Fall 2019 survey of Lyft and Uber drivers in Los Angeles

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EXECUTIVE SUMMARY

Battery electric vehicles (simply EVs here) are considered a critical piece in a sustainable personal transportation infrastructure. Basic economic intuition suggests that the more intensive the utilization of a capital investment, the quicker the return on that investment. From this simple logic, it is evident that EVs that are driven more will payback faster (relative to a gasoline or diesel-powered vehicle) and furthermore, also deliver greater life cycle cost savings and emissions reductions relative to EVs that are driven less. However, public policies to support EV adoption to date have not tried to target those individuals or applications that entail greater vehicle utilization, such as taxi and ridehailing vehicles (like those driven for Lyft and Uber), and related on-demand services (e.g. food delivery). Furthermore, since vehicle owners in such services tend to have lower incomes than the typical EV owning household today, shifting policies to help such users adopt EVs would not only deliver greater fuel and cost savings, and environmental benefits, but also make EV and alternative vehicle policies more equitable. Last but not least, new research shows that electrification of ridehailing and taxi fleets could be achieved at little or no additional cost of service.

The state of California has long been a leader in devising a comprehensive and multi-pronged approach to increase the adoption of zero emission vehicles (ZEV) for personal transportation (specifically, through policies such as the ZEV regulation, Clean Vehicle Rebate Project (CVRP), and the more recently adopted SB1014 – The Clean Miles Standard). Even more uniquely, California seeks to ensure that public investments in pollution reduction benefit dis-advantaged and low-income groups directly through a suite of legislations and programs including SB 535, AB1550, SB1275, and again, CVRP. Notwithstanding this impressive suite of policies, there is still a need for additional targeted measures aimed at lower-income and high-mileage drivers.

Given this context, the objective of our research was to understand the potential of, as well as the barriers to, the adoption of EVs in ridehailing and related high-use applications. As our detailed literature review shows, there has been limited empirical assessment in this specific context of EVs. In this report we describe the results and findings from a structured questionnaire-based survey of 195 Lyft and Uber drivers in Los Angeles, and an online survey of 396 individuals (not exclusively from Los Angeles region) who report driving more than 60 miles per day but are not employed in the ride-hailing services sector. These surveys were conducted between September through December 2019.

Our work reveals the following. A substantial portion of ridehailing vehicles clock over 3X the miles of the typical household vehicle and possibly even 4X that of the average EV vehicle today. Electrifying these vehicles would therefore deliver 3X to 4X faster payback, environmental benefits and greater life cycle cost savings. Owners of these vehicles are lower income relative to the typical EV owner and so the upfront cost barrier looms larger. Our findings also show that ridehailing drivers care for the environment and want to contribute to reducing pollution from driving and be socially responsible citizens. However, they are concerned about running out of charge and having easy access to fast charging, don't mind spending an hour to charge up provided their charging stations offer some amenities to rest up and refresh, and desire additional compensation for green

miles among other suggestions they offer. Finally, they also seem to have incomplete and outdated information about EVs, tax incentives and short-term rental leasing options.

Based on our work, we suggest the following additional measures to accelerate EV adoption among low-income and high-mileage vehicle owners. Firstly, ridehailing drivers would directly benefit from **low interest financing to overcome credit constraints coupled with a subsidy per mile of vehicle travel**. The subsidy could be in lieu of an upfront vehicle subsidy in which case drivers would then need help financing the purchase through a loan, or better, a lease (more on this below). Alternatively, should the finances permit this could be additional to the vehicle subsidy. Given that the federal tax credit may not apply to some vehicles and given the uncertainty of the extension and level of this rebate, ZEV adoption could decline without financial help from the states. A per mile subsidy would help overcome this shortfall and direct incentives to those who would help fossil fuel use and pollution the most. See **Rajagopal and Phadke** (2019) for a detailed exposition of the practical case for a policy pivot to incentivizing electric vehicle miles travelled (eVMT).

Secondly, a complementary strategy is increasing **financial and programmatic support for leasing EVs.** Leasing could help overcome the upfront cost barrier, mitigate credit constraints, and help adopters benefit from learning-by-using akin to learning-by-doing. Since the ridehailing industry is characterized by rapid driver turn around and low retention rates (the average driver in our survey expects to work less than a year, which is close but still shorter than a 1.5 to 2 year payback to EV), leasing mitigates the risk of an investment in EV turning out to be costly in the event of an early exit from ridehailing by a driver. Our survey reveals limited knowledge about the existence of short-term rental programs including those that offer EVs in LA, such as BlueLA and Maven.

Thirdly, the **barriers to charging faced by this group of vehicle owners are different to those faced by the average EV owner** today. Most EV owners today tend to be homeowners and have access to a dedicated parking space with an electrical outlet. In contrast, the majority of ridehailing drivers reported living in rented and multi-unit dwellings. While they do seem to have access to a dedicated parking space, they may not have access to an electrical outlet or lack the freedom to install one. Furthermore, the nature of their vehicle use is such that they would still need access to charging away from home, which is what our survey respondents suggest. Furthermore, those likely to adopt EVs state a stronger preference for fast charging in contrast to the typical slower (Level 2 chargers) that seem adequate for most purely private users who own a home. See Bauer et al. (2019) who simulate an all-electric ridehailing and taxi fleet for New York and San Francisco and show that electrification can be achieved at little to no increase in cost of service.

Fourthly, our surveys reveal a need for **better information and outreach to educate** ridehailing drivers to allay concerns arising from incomplete and outdated information on the relative costs and benefits of EVs (especially for high mileage users), options to lease (which need to be expanded as mentioned above), and the various incentives and subsidies available to demonstrate how they can meet and manage their charging needs. To reiterate, educating not just the drivers but also the broader population about short-term rentals, specifically those that offer EVs, is needed.

Finally, our work highlights the **role of TNCs and private fleet operators in complementing the public investments** and programs in each of the above areas with their own investments. They have an important role in helping with the procurement and financing of EVs. Their duties include helping with leasing, making investments in charging infrastructure, more aggressively marketing their green fleets by instituting a green premium and credits for selecting greener options, and creating their own information and outreach program. Our surveys show that drivers are open to sharing their battery status information, which would allow TNCs and fleet operators to dispatch vehicles more efficiently and also direct them to nearest charging station at appropriate times. If these charging stations are convenient and drivers have access to amenities for rest and relaxation, drivers may even be willing to recharge without monetary compensation for downtime, although this would certainly help. To this end, TNCs and fleet operators should be educated to enthusiastically support these efforts considering their obligation to under policies such as the Clean Miles Standard.

The aforementioned policies and measures were quite timely even before the CoVid-19 pandemic hit as the federal incentives for producing vehicles were slowly drying up for the major EV automakers and EV owners were not high mileage users anyway. The emergence of the CoVid-19 pandemic and its economic fallout, which is likely to drastically decrease public and private funds for supporting clean technologies, coupled with the precipitous fall in oil prices due to both the collapse of OPEC and decline in oil demand, only accentuate the rationale for the policies we suggest. It has become even more important that policies target EV adoption and provide incentives to those individuals and commercial operations that are in real need of support and can deliver the most environmental benefits to society. This report provides some of the first data-driven insights on how lower-income households employed in ridehailing services can benefit economically and also deliver substantial environmental benefits rapidly and more cost-effectively, contributing to the success of California's pollution reduction goals.

1   Introduction

With six-times greater energy efficiency and emitting only a fraction of the pollution relative to the average gasoline vehicle, it is quite clear now that battery electric vehicles (simply EVs henceforth) are a central piece in a more sustainable personal transportation infrastructure. Furthermore, the last decade has witnessed a dramatic decline of over 85% in the cost of battery packs (from about $1180 per kilo Watthour (kWh) in 2010 to about $156 per kWh in 2019).[3] In fact, a National Academies study from 2015 with more conservative assumptions about battery price reduction predicted that EVs would remain costlier in the future. Indeed, this is true today even after the substantial reductions in battery cost. Just for reference, in the US, the Chevy Bolt costs 50% more than a comparable gasoline vehicle even after taking into account a $7500 federal tax credit.[4] The lower fuel and maintenance cost of an EV notwithstanding, for a typical annual vehicle usage of 10,000 miles, the excess upfront cost entails a decade long payback on investment (Rajagopal and Phadke 2019). See Figure 1 and the detailed caption for the calculations underlying this claim. Such long payback periods suggest that EVs are not a cost-effective means to reducing household expenditure on transportation, and that the motivation to adopt EVs hinges on consumers' environmental preferences. Also note that the federal tax credit expires once any given automaker achieves sales of 200,000 EVs, and its implications for EV demand are obvious. Furthermore, combining data on EV use and data from the National Household Travel Survey (NHTS) on annual average VMT per household vehicle demonstrates that annual VMT for EVs is substantially below levels of annual VMT required to justify an investment in EVs for purely private economic reasons.[5] Lastly, in the absence of a price on carbon, a large-scale transition to EVs will reduce the price of gasoline, which reduces the competitiveness of EVs. Therefore, policies such as tax credits for EV purchase appear unlikely to stimulate mass adoption without much greater subsidies.

Secondly, EV ownership is disproportionately concentrated in high-income households and communities. While this might not be surprising per se, data from the Clean Vehicle Rebate Project (CVRP) suggest that only 6% of the California rebates for PEVs were captured by households in disadvantaged communities (Williams and Anderson, 2016). Therefore, under current policies, the benefits from clean vehicle policies to low income households accrue mainly through indirect means i.e., through reduction in aggregate pollution from adoption of clean vehicles by wealthier households. Viewed through an equity and environmental justice lens, more work is urgently needed to facilitate low-income households' direct access to the benefits associated with these policies.

California has of course been a pioneer not only within the US but also globally both in terms of pursuing ambitious targets for adoption of zero emissions vehicles (ZEVs) and offering an additional subsidy of up to $2500 for EVs. Even more salient to California is a suite of policies that aim to make

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[3] https://about.bnef.com/blog/battery-pack-prices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/

[4] Assuming a retail price of $37500 for a Chevy bolt and $20000 for a comparable gasoline vehicle.

[5] For instance, according to an online survey of California PEV owners conducted by Center for Sustainable Energy in coordination with the California Air Resources Board (ARB) in the first-half of 2012, 15% of owners drove less 5475 miles per year (mpy), 66% drive less than 10950 mpy, 94% drive less than 16425 mpy. Therefore, about 70% of EV owners utilize less than half the range of the only major pure EV in the market the which was the Nissan Leaf. One might interpolate that the annual VMT of the median EV owner is about 70% that of average annual VMT for LDVs

public investments in clean technologies accessible and beneficial to lower-income and socio-economically disadvantaged communities and households, which historically only benefit indirectly from investments in cutting edge clean technologies. In this regard, legislations such as AB1550, which directs 25% of California's climate investments[6] to disadvantaged communities, the Sustainable Transportation Equity Program (STEP), which is part of the California Climate Investments, and the Clean Vehicle Rebate Project are some noteworthy initiatives that are synergistic with EV policies.

This diverse array policies notwithstanding, there is a clear need for some additional targeted measures aimed at lower-income and high-mileage drivers today, the focus here. In light of CoVid-19's economic fallout, which is likely to drastically increase scarcity of public and private funds for supporting clean technologies, coupled with the precipitous fall in oil prices both due to the collapse of OPEC and decline in oil demand, it is imperative that policymakers target EV adoption ever more precisely on those segments of society that are both in real need of support and can deliver the most environmental benefits. In this context, this work provides some of the first data-driven insights on how the lower-income households employed in providing ridehailing services can both benefit economically and deliver substantial environmental benefits to society rapidly and more cost-effectively and contribute to the success of California's pollution reduction goals. Last but not least, research shows that electrification of ridehailing and taxi fleets can be achieved at little or no additional cost of service provision (Bauer et al. 2019).

The focus of this research is the barriers to adoption of EVs in ride-hailing applications for the following reasons. Firstly, ride-hailing is salient in that it likely entails a much higher average utilization rate for EVs. For instance, an EV operating as ride-hailing vehicle traveling 200 (electric) miles per day would travel 50000 miles per year, 5X that of a private automobile, which means both 5X faster payback (~ 2 to 3 years) and 5X less pollution.[7] Secondly, given the high turnover rate among ride-hailing drivers[8], a payback on the order of 2 to 3 years seems commensurate with their expected typical duration of employment so that they will be able to recover their investment in a short time, and then continue to derive substantial fuel savings from potentially purely personal use in the future. Thirdly, drivers of ride-hailing services belong to low-to-moderate income households. This is an assumption we will test through our surveys as there does not exist reliable, publicly available data on the economic characteristics of Lyft and Uber drivers. One of the merits of this research is to fill this data gap. Fourthly, with complete vehicle to grid integration, EVs could generate income even when not being driven just as owners of roof-top solar panels benefit from net metering policies.[9,10]

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[6] California climate investments are those funded revenues from California' Cap and Trade program (which is part of California's AB32 Global Warming Solutions Act)

[7] We chose 200 miles as it is below the range of two major pure EVs in the market today – Chevy Bolt (238 miles per full charge) and Tesla Model 3 (220 miles per full charge with a 50 kWhr battery). The calculations are based on EVCalc Tool (Rajagopal 2018) built by the PI. For more details see the caption in Figure 1

[8] https://www.cnbc.com/2017/04/20/only-4-percent-of-uber-drivers-remain-after-a-year-says-report.html

[9] Specific examples include Maven Gig, General Motors' car-sharing service for Lyft and Uber. http://www.latimes.com/business/autos/la-fi-hy-maven-gig-la-20170809-story.html

[10] See this link for a recent press release about tie-ups by Uber and Ola, a competitor in India for plans to roll out electric ride-hailing services in India https://www.reuters.com/article/us-uber-mahindra-india/uber-to-partner-with-mahindra-to-pilot-electric-vehicles-in-india-idUSKBN1DO0MQ

Assumptions for comparing the economics of elec. and gasoline vehicles		
Model input	**EV (Chevy Bolt)**	**Honda Civic**
Vehicle cost	$31,000	$19,000
Federal EV subsidy	$7,500	
Fuel economy	32 mi/gal	4 mi/kWhr
Fuel price	$3.2/gal	$ 0.1/kWhr
Annual fuel price inflation	2%	2%
Fuel carbon intensity (life cycle basis)	11600 gCO2e/gal	300 gCO2e/kWh
Maintenance cost per mile	$0.06	$0.02
Battery life (miles)		150000
Vehicle life (miles)	150000	150000
Discount rate	10%	

Figure on the right shows the exponential rate of improvement of performance with vehicle miles travelled (VMT). For instance, at 10000 miles per year, which is the annual VMT for the average US household automobile, the payback is around 15 years and the EV does not offer net savings and is in fact costlier by $2600 relative to a gasoline vehicle even after accounting for a tax credit of $7500 (See Table 1). However, for a VMT in excess of 25000 miles, the payback is less than 5 years and is cheaper to own. Table 1 additionally also shows the cost at which EV's are reducing GHG emissions, which is also exponentially decreasing with VMT. These results point to the importance of targeting high VMT applications. Of course, the calculations are sensitive to assumptions related to vehicle cost, tax credits, fuel cost, fuel economy, battery life and replacement cost etc. The basic mathematical model to calculate total life cycle cost and other financial performance metrics has been implemented as a spread tool and posted to the PI's website at https://www.ioes.ucla.edu/person/deepak-rajagopal/evcalc1-0-public/. Nevertheless, the basic point is that the potential variability that in annual average VMT across the population makes this the key variable of interest.

Performance of EV relative to a comparable gasoline vehicle under different levels of average annual vehicle use.

Annual average VMT	Average daily VMT	Battery life (years)	Simple payback (years)	Difference in TLCC ($)	Cost-effectiveness of GHG reduction ($/metric tonne of CO2eq)
5000	14	9.1304	20.87	5913.7	137.13
10000	27	4.5652	10.435	2603.1	60.362
15000	41	3.0435	6.9565	859.78	19.937
20000	55	2.2826	5.2174	-192.95	-4.4741
25000	68	1.8261	4.1739	-893.79	-20.726
30000	82	1.5217	3.4783	-1392.9	-32.3
35000	96	1.3043	2.9814	-1766.1	-40.954
40000	110	1.1413	2.6087	-2055.6	-47.666

Figure 1: Effect of vehicle miles traveled (VMT) on return on investment and cost of emissions reduction in $/metric ton of CO_2eq

The rest of the report is organized as follows. The next section provides a comprehensive overview of the literature on the socioeconomics of electric vehicles and ridehailing services. Following this in Section 3, we outline the research questions and in Section 4, we detail our research methodology and the data collection strategy – which is basically to conduct two sets of surveys – one focused on ridehailing drivers and a second focused on a comparison group involving high mileage private car owners who are not employed in the ridehailing sector. Section 5 presents the results and describes the findings. Section 6 presents some policy implications arising from this work. Section 7 concludes the report.

2   Background on the ridehailing industry and EV ownership

This section develops an understanding of the attributes of the typical EV owner in the US today and their motivations to adopt an EV. We also present a detailed profile of today's ridehailing drivers and discuss how the socio-economic and demographic attributes of these two groups compare, since this work centers on the adoption of EVs by the latter. We conclude this section with some general facts and figures about the so-called transportation networking companies (TNCs) such as Lyft and Uber.

TNC and other commercial light duty vehicles (LDVs) traverse substantially greater miles relative to typical household LDVs. It is, therefore, not surprising that users in such applications stand to gain the most in the form of life cycle cost savings from reductions in fuel and maintenance costs by

switching to EVs from gasoline vehicles (Jenn, 2019). Uber, founded in 2009, and Lyft, founded in 2012, employ a diverse, shifting, and ever-growing workforce. Indeed, there is a large amount of variability in terms of their drivers, what motivates them, their compensation, and the regional conditions in which they are working. Despite their diversity, TNC drivers are overwhelmingly reluctant to make the switch to EVs, largely due to the initial cost (Egbue & Long, 2012). This upfront cost is often prohibitive since drivers' earnings tend to be quite low, with the majority of drivers earning less than their state's minimum hourly wage (Zoepf, Chen, Adu, & Pozo, 2018). Moreover, some estimates place driver retention after one year at only 4% (McGee, 2017), which might limit the driver's return on investment over the long term. Other barriers to adoption include battery range and charging infrastructure (Egbue & Long, 2012), with the latter as the larger barrier for high mileage applications. Below, we summarize the various strands of literature on EVs and on ride-hailing, which informed the questions in our survey questionnaire (see Appendix)

2.1   Who are the EV owners today and what are their motivations to adopt an EV?

Understanding the similarities and differences between electric vehicle (EV) drivers and rideshare drivers is an important component of widespread EV acceptance in the United States. While there is a dearth of knowledge regarding ride-share drivers' environmental concern (something we seek to ascertain through our surveys), there is an abundance of information on electric vehicle (EV) drivers' environmental identity and concern. More specifically, most research outlines EV drivers' environmental attitudes in comparison to the general population. This environmental concern lends to EV drivers deriving value from their vehicle, including social value from the conspicuous promotion of their environmental identity (Han, Wang, Zhao, & Li, 2017). Indeed, environmental symbolism has been shown to be highly predictive of EV adoption, suggesting that environmental identity is highly salient among most EV drivers (White & Sintov, 2017).

Research shows that 83% of households that have purchased an EV have a yearly income higher than $100K, and 46% of these households have incomes higher than $150K (Tal, 2013). Furthermore, EV adopters are largely urban or suburban, have access to private garage with electrical power, low mileage (about 15 miles per day on average), concerned about the environment, dependence on foreign oil, political active, and have a willingness to pay for convenience (Mobile Source Technical Review Sub-committee (MSTR), 2012). Consistent with the above, they have higher levels of education relative to the average population (42% have post-graduate degree). They, however, differ insignificantly in age and marital status. When it comes to motivation for purchasing EVs, this MSTR (2012) study also reveals that 90% of EV buyers cite gas mileage compared to 40% for all buyers; environmental impact 70% v. 10%; and advanced technology 70% v. 32% (Mobile Source Technical Review Sub-committee, 2012). Furthermore, a study analyzing the consumer groups in the EV purchasing market identified three common categories of EV buyers: *Advocates* – universally committed to green (21% of study sample,) *Moderates* – sometimes committed to green (66% of study sample) and *Resisters* – consumers who do not embrace any green initiatives (13% of study sample).

In general, greater environmental concern is predictive of EV adoption; however, environmental concerns are secondary to the cost and performance of the vehicle for many (Egbue & Long, 2012). For instance, a UK study found that members of the mainstream population prioritized personal

mobility needs over the environmental benefits of EVs, and that these individuals were actually *disincentivized* by the social aspects of driving an EV (Graham-Rowe et al., 2012). For others who do possess environmental concern, the financial barriers surrounding EVs prevent their adoption (Zarazua de Rubens, 2019). That is, for individuals with restrictive incomes—such as ride-share drivers—the price of EVs can be prohibitive even for the most environmentally-oriented (Canepa, Hardman, & Tal, 2019). Still, environmental concern can also hinder the adoption of EVs for those who could otherwise afford it; some consumers believe that EVs contribute to environmental degradation, owing to electricity and battery production, as well as pollution from disposed batteries (Li, Long, Chen, & Geng, 2017). Thus, while EV drivers are on average higher in environmental concern than the general population of drivers, there are environmentalists who abstain from EV adoption *because of* environmental concern or other barriers to adoption, such as their salaries.

2.2   Who are the rideshare drivers and what are their motivations?

Of Uber's driver-partners, 19% are under age 30, and 24.5% are age 50 or older. 40% are white, 20% are black, 17% are Asian, and 18% are Hispanic. Women make up 14% of Uber's driver-partners (Hall and Krueger, 2017). Half of Uber's driver-partners are married, and 71% of Uber's driver-partners report that they support financial dependents (Hall and Krueger, 2017). Prior to partnering with Uber, 6% of drivers were students, 4% were retired, and 3% were stay-at-home parents (Hall and Krueger, 2017). Among those working prior to partnering with Uber, 81% reported that they had a permanent job, and many continued their employment while partnering with Uber (Hall and Krueger, 2017). Nearly 20% of drivers had worked in transportation services previously, and 28% had worked as a driver at some point in their career, but no other industry accounted for more than 10% of drivers' previous jobs, indicating the wide variability among the driver population (Hall and Krueger, 2017). Because only 25% of survey respondents were actively looking for a full-time job, another 25% were looking for a part-time job, and 10% were looking for either a part- or full-time job, it is possible that Uber provided an opportunity that engaged many people to work a second job who might not have done so otherwise (Hall and Krueger, 2017). In 2015, 52% of driver-partners worked full-time on another job, 14% of driver-partners had a part-time job apart from partnering with Uber, and 33% of driver-partners had no other job (Hall and Krueger, 2017). Not surprisingly, only 13% of those who reported having another part-time job, and 3% of those who reported having another full-time job worked more than 35 hours a week on average (Hall and Krueger, 2017).

The most common driver motivations to work for Uber were "to earn more income to better support myself or my family" (91%); "to be my own boss and set my own schedule" (87%); "to have more flexibility in my schedule and balance my work with my life and family" (85%); and "to help maintain a steady income because other sources of income are unstable/unpredictable" (74%) (Hall and Krueger, 2017). 48% of driver-partners view income earned on the Uber platform as a supplement to their income but not a significant source (Hall and Krueger, 2017).

Though it is difficult to calculate the number of drivers at any given time because many will drive only every few months, a study calculated the number of driver-partners who provided at least four trips to passengers in a given month (Hall & Krueger, 2017). Drivers are also somewhat evenly distributed according to the United States population centers (Hall & Krueger, 2017). More than

460,000 drivers in the United States actively drove with Uber by the end of 2015, and the number approximately doubled every six months from 2012 to 2015. At this growth rate, every American will be an Uber driver within five years—the growth rate will inevitably slow down. Uber drivers are spread throughout the age and race distributions, mirroring the workforce as a whole.

However, while staggering numbers of people have tested the waters of rideshare driving, 73.3% of all drivers are inactive and eventually stop driving (Kooti, 2017). About 11% of driver-partners became inactive after one-month of using the service (Cook et al., 2018). After half a year, 70% of drivers are still active, but only a little over half were still active after a year, and less than one-third were active after two years (Cook et al., 2018). The temporary nature of the job has been attributed to lack of driver retention. Drivers with at least 2,500 trips earn about $3 per hour (more than 10%) more than a driver in his or her first 500 trips (Cook et al., 2018). This is attributed to better allocation of driving time during surge hours, etc. and strategically accepting and denying rides. Those who tend to persist longer tend to be older; the average age of an inactive driver is 37.1, while a high-activity driver's average age is 43.6 (Kooti, 2017). According to a popular blog "The Rideshare Guy" maintained by Harry Campbell, who is a former ride-hailing driver, the top reasons why drivers quit are: poor customer support, an unreasonable ratings system that requires drivers maintain a lofty 4.6 rating, fare reductions that hurt driver earnings, income variability and drops after sign-up bonuses, as well as weak training and mentoring (although Lyft does report having a mentor program) (Rideshare Guy, 2016).

Amongst the millions of existing and previous rideshare drivers, there tends to be high variability in the motivations for participating in the industry (Rosenblat, 2016). A root of this variability could be based on the drivers' characteristics—are they categorized as a hobbyist, part-time or full-time earner, a driver in transition? These are just to name a few (Rosenblat, 2016). Retirees' motivations tend to fall along the lines of wanting to keep busy in their spare time. Some drivers are motivated by social reasons such as having no one at home to interact with, or maybe they simply own a car that they feel they aren't putting enough use into (Rosenblat, 2016). Other motivations include needing an income while making a career transition, capitalizing on the technology boom, having autonomy over scheduling and flexibility, and learning a new language (Rosenblat, 2016). For most respondents in this study, the decision to become a driver was influenced by the conditions of another job/other employment opportunities (Rosenblat, 2016).

Berliner found that motivations to drive can be explained by three broad areas: attitudes, socio-demographics, and personal travel choices (Berliner, 2018). In this study, key motivators were the desire to earn money, the enjoyment of driving, meeting new people, and offsetting the cost of owning a vehicle. They also found that being a parent/having more children requires a more flexible job, so parents were more likely to become rideshare divers (Berliner, 2018). Another statistic that suggests flexibility/ease of employment is a key motivator a higher percentage of Uber drivers are veterans (7%) compared to all workers (5.2%)(Berliner, 2018). In addition, trust, time benefit, economic benefit, and transportation anxiety were all found to be important promoters of rideshare driving (Amirkiaee & Evangelopoulos, 2018).

A series of case studies by Alex Rosenblat and Tim Hwang examining regional diversity in autonomy and work among Lyft and Uber drivers determined five main subsets of driver motivation (Rosenblat and Hwang, 2016). Career transition, or relying on driving in the short-term to subsidize income in between jobs, is one common driver motivation. A 2018 study determined that only 8% of drivers were unemployed just before they started working for Uber (Hall and Krueger, 2017). Additionally, some drivers, such as retirees, work in the industry as a 'hobby' in order to keep busy or meet people but are not dependent on the employment for income. Additional subsets include driving to support small businesses within the community, using the employment opportunity to practice learning a new language, or finding an opportunity to work when one does not speak English as a first language, since the majority of the transaction is automated. Finally, there is the perception that driving for Lyft and Uber provides worker autonomy and flexibility and allows drivers to 'be their own boss'—a perception that is debated among drivers and economists (Rosenblat and Hwang, 2016). 42% of women and 29% of men said that a major reason for driving with Uber was that they "can only work part-time or flexible schedules" because of "family, education, or health reasons" (Hall and Krueger, 2017).

All in all, pay and flexibility seem to be the top motivators (Hall and Krueger, 2018; Rideshare Guy, 2018). Traditional motivators for work tend to be the desire for interesting work, self-expression, satisfaction, pay, security, and co-workers (Center and Bugental, 1966). However, pay, security, and co-workers are much higher motivators for blue-collar workers than white-collar workers, and vice versa for interesting work, self-expression, and satisfaction (Center and Bugental, 1966).

2.3   Comparison of EV owners and rideshare driver demographics

Overall, EV drivers have significantly higher income than the general population, but how this compares with rideshare drivers' incomes is difficult to determine as most studies on rideshare drivers have focused on income earned through driving, but have not sought to capture entire income from other jobs, which the majority of rideshare drivers hold. Overall, EV drivers are significantly older than the general population, while rideshare drivers are slightly younger than the average American. Overall, EV drivers are significantly more educated than general population (86% college or higher vs 41.1%), while rideshare drivers are slightly more educated than general population (47.8% college or higher vs 41.1%) (Farkas & Shic Shin, 2018; Hall & Krueger, 2017; U.S. Census Bureau, 2018). Additionally, only 25% of EV drivers are female and 13.8% of rideshare drivers are female relative to 50.8% of Americans (Farkas & Shic Shin, 2018; Hall & Krueger, 2017; U.S. Census Bureau, 2018). The majority of EV drivers and the general population is white while ˜60% of rideshare drivers are non-white (Farkas & Shic Shin, 2018; Hall & Krueger, 2017; U.S. Census Bureau, 2018). The family makeup of rideshare drivers is similar to that of the general population, while a significantly higher proportion of EV drivers are married (85%) (Farkas & Shic Shin, 2018). While the majority of EV drivers are liberal compared to a majority conservative nation, there is no information readily available on the political orientation of rideshare drivers.

Table 1 Summary of the estimates from the literature on demographics of rideshare and EV drivers.

Demographic Breakdown	Rideshare Drivers	EV Driver	General Population
Total Population	Estimated 3 million uber drivers worldwide (1 million U.S) and 700,000 Lyft Drivers. Since 60% drive for both, likely 400,000-600,000 Rideshare drivers in the U.S.	Outlook projects 4 million EV sales in 2020	327,167,434
Median Household Income	Lyft: $17.50 per hour Uber: $15.68 per hour	32% >100K 39% 100K-200K 17% 200K + 12% preferred not to answer	$57,652
Age	19.1% 18-29 30.1% 30-39 26.3% 40-49 21.8% 50-64 2.7% 65+	10.5% 18-29 24.1% 30-39 22.8% 40-49 19.4% 50-59 22.4% 60+	21.8% 18-29 22.5% 30-39 23.4% 40-49 26.9% 50-64 4.6% 65+
Education	3% <high school 9.2% high school 40% some college 36.9% college degree 10.9% postgrad	0.2% <high school 6.6% high school 6.2% some college 28% college degree 58.9% postgrad	9.3% <high school 21.3% high school 28.4% some college 25.1% college degree 16% postgrad
Political Orientation	Information unavailable	13.9% Conservative 21.4% Independent 51.6% Liberal	35% Conservative 35% Moderate 26% Liberal (2019 Gallup Poll)
Gender	13.8% Female	25% Female	50.8% Female
Race	40.3% White 19.5% Black 16.5% Asian 17.7% Hispanic	85% White 4.1% Black 6.6% Asian 2.3% Hispanic	55.8% White 15.2% Black 7.6% Asian 19.5% Hispanic
Family	50.4% Married; 46.4% Have children at home.	85% Married	52.6% Married; 42.2% Have children at home.

2.4 What it means to drive for Lyft and Uber

According to a study by Cook et al. (2018) the average weekly earnings for US drivers was around $376, with an hourly earning rate of $21.07 over 17.06 hours driven per week. Additionally, the average driver makes just under 30 trips per week. There are variations in earnings and trips by gender, however, with men earning roughly 7% more per hour than women; they are also less likely to stop driving for Uber than women—65% of men stop after 6 months, whereas 76.5% of women stop after the same length of time. These differences may be attributed to males' willingness to drive in more profitable locations, such as areas with high rates of violence and crime and more alcohol-serving businesses. Below is a table excerpted from this study.

Table 2: Excerpted table from a study by Cook et al. (2018)

	All	Men	Women
Weekly earnings	$376.38	$397.68	$268.18
Hourly earnings	$21.07	$21.28	$20.04
Hours per week	17.06	17.98	12.82
Trips per week	29.83	31.52	21.83
6 month attrition rate	68.1%	65.0%	76.5%
Number of drivers	1,873,474	1,361,289	512,185
Number driver/weeks	24,832,168	20,210,399	4,621,760
Number of Uber trips	740,627,707	646,965,269	93,662,438

There is extreme variation in the number of hours worked by rideshare drivers, while individual drivers exhibit somewhat similar driving patterns week-to-week (Chen et al., 2018). Additionally, men drive, on average, about 5 hours more per week than women (Cook et al., 2018). An overwhelming majority of the drivers work part-time on the platform (Chen et al. 2018).

Driver compensation comes in the form of ride payment, tips, and bonuses for both Lyft and Uber. Ride payment is calculated from a base fare, the cost per mile, and the cost per minute. The rate drivers are paid varies by the city in which they drive. Tips are determined by the individual rider and vary substantially. Bonuses are given by both Lyft and Uber for variables such as length of time one has been driving with the platform, hours driven per week, driver rating, etc. A new Uber Pro system has been tested in a variety of cities across the United States starting in November 2018 that allows drivers to unlock rewards if they have high ratings (above 4.85 stars) and low cancellation rates (below 4%) (Lekach, 2018). Lyft also implements similar hourly bonuses for their drivers. There are also refer codes that reward the new referral as well as the referee, in addition to starting bonuses (Rideshareguy.com, 2018). While these bonuses appear attractive to drivers, a study showed that these bonuses account for less than 9% of drivers' total weekly earnings (Cook et al., 2018).

While Uber brands itself as an intermediary between drivers and passengers, Lyft and Uber use various mechanisms to control their workforce, and therefore "algorithmic management cannot be conflated with worker autonomy" ("The Truth About How Uber's App Manages Drivers," 2016, p.1). Uber's driver-partners are not reimbursed for their driving expenses, such as gasoline, maintenance,

depreciation, or insurance (Hall and Krueger, 2017). In addition, there are unpaid rider cancellation fees, and GPS issues that fail to calculate the entire trip, often calculating the ride cost with a straight line rather than the actual route travelled ("How Can Wage Theft Emerge in App Mediated Work," 2016). A study using American Automobile Association's (AAA) "Your Driving Costs" reports in combination with data from the Uber app calculated average cost to drivers per vehicle type (Hall and Krueger, 2017).

Uber utilizes a "choice architecture" through tools like the rating system, performance targets and policies, algorithmic surge pricing, and insistent messaging and behavioral nudges on how to get 5-star ratings ("The Truth About How Uber's App Manages Drivers," 2016). Uber also has a list of eligible cars of specific makes and years in each city, shifting vehicle costs to their employees. On their website, they claim drivers without cars can rent "affordable, low-commitment cars from our vehicle partners (Fair, Getaround, Hertz)," but in the fine print at the bottom of the webpage states "drivers renting with any vehicle partner qualify for trip surge areas, but except as specified above may not qualify to participate in other promotional offers such as Boost, Consecutive Trips, or Quest promotions" ("Need a Car to Earn?" 2019). These various tools steer drivers to drive particular vehicles, work at particular places and drive at particular times, all while maintaining that their workers are in control and simply using the Uber app as an intermediary ("The Truth About How Uber's App Manages Drivers," 2016).

Inherent in the business model is the reality that workers are willing to assume the burden of risks and costs associated with driving for the company. By nesting themselves in a "legal void" protected from industry regulation and employer responsibilities, the drivers cannot receive the same rights as typical employees ("The Truth About How Uber's App Manages Drivers," 2016). In return, drivers are supposedly given autonomy, however the employers still seek to control when and how drivers drive through the promise of higher surge pricing, during high-demand times, such as on weekends, holidays, and late at night. However, drivers' perceptions of these, shown by warnings to "don't chase the surge" on rideshare driver blogs are reflective of studies finding the promise of higher pay is unreliable. For example, if too many drivers converge at a surging area, there is a risk that they will find the supply is no longer too low and the surge premium had disappeared ("The Truth About How Uber's App Manages Drivers," 2016). Additionally, because the promise of higher wages is based on passenger (not driver) location, drivers traveling to surge zones in search of fares advertised at a given rate would still receive ride requests from passengers in adjacent non-surging areas and have to stop to pick them, or risk their cancellation rate go up, which can harm ratings.

Furthermore, employment is contingent upon ratings: drivers who average a rating below 4.7 stars are automatically "deactivated" and banned from driving for Uber ("The Truth About How Uber's App Manages Drivers," 2016). The lack of employer protections and benefits make driving for Lyft and Uber a risky and a fairly unreliable source of income, which may explain why many drive for a short time, as a hobby or way to earn extra money, or when they lack other employment options ("The Truth About How Uber's App Manages Drivers," 2016). Still, because most drivers do not rely on Uber as their primary source of income, overall, 81% of driver-partners said they are very satisfied or somewhat satisfied with Uber in 2015 (John & Alan, n.d.)

Additionally, regional differences have important equity and regulatory implications for Lyft and Uber drivers. Some class-action lawsuits dealing with employee misclassification have been brought up, arguing that Uber unlawfully classifies their drivers as independent contractors instead of employees, allowing them to evade the costly protections and benefits guaranteed to workers in a standard employer-employee relationship (Isaac, 2014). Uber also exempts itself from expensive taxi laws and regulations by classifying itself has a "technology company" instead of a transportation company (Isaac, 2014). Platform trust is also an issue—for example, drivers in Montreal operate in secret as Uber is outlawed in the area (Isaac, 2014). The driver-employer relationship varies across regions, and can be either fractured and contentious, in alliance with, or generally neutral in the local context. This leads to drivers having vastly different experiences of working conditions and community, from collaborative co-work to relative isolation (Isaac, 2014; Rosenblat and Hwang, 2016).

Drivers have noted that the employee relations and evaluation process with Lyft is more holistic from a human perspective than Uber's. For example, Lyft offers a link to driver forums in which you can interact with the Lyft driver community, and the screening process involves a ride with a Lyft representative, while Uber's screening process is done entirely online (Shanan, 2019). Additionally, Lyft encourages driver tips via the app, whereas Uber discourages them by saying they are not necessary and not including the option in the app. Still, neither Lyft or Uber drivers get health insurance or other normal employee benefits. Finally, Lyft seeks to differentiate itself from Uber by offering more robust green initiatives than its competitor.

2.5   The Role of Charging Infrastructure

Limited range, recharge time, and lack of charging infrastructure are some of the main barriers to EV adoption that drivers identify. Efficient charging infrastructure is essential for large-scale EV adoption among rideshare drivers and the general population. Research on driver charging patterns can help urban planners make more informed spatial decisions involving the distribution of charging stations. Policy-makers must consider existing charging infrastructure, the time of day when charging demands peak, and where this demand is highest.

Range anxiety is a major barrier to EV adoption and plays an even more significant role for rideshare drivers who must drive more miles than the typical driver per day (Young & Ernst, 2017). In fact, a recent survey among British drivers revealed that concerns regarding local access to rechargers and vehicle range are a larger concern than vehicle cost (Broadbent, G.H., Drozdzewski, D., Metternicht, G., 2017). Yet, the majority of mainstream consumers have low awareness of the availability and logistics of charging infrastructure for EVs and overestimate the number of miles they drive per day (Hardman, 2018). In Europe, a survey of 4,000 respondents interviewed (1,000 from the US, 1,000 from Europe, 1,000 from China, and 1,000 from Japan), showed that 60% of drivers would not consider a driving range of less than 100 miles acceptable, despite only 2% driving over 100 miles a day (Young & Ernst, 2017). Additionally, only 33% of U.S. respondents said they would be willing to pay for charging infrastructure in their communities (Young & Ernst, 2017).

A 2018 survey of taxi drivers for Yellow Cab Columbus (YCC) revealed that while 50% of respondents said they would seriously consider switching to an EV, 35% of respondents felt that lack of charging infrastructure was the largest barrier to adopting EVs, followed by perceived disadvantages of the limited range and time to recharge (Scott, Busco, & Hampshire, 2018). In fact, recent modelling showed investment in recharge stations was three times more effective than subsidizing EV purchases (Broadbent et al., 2017). The study concluded that placing DC Fast chargers in the downtown Columbus area and Grandview Yard—areas relatively close to major highways—would be most the most successful locations for charging stations, as these are areas where breaks during shifts can be taken (Scott, Busco, & Hampshire, 2018). In California, 40% of the population lives in multi-residential buildings, which creates an opportunity for increased installation of rechargers near apartment complexes due to legislation passed in 2014 (Broadbent et al., 2017). Businesses may also install rechargers, allowing drivers to recharge at workplaces, although this would likely be unhelpful for rideshare drivers during their workday (Broadbent et al., 2017).

Lyft and Uber both report that most of their drivers lack access to at-home charging stations and would need to rely upon public charging ports if they were to adopt EVs (Purchia, 2019). Compared to the average EV, those owned by TNC drivers would need to be charged more frequently owing to their increased use. More specifically, TNC EVs need to be charged at different times of day and make more stops at public charging stations (2.5 per day) compared to other EVs (Jenn, 2019). The increased need to charge one's EV translates to a loss in earning time, as recharging is a more time-intensive process than refueling with gasoline (Ke, Cen, Yang, Chen, & Ye, 2019; Lane et al., 2018). It follows that TNC EV drivers must be more cognizant of their driving distance and must pre-coordinate a time and location for the recharging of their vehicle (Ke et al., 2019). For TNC drivers who do choose to adopt EVs, this planning can be made especially difficult due to "saturation" at certain chargers by other TNC drivers (Jenn, 2019). This is suggestive of a general shortage of EV charging stations in areas where they are most needed by TNC drivers, which presents yet another barrier to EV adoption.

There are various options when it comes to vehicles and chargers among EV drivers (Hardman, 2018). Battery-Electric-Vehicles (BEVs) are powered only by a large battery pack (17–100 kWh), and typically have a driving range of between 70 and 120 miles, with some vehicles now having ranges of 200–300 miles (Hardman, 2018). Plug-in Hybrid-Electric-Vehicles (PHEVs) have a smaller battery pack (4-17kWh) and an internal combustion engine (ICE), with an electric driving range of 10 to 50 miles (Hardman, 2018). The charge time of all EVs depends primarily on the charge level of the battery, the technology in the car (limited by ability of the battery to accept a high charge rate), the charging cable used, and the charging station (Electric Vehicle Supply Equipment, EVSE) (Hardman, 2018).

Level 2 chargers add about 25 miles of range to the Bolt EV for every hour of charge (Scott, Busco, & Hampshire, 2018). An option for faster charging is the DC Fast charger which adds roughly 90 miles of range in half an hour (Scott, Busco, & Hampshire, 2018). For rideshare drivers, the DC Fast charger appears to be a better option if taking a break to recharge in between shifts, while a Level 2 charger is perhaps a better option for home among rideshare drivers (Scott, Busco, & Hampshire, 2018). Fast chargers can help negative consumer perceptions regarding charging times (Hardman, 2018). For

reference, the average cost to add 50 miles of range on a gas-powered vehicle is $4.76, while adding 50 miles of range on a Level 2 and DC fast costs about $1.18 and $2.66, respectively (Scott, Busco, & Hampshire, 2018). A modelling study revealed that 500 optimally located fast chargers could support 500,000 PEVS (Hardman, 2018). Below is a table describing the 4 modes of charging, the power associated with these levels, the typical locations of the chargers, and the time to charge 100 miles of range (Hardman, 2018). For reference, a full-time rideshare driver is estimated to drive between 200 and 300 miles a day (Hardman, 2018).

There is a direct correlation between investment in charging infrastructure (both Level 2 and DC fast chargers) and EV market share globally. The figure below depicts EV adoption and public charging infrastructure development in the top EV markets by share of new vehicles in 2016. (Hall and Lutsey, 2017).
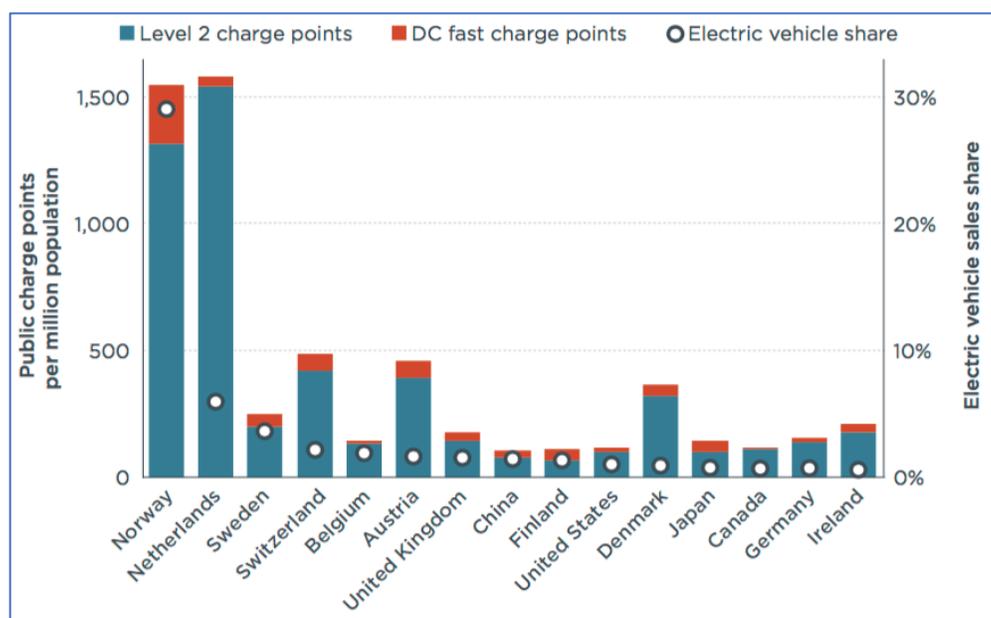
Figure 2: Figure Excerpted from Hall and Lutsey 2017 showing public charge points, speed of chargers and EV sales in different countries around the world.

Overall, while EV adoption leads to large savings in the long run, research shows that range anxiety is a real concern, and that in order to promote EV adoption among rideshare drivers there must be a significant increase in accessibility to charging infrastructure.

2.6   Fleet composition and Rental programs

In terms of fleets, there is sparse data on what cars Lyft and Uber drivers are most often driving. However, the top three appear to be, in order, the Toyota Prius, Honda Civic, and Toyota Camry. In an analysis by "The Rideshare Guy," the Toyota Prius is the "perfect car" for a rideshare driver when

considering initial purchase price, cost of fuel, etc., (Rideshareguy.com, 2018). For "green" incentive programs, Lyft recently introduced what is called "Green Mode" in February 2019 (Siddiqui, 2019). This program will introduce thousands of electric vehicles to Lyft's driver rental program, Express Drive. Drivers will pay less in rental fees when they borrow an electric vehicle and unlimited charging is included (Siddiqui, 2019). Lyft will also integrate the hybrid and electric vehicles that are already used by their drivers into the incentive program as well. This is currently being piloted in Seattle (Siddiqui, 2019). Uber has some green initiatives as well, but their biggest venture is currently overseas in London (Feld, 2018).

2.6.1   Uber Rental programs

Uber offers a rental program allowing drivers without cars to rent affordable, low-commitment cars from its vehicle partners: Fair, Getaround, and Hertz. To incentivize drivers to rent from Fair, drivers will receive an extra $185 from Uber if they complete 70 trips a week, and an extra $305 if they drive 120 trips in a week. This money could cover the weekly car payments, which can be as low as $90 a week. This service is available exclusively in California to drivers in the Inland Empire (CA), Los Angeles, Orange County, Sacramento, San Diego, and the San Francisco Bay Area ("Need a Car to Earn?" 2019). The following EVs were included in the Fair fleet as options for Uber drivers to rent: 2015 Nissan Leaf-S ($150/week), 2016 Kia Soul E+ ($150/week), 2014 Ford Focus Electric ($190/week), 2016 Nissan Leaf-SV ($210/week), 2017 Nissan Leaf-SV ($240/week), and the 2016 Nissan Leaf SL ($240/week). It is expensive to rent an EV with Fair relative to non-EVs, which could be a barrier to EV rental for rideshare drivers. Out of 7,214 vehicles offered by Fair, only 7 were EVs.

Getaround offers a free first day to rideshare drivers renting and offers prices as low as $5 an hour. Getaround is offered in more locations, including Atlanta, Boston, Denver, LA, Philadelphia, San Diego, San Francisco and Washington D.C. Additionally, Getaround allows people to list their cars and earn money when others rent their vehicles, which makes it difficult to track the proportion of EVs in the fleet. However, EVs are significantly more expensive to rent with Getaround relative to the non-EV car. For example, a 2013 Tesla Model S had a 6-hour minimum rental and a 6 hour trip would have cost $197.76, compared to other vehicles which cost as low as $5 an hour.

The Hertz rental partnership is widely available in Atlanta, Austin, Boston, Chicago, Denver, Los Angeles, Miami, New Orleans, Orange County, San Antonio, San Diego, the San Francisco Bay Area, and Seattle. It also comes with significantly higher driver costs: The Hertz weekly rental base rate is $214 per week. This excludes taxes, fees, gas, and other additional charges. A $200 refundable security deposit is also collected by Hertz when drivers pick up the car. Only vehicles classified as "intermediate vehicles" can be rented as a rideshare driver, which excludes EVs. In conclusion, cost and availability can be a significant barrier to EV renting for Uber drivers.

2.6.2   Lyft Driver Rental Programs

Lyft offers a rental program called Express Drive that comes with unlimited miles, so drivers can earn with Lyft *and* drive for personal use. Lyft partners with Hertz, Flexdrive, and Avis. Drivers are required to give a minimum of 20 rides each week. Rental costs are subtracted from weekly earnings.

The program is currently live in: Atlanta, Austin, Baltimore, Boston, Charlotte, Chicago, Dallas/Fort Worth, Denver, Detroit, Houston, Las Vegas, Los Angeles, Miami, Nashville, New Orleans, New York, Orange County, Orlando, Philadelphia, Phoenix, Pittsburgh, Portland, Richmond, Sacramento, Salt Lake City, San Antonio, San Diego, San Francisco, San Jose, Seattle, Tacoma, Tampa Bay, and Washington, D.C. Drivers must be at least 25 to participate. Lyft has been publicly promoting EV rentals as part of their green initiatives. According to a spokesperson for Lyft, "drivers consistently tell us they want to increase their hourly net earnings by lowering fuel costs. In addition, over 80% of those drivers told us they favor eco-friendly vehicle options" (Shanan, 2019). In order to launch this program, Lyft will include unlimited charging in the weekly rental rate. Lyft maintains that "since electricity is less expensive than gasoline and EVs are significantly more fuel-efficient than conventional vehicles, the typical cost to travel in an EV is half that of traveling in a gasoline-powered car. Combining lower fuel costs with affordable rental rates, we anticipate that individual drivers can save hundreds of dollars per month, and thousands of dollars per year, on fuel costs alone" (Shanan, 2019). Express Drive EVs will be introduced throughout the year and are already in Seattle and Atlanta fleets (Shanan, 2019). Additionally, Lyft is looking to sustainability as a differentiator from their more successful competitor, Uber. This year, Lyft hired a company called 3Degrees to oversee carbon-offset investments that include efforts to reduce pollution in auto manufacturing and promote forest conservation (Shanan, 2019).

A journalist for CleanTechnica interviewing riders regarding Lyft's green initiatives (as she drove for Lyft using an electric car) said she would generally mention to riders that we were in an all-electric car as a slight educational tool and an effort to promote EVs. This stimulated a line of questions many times — *How long does a charge last? Where do you charge? How far can you drive on a charge? How long does it take you to charge?* – demonstrating rider, and potential driver, perceptions and concerns regarding EVs (Shahan, 2019).

In summary, the comprehensive review of the literature we undertook reveals several important intuitive insights into what might be the barriers to adoption of EVs in ride-hailing applications. However, the current body of literature appears to lack a rigorous study focused exclusively on understanding the perceptions of ride-hailing drivers towards EVs and how public policy may help overcome the barriers to adopting EVs. While our focus is primarily EVs, we also hope to uncover new insights on the economics of ride-hailing that might suggest public policies that generally improve the economic outcomes for all ride-hailing drivers.

3 Research objectives

1. Develop a detailed understanding of the economic realities and constraints that ride-hailing drivers confront and their decision-making process in choosing to work in this sector. While there have been several reports in the popular press on driver earnings and their economic conditions, there has been little, if any, systematic research focused on the motivations, behaviors, and travel patterns of ride-hailing drivers (Shaheen, Chan and Rayle 2017).

2. Identify the biggest opportunities for and barriers to EV adoption among ride-hailing drivers. For instance, how do different potential concerns such as vehicle cost, electricity price, access to low-

cost financing, long payback periods, expected duration of employment in the ride-hailing sector, range concerns, and access to fast charging rank relative to each other? Some specific related hypotheses we will test include: i) Drivers who spend more hours driving are more likely to adopt EVs; ii) Adoption is more likely when drivers are assured of easy access to fast-charging; iii) Drivers are more likely to adopt EVs when presented with a payback period that is shorter than their expected duration of employment as a ride-hailing driver; iv) Drivers are more likely to adopt EVs if they feel confident in being able to drive the requisite miles within a reasonable amount of time.

3. What additional targeted public policies and city-level planning and investment are needed to overcome the key barriers identified above? Some specific related hypotheses we will test include i) Drivers perceive fast charging as more important than free charging; ii) Convenient access to a public fast charging network can mitigate the need for costly investments at an individual home or multi-family dwelling; iii) Drivers are more likely to consider leasing EVs than purchasing EVs; iv) Drivers are more likely to adopt EVs if they can get a per mile green subsidy for driving EVs.

4   Data collection strategy and survey questionnaire

We conducted two sets of surveys – one focused on ride-hailing drivers in the West Los Angeles region and a second directed at all US non-ridehailing drivers who drive at least 60 miles per day (double the daily miles traveled by the average American household vehicle). The first survey was conducted in person by hailing rides on Lyft and Uber and then recruiting driver participants in exchange for $10 cash payment (further details below). The second set of surveys was conducted online using Prolific Inc. We will refer to the respondents of this survey as the comparison group. The questionnaire for ride-hailing drivers was comprised of 71 questions while our questionnaire for the online comparison group was comprised of 54 out of the same 71 questions. This survey was shorter because we excluded 17 questions that were specific to ride-hailing riders. Our questionnaire for ride-hailing drivers consisted mainly of multiple-choice questions with a few open-ended, short-answer questions that asked for suggestions on ideal locations for charging infrastructure and for the types of additional support they would like to see from the government and ride-hailing companies. The second survey did not include any short-answer questions.

Our questionnaire was comprised of the following categories of questions:
1. **Preferences for EVs** (such as next vehicle purchase, willingness to pay to purchase, willingness to rent or lease, credit concerns),
2. **Charging** (such as importance of charging considerations in decision to adopt, range anxiety, ease of charging, speed of charging, duration willing to wait for charging, suggestions for citing charging stations,
3. **Perceptions about EVs relative to gasoline vehicles** (such as upfront, fuel and maintenance cost relative to gas),
4. **Ridehailing** (such as level of satisfaction with work, hours of driving, miles driven per week, percent income from driving, expected duration of continuation driving, satisfaction with the job),

5. **Knowledge and preferences about leasing programs**,
6. **Personality and symbolic attributes** (such as risk preferences, pro-environment, pro-social behavior),
7. **Demographics** (such as age, gender, education, household income, home type and ownership status, credit, race, political affiliation)

So as to ensure that we only counted the results of surveys in which participants were actually reading the questions and not responding at random, our questionnaire contained attention checks. These attention checks were simple questions such selecting whether certain statements were true or false, and a failure to respond correctly indicated lack of attention. The surveys were conducted during the period starting late September 2019 through December 2019. The complete questionnaire of ride-hailing drivers is part of the Appendix. Details on the procedures used to recruit participants are explained below.

4.1 Survey of ridehailing drivers

We recruited a group of five undergraduate student assistants to recruit Lyft and Uber drivers in the Los Angeles Area to complete the survey. We tried to have an equal representation of rides hailed from both Uber and Lyft. Because of resource constraints, we had to confine our study to West Los Angeles. Within this region we identified 6 zones: (1) Westwood/Brentwood, (2) West LA/Santa Monica/Venice, (3) Palms/Mar Vista/Culver City, (4) Mid-City/Pico Robertson/Century City, (5) Beverly Hills/Hollywood, West Hollywood, and (6) Central LA/Downtown/West Adams. Each student took responsibility for one or two zones each week. The rides were hailed between the hours of 7am to 7pm across the entire week. We tried to have an equal representation of rides across the different days and hours of the week.

The students followed a strict survey protocol. After hailing a ride, the student assistants checked the license plate of the vehicle with a Google Sheet (accessible only to the research team) to see if the vehicle had already been logged. On a few occasions in which they did encounter the same, they still completed the ride without cancelling in order to not disadvantage the drivers in any way on account of this study. Drivers who had already been asked to participate in the study were not asked to participate in the survey another time. The student assistants were equipped with name tags, clipboards, iPads, and paper surveys (in the case of iPad malfunctions or driver preference) and were provided with a script. The student assistants explained the study as well as the cash compensation ($10) to the drivers once in the car. They also stressed that participation in the survey would not affect driver ratings. Drivers who agreed to take the survey pulled over to a safe spot at the end of the ride and were handed an iPad (survey via Qualtrics) or a paper survey.

Surveys were distributed to drivers based on what type of vehicle they were driving: drivers who were not driving an electric vehicle were given the Ride-hailing driver survey, and drivers who were in electric vehicles were given the EV Driver Survey. The ridehailing driver survey consisted of 71 multiple choice and short answer questions that assess driving characteristics (e.g. tenure as a ride-hailing driver, average miles/hours driven daily/weekly, make/model/year of the vehicle used for ride-hailing, etc.) and demographic characteristics. The EV Driver Survey focused on drivers'

experiences with driving EVs in ride-hailing services and asks for recommendations for other drivers.

Drivers were shown a consent form before starting the survey that addressed privacy concerns and provided information on whom to contact if they had questions. The drivers completed the surveys in the privacy of their own cars. The surveys took approximately 10-25 minutes to complete for most drivers, but times ranged from 4 to 50 minutes. Respondents were allowed to stop their participation in the survey at any time and remain eligible for full compensation. The student assistants were able to answer any questions that drivers may have had as long as their answers were not leading. At the end of each survey, drivers handed back the iPad or paper survey back to the student assistant and received $10 in cash. That concluded driver participation in the study.

Drivers who were interested in taking the survey at a time of their convenience could share their email address and select whether they were driving an electric vehicle or not. Allison Yang, the graduate student researcher, served as the contact person and emailed all drivers who provided email addresses with a link to either the ride-hailing driver survey or the EV driver survey, depending on the vehicle indicated. These respondents were able to take the survey (via Qualtrics) whenever and wherever they preferred. Drivers who completed the survey via the emailed links received a $10 compensation via a Tango Card. They were not contacted after being sent the initial email inviting them to take the survey. In fact, we only had one person respond to the email invitation.

Eligibility was dependent on four criteria: whether the respondent (1) was over the age of 18, (2) identified the United States as their country of residence, (3) worked as an Uber or Lyft driver, and (4) was able to read and write English. Respondents were not excluded on any demographic or socioeconomic basis. Non-English speakers were excluded from the study since the surveys were only available in English, which again was due to resource constraints. Eligibility was determined by the student assistants as well as the drivers. Drivers were advised to use their own discretion concerning their ability to read and write English. In instances where it was apparent that drivers were not reasonably fluent in English, the student assistants did not offer the survey.

Our original goal was to collect responses from about 300 ride-hailing drivers. However, on account of budgetary and time constraints[11] we stopped recruitment after obtaining 195 survey responses. After removing responses that failed either of the two attention checks, we ended up with 148 eligible responses on which we conducted statistical analyses (described in the section titled Results). We did not anticipate many responses for EV Driver Survey, since pure EVs are not common among ridehailing drivers but we received 2 eligible responses. Table 2 summarizes the various responses to the request to participate in our survey

Table 2: Rides hailed and response received

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[11] We experienced a lower than budgeted rate of participation per ride hailed, a longer than budgeted time for completion of each survey as well as the time per ride because of traffic in Los Angeles and constraints on undergraduate assistants work schedules. Details on the survey response rates are provided in the results section.

# Rides hailed	405
# YES - Tablet	175
# YES - Paper	19
# No - Prefer Email	49
# No – Refusal	73
# No - Ineligible	82
# No - Missing reason	7

4.2   Comparison group survey

The second set of surveys acted as a comparison group for the study. This survey was open to all non-ridesourcing drivers in the nation that are 18 or older, reside in the US, and drive more than 60 miles per day. Respondents were not excluded on any demographic or socioeconomic basis.

This set of surveys was conducted via Prolific Academic (ProA), an online research platform that is similar to Amazon Mechanical Turk (MTurk). According to one study ProA participants have been found to be more demographically diverse, naiver, and less dishonest than MTurk participants (Peer, Brandimarte, Samat, and Acquisiti, 2017).

Respondents were required to take a screening survey before they were invited to take the ProA survey, which asked the same series of measures assessing perceptions of EVs as did the ridehailing survey. The ProA survey simply omitted questions about ride-share driving experiences. Those who met eligibility criteria for the full study were invited to participate in the ProA survey, which could be completed any time from any internet-connected device while the study was live in September 2019. On the study's ProA front page, participants read an informed consent statement along with the study description. After agreeing to participate, participants were directed to an online platform hosted by Qualtrics to complete the survey, which took approximately 7 minutes. Participants were compensated $1 after completing the survey. They were not contacted at any point of the survey, and their participation concluded after survey completion. All respondents could only participate in the study once, and all respondents received monetary compensation. 15,000 ProA users responded to the first screening survey. 400 of those who met eligibility were randomly invited to take the ProA survey. 396 of the 400 invited respondents completed the ProA Survey.

5   Data analysis

This section is structured as follows. We first present a comparison of the mean responses for the ridehailing group and non-ridehailing comparison group to ascertain some of the demographic attributes, personality traits and perceptions about EVs vis-à-vis gasoline vehicles in terms upfront cost, fuel and maintenance costs, and perceptions and preferences related to charging. Following this, we focus only on the extreme preferences within each group in response to the question: "Think about your next vehicle purchase. How likely are you to purchase or lease an EV?". We focus on how respondents who answered more likely and those who answered more unlikely differ on the various dimensions mentioned above (i.e., demographics, perceptions about EVs etc.). Finally, we graphically

plot out each of the responses to a select set of questions to give a better sense of the distribution of the responses.

As mentioned earlier, 148 out of the 195 driver surveys passed the attention checks. Furthermore, in the following analysis, we dropped a handful observations for which the miles of driving per week exceeded 2000 or hours of driving exceeded 100 hours as these seemed extreme and were skewing the mean. Table 3 shows side-by-side the mean, standard deviation and number of observations for both the ridehailing drivers and the online comparison group. For each of the variables, the coding scheme employed to convert the categorical choices to a numerical mean is shown in parentheses.

5.1 Comparing means for ridehailing and comparison groups

Table 3: Summary statistics for responses to select subset of questions
Note: *The number of observations various for each variable as some questions were skipped and some seemed to contain extreme responses that seemed to erroneous which we dropped as they were biasing the mean*

	Variable	Ridehailing drivers			Comparison Group		
		N	Mean	Std.	N	Mean	Std.
	Questions related to EV and EV relative to gas vehicles						
1	How likely is your next purchase to be an EV (1: Ext. unlikely, 7: Ext likely)	138	4.1	2.1	381	3.6	2.0
2	Own or lease EV in 5 years (1: Strongly disagree, 7: Strongly agree)	138	4.5	2.0	381	3.6	1.9
3	Rel. to gas: willing to pay more or less for EV (1: much less, 7: much more)	137	4.1	1.6	381	4.2	1.2
4	Rel. to gas: buying an EV is costlier/cheaper (1: much less, 7: much more)	138	3.7	1.1	380	4.0	0.8
5	Rel. to gas: fuel cost of an EV is costlier/cheaper (1: much less, 7: much more)	137	2.5	1.4	380	2.3	1.1
6	Rel. to gas: maintenance cost of an EV is costlier/cheaper (1: much less, 7: much more)	137	3.3	1.3	380	3.5	1.2
7	Worry about credit when buying EV (1: Strongly disagree, 7: Strongly agree)	138	3.3	2.0	381	2.8	1.9
8	Which vehicle would you pick?*	133	1.2	0.4	380	1.4	0.5
	Questions related to Rentals						
9	Familiarity with short-term car rentals (1: Not at all familiar, 5: Extremely familiar)	134	1.6	1.1	381	1.1	0.5
10	How likely to rent car through these rentals (1: Ext. unlikely, 7: Ext likely)	136	3.6	2.3	381	3.4	1.9
11	How likely to rent EV through these rentals (1: Ext. unlikely, 7: Ext likely)	135	3.9	2.3	381	3.4	1.9

#	Question	N	Mean	SD	N	Mean	SD
	Questions related to Ridehailing						
12	Enjoy this work (1: Strongly disagree, 7: Strongly agree)	138	5.2	1.5			
13	Miles driven per week	138	639.4	449.3	315	252.9	197.7
14	Hours driven per week	138	35.4	14.9			
15	Percent miles for ridehailing	138	75.8	20.2			
16	Percent income from ridehailing	86	41.2	24.8			
17	How long do you expect to continue driving? (1:<1 mo., 2: 1-3 mo., 3: 4-6 months, 4: 7-12 mo., 5: >1 yr)	137	4.1	1.2			
18	Did you acquire car for this job? (1: Yes, 2: No)	138	1.6	0.5			
	Questions related to EV Charging						
19	Worry about running out of charge (1: Strongly disagree, 7: Strongly agree)	136	5.2	1.6	380	5.3	1.5
20	How important is accessibility of charging to buy EV (1: Ext. unimp. , 7: Ext imp)	137	6.0	1.8	380	6.3	1.2
21	Charging an EV is hard/easy (1: Ext diff., 7: Ext. easy)	137	4.0	1.8	380	4.3	1.7
22	Time to charge would limit EV use (1: Strongly disagree, 7: Strongly agree)	138	4.6	1.6	380	4.8	1.5
23	How important is charging speed in adopting EV? (1: Ext. unimp, 7: Ext imp)	138	6.0	1.4	380	5.9	1.1
24	How many minutes will you wait for charging?	133	64.4	81.5	323	49.3	56.4
25	Time for charging would limit earnings (1: Strongly disagree, 7: Strongly agree)	138	4.2	1.8			
26	Share battery state with TNC (1: Ext. unlikely, 7: Ext likely)	137	5.4	1.8			
27	Value of charging cafes with amenities? (1: Not at all valuable, 4: Very valuable)	138	3.0	1.0			
28	If charging cafes were widespread, how likely to adopt EV? (1: Ext. unlikely, 7: Ext likely)	138	5.2	1.5			
	Questions related to one's personality						
29	Risk taker (1: Not at all, 5: moderate, 10: high)	137	7.0	2.9	381	6.2	2.2
30	Act environment friendly (1: Strongly disagree, 7: Strongly agree)	138	5.7	1.2	381	4.9	1.3
31	Adopt new tech. (1: Strongly disagree, 7: Strongly agree)	138	5.3	1.5	381	4.4	1.6
32	Care about society (1: Strongly disagree, 7: Strongly agree)	138	6.2	1.1	381	5.5	1.1
33	Driving EV means I care for environment (1: Strongly disagree, 7: Strongly agree)	137	5.4	1.4	381	4.8	1.5
34	Driving EV signifies to others I care (1: Strongly disagree, 7: Strongly agree)	137	5.4	1.5	381	5.0	1.4

#							
35	Driving EV means cutting edge (1: Strongly disagree, 7: Strongly agree)	137	5.2	1.5	381	4.8	1.4
36	Driving EV means tech savvy (1: Strongly disagree, 7: Strongly agree)	137	4.8	1.6	381	4.2	1.5
37	Driving EV means good community (1: Strongly disagree, 7: Strongly agree)	137	4.7	1.7	381	4.1	1.6
	Demographic questions						
38	Age (years)	134	43.0	13.2	380	38.0	11.2
39	Gender (1: Man, 2: Woman)	137	1.2	0.4	381	1.4	0.5
40	Education level (1: No high sch., 2: High sch/GED, 3: Some coll., 4: 4-year coll., 5: post-grad)	137	3.4	1.0	380	3.7	0.9
41	Annual household income bracket (1:<$10K, 4: $25-$35K, 7: $75-$99K, 10:>$200K)	134	5.5	1.6	380	6.1	1.8
42	Primary residence type (1: Sing. family home, 2: Multi-fam 3: Duplex, 4: Townhouse, 5: Mobile, 6: Other)	137	1.7	0.9	381	1.4	0.9
43	Owned or Rented (1: Own, 2: Rent)	137	1.8	0.5	381	1.4	0.6
44	Dedicted parking space (1: Yes, 2: No)	137	1.1	0.4	381	1.1	0.4
45	Electrical outlet in park. Space (1: Yes, 2: No)	136	1.6	0.5	381	1.4	0.5
46	Fuel type of car (1: Gas. 2: Diesel, 4: Elec. 4: Hyb., 5: Oth)	138	1.6	1.2	381	1.2	0.7
47	Currently own or lease (1: Yes, 2: No)	138	1.1	0.4	381	1.1	0.3
48	Hispanic/Latino/Spanish (1: No, 4: Mex. 5: PR, 6: Cuban, 7: Yes, other)	135	2.3	2.1	380	1.4	1.2
49	Political Affiliation (1: Very lib, 4: Mod., 7: Very cons.)	133	3.6	1.4	380	3.2	1.6

On average, each group reports that they are neither likely nor unlikely to purchase an EV as their next vehicle and return a similar mean response when it comes to the likelihood of owning or leasing an EV in the next 5 years. However, ridehailing drivers report being relatively more likely when compared to the comparison group. When asked to compare EVs to gasoline cars, both groups report that they are willing to pay about the same amount to acquire an EV, perceive EVs to cost about the same as a gasoline vehicle but are cheaper to fuel and slightly cheaper to maintain. We also presented the choice depicted in Figure 3 between EV and gasoline vehicles showing a tradeoff between upfront and operating costs and the mean response for each group leaned heavily towards the EV (mean (std. dev.) were 1.2 (0.4) and 1.4 (0.5) for the ridehailing and comparison groups respectively)

Neither group reports being strongly worried about access to credit as a barrier to acquiring an EV, although ridehailing drivers appear slightly more concerned. Ridehailing drivers report low familiarity with any of the various short-term rental and leasing programs available in LA (such as Blue LA, Maven) or those available through Lyft or Uber and also report being, on average, neither likely nor unlikely to rent a car or EV through such programs, which is indicative of their preference to drive their own vehicle.

Electric Vehicle	
Price	$29,990
Fuel	Electric Energy
Range	150 miles
CO2 emissions	0 g/km

Gasoline Vehicle	
Price	$21,845
Fuel	Gasoline
Range	425 miles
CO2 emissions	172 g/km

*Range refers to the distance the car can travel before needing to refuel

5-year Estimated Costs

	Electric Vehicle	Gasoline Vehicle
Fuel	$9,206	$20,660
Repairs	$773	$1,183
Maintenance	$3,405	$4,438
Insurance	$7,850	$6,966

The graph above shows the estimated 5-year costs of owning each vehicle. These include the cost of fuel, repairs, maintenance and insurance.

Figure 3: Information given to the participant asking as to which among the two choices – EV or gasoline would he/she pick (question 8 in Table 3)

Ridehailing drivers report somewhat agreeing that they enjoy their job, clock about 640 miles per week (std. dev. 450) which comprises about 75% (std. dev. 20%) of their total vehicle miles travelled in a year, work about 35 hours per week (std. dev 15%) driving for the platform, deriving about 41% (std. dev 25%) of their income, expect to continue working in this job for more than year more (std. dev. 2 months), and are less likely to have a bought car because of this job. None of these questions apply to comparison group. However, the comparison group clocks about 252 miles per week (std. dev. 198 miles). Therefore, ridehailing drivers clock 2.5X more miles relative to high mileage non-ridehailing households and about 3X relative to the average American private automobile.

We asked a total of 15 questions related to charging. Overall, both groups state a similar mean level of concern over running out of charge. In addition, both groups state that both easy accessibility to charging and fast charging are important considerations in acquiring EV. Interestingly, ridehailing drivers state that they are willing to wait about 64 minutes for charging (std. dev 81 minutes) while the mean for the comparison group is 49 minutes (std dev. 56 minutes). Ridehailing drivers are not

too concerned that time spent charging will limit earnings. They also report that they are generally willing to share their battery status with the platform so that they can be automatically directed to a charging station at the right time. We also asked them to imagine that there is a network of EV charging cafes throughout the southern CA region, where ride-share drivers can stop, re-charge their vehicles, and re-charge themselves. The cafes would offer lounge space, restrooms with showers, a marketplace, beverages, and food. They can only be accessed by rideshare drivers who drive EVs and only during ride-sharing shifts. Drivers do not get paid while stopped at a café. When asked how valuable this would be for drivers, the mean response reveals that this would be valuable, and drivers report a higher likelihood of adopting EV in such a case. We also asked an open ended question soliciting their suggestions of where these cafes should be located. We received the following responses in descending order of frequency of their mention which is shown in parentheses: gas stations (52), grocery stores (21), malls (21), parking lots (15), everywhere (13), airports (13), and parks (9). Other suggestions included nightclubs, cafes, metro stations, and gyms and fitness centers.

When it comes to their personality traits and preferences for symbolic attributes, the two groups are again not dissimilar. They both, on average, identify themselves as somewhat technologically savvy, more on the risk-taking side, slightly environment friendly, caring about society, and eager to adopt to adopt cutting edge technology.

Demographically the two groups also appear to be quite similar. On average, ridehailing drivers report an age between 40 and 45 years, annual incomes between $35K and $50K, have slightly less than 4 years of college, are more likely to live in multi-family housing, are more likely to rent, are likely to have access to a parking space, but are less likely to have access to an electrical outlet at their parking space, are politically moderately liberal, and are likely Hispanic. Relative to the comparison group, ridehailing drivers are a bit older, comprise a higher ratio of men, have slightly lower incomes ($50K and $75K for comp. group), are more likely to drive gasoline cars, are more non-Hispanic, and are slightly more liberal.

We also solicited suggestions from the ridehailing drivers as to what other types of public policies or incentives from the platform would make them likely to drive an EV. We received the following responses in descending order of frequency of their mention which is shown in parentheses: more money per mile or bonus pay (29), nothing (17), discount on car rental/purchase (14), I don't know (10), tax incentives (8), help with maintenance costs (5), and paid charging time (3). Some other less frequent responses included more rides, unsure, and priority ride dispatch.

5.2   Within group variation based on EV preference

We now discuss the variation within each of the two sets of survey responses based on how participants responded to the first question in Table 3, which reads exactly as follows: "Think about your next vehicle purchase. How likely are you to purchase or lease an EV?" This is the We offered seven categorical choices: (1) Extremely unlikely, (2) Moderately unlikely, (3) Slightly unlikely, (4) Neither likely nor unlikely, (5) Slightly likely, (6) Moderately likely, and (7) Extremely likely (7). We combined the respondents within each of the two surveys into three groups.
- Unlikely - those who chose 'Extremely unlikely' and 'Moderately Unlikely'

- Moderate- those who chose 'Slightly likely,' 'Neither likely nor unlikely,' 'Slightly unlikely'
- Likely - those who chose 'Extremely likely' or 'Moderately likely'

For the sake of brevity, we only focus on the defined likely and unlikely sub-groups within in each set of surveys, and subsequently compare these two sub-groups across the two sets of surveys

Table 4: Mean responses and attributes of participants with strong preferences for purchasing EV
Note: Figure in parentheses is standard deviation

Variable	Ridehailing Group		Non-Ridehailing Group	
	LIKELY N=47	UNLIKELY N=42	LIKELY N=82	UNLIKELY N=141
Questions about EVs & EV relative to gas veh.	Mean	Mean	Mean	Mean
Next purchase EV (1: Ext. unlikely, 7: Ext likely)	6.4	1.5	6.3	1.5
Own or lease EV in 5 years (1: Strongly disagree, 7: Strongly agree)	5.9	3.1	5.6	2.0
Rel. to gas: willing to pay more or less for EV (1: much less, 7: much more)	4.4	3.9	4.9	3.7
Rel. to gas: buying an EV is costlier/cheaper (1: much less, 7: much more)	3.4	4.1	3.9	3.9
Rel. to gas: fuel cost of an EV is costlier/cheaper (1: much less, 7: much more)	2.3	2.8	2.0	2.3
Rel. to gas: maintenance cost of an EV is costlier/cheaper (1: much less, 7: much more)	3.0	3.3	3.0	3.7
Worry about credit when buying EV (1: Strongly disagree, 7: Strongly agree)	3.7	3.1	2.8	2.9
Which vehicle would you pick?*	1.1	1.4	1.2	1.6
Questions related to Rentals				
Familiarity with short-term car rentals (1: Not at all familiar, 5: Extremely familiar)	1.5	1.7	1.4	1.0
How likely to rent car through these rentals (1: Ext. unlikely, 7: Ext likely)	4.2	3.0	4.1	2.8
How likely to rent EV through these rentals (1: Ext. unlikely, 7: Ext likely)	4.7	2.9	4.4	2.5
Questions related to Ridehailing				
Enjoy this work (1: Strongly disagree, 7: Strongly agree)	5.1	5.3		
Hours driven per week	33.9	36.4		
Miles driven per week	700 (475)	559 (398)	222 (199)	234 (177)

Percent miles for ridehailing	74.3	75.8		
Percent income from ridehailing	41.8	44.2		
How long do you expect to continue driving? (1:<1 mo., 2: 1-3 mo., 3: 4-6 months, 4: 7-12 mo., 5: >1 yr)	3.9	4.3		
Did you acquire car for this job? (1: Yes, 2: No)	1.5	1.6		
Questions related to EV Charging				
Worry about running out of charge (1: Strongly disagree, 7: Strongly agree)	4.8	6.0	4.7	5.6
How important is accessibility of charging to buy EV (1: Ext. unimp. , 7: Ext imp)	5.8	6.3	6.3	6.4
Charging an EV is hard/easy (1: Ext diff., 7: Ext. easy)	4.5	3.3	4.9	3.8
Time to charge would limit EV use (1: Strongly disagree, 7: Strongly agree)	4.0	5.1	4.3	5.0
How important is charging speed in adopting EV? (1: Ext. unimp. , 7: Ext imp)	6.0	6.3	5.9	6.0
How many minutes will you wait for charging?	73 (88)	54 (66)	57 (62)	42 (58)
Time for charging would limit earnings (1: Strongly disagree, 7: Strongly agree)	3.7	4.6		
Share battery state with TNC (1: Ext. unlikely, 7: Ext likely)	6.1	5.3		
Value of charging cafes with amenities? (1: Not at all valuable, 4: Very valuable)	3.2	3.2		
If charging cafes were widespread, how likely to adopt EV? (1: Ext. unlikely, 7: Ext likely)	5.9	5.0		
Questions related to one's personality				
Risk taker (1: Not at all, 5: moderate, 10: high)	7.2	6.6	6.6	5.9
Act environment friendly (1: Strongly disagree, 7: Strong agree)	6.1	5.6	5.6	4.5
Adopt new tech. (1: Strongly disagree, 7: Strong agree)	5.9	5.0	5.3	4.0
Driving EV means I care for environment (1: Strongly disagree, 7: Strongly agree)	6.4	6.1	6.0	5.3
Care about society (1: Strongly disagree, 7: Strongly agree)	5.6	5.4	5.5	4.3
Driving EV signifies to others I care (1: Strongly disagree, 7: Strongly agree)	5.7	5.4	5.5	4.6
Driving EV means cutting edge (1: Strongly disagree, 7: Strongly agree)	5.4	5.2	5.3	4.5
Driving EV means tech savvy (1: Strongly disagree, 7: Strongly agree)	5.0	4.7	4.8	3.8

Driving EV means good community (1: Strongly disagree, 7: Strongly agree)	5.0	4.5	4.9	3.6
Demographic questions				
Age (years)	42.1	44.8	35.7	38.0
Gender (1: Man, 2: Woman)	1.2	1.2	1.4	1.4
Education level (1: No high sch., 2: High sch/GED, 3: Some coll., 4: 4-year coll., 5: post-grad)	3.5	3.4	3.8	3.5
Annual household income bracket (1:<$10K, 4: $25-$35K, 7: $75-$99K, 10:>$200K)	5.7	5.5	6.4	5.8
Primary residence type (1: Sing. family home, 2: Multi-fam 3: Duplex, 4: Townhouse, 5: Mobile, 6: Other)	1.7	1.7	1.3	1.6
Owned or Rented (1: Own, 2: Rent)	1.8	1.8	1.4	1.4
Dedicated parking space (1: Yes, 2: No)	1.2	1.2	1.1	1.2
Electrical outlet in park. Space (1: Yes, 2: No)	1.5	1.7	1.3	1.4
Currently own or lease (1: Yes, 2: No)	1.1	1.2	1.0	1.1
Fuel type of car (1: Gas. 2: Diesel, 4: Elec. 4: Hybrid, 5: Other)	1.8	1.6	1.4	1.1
Hispanic/Latino/Spanish (1: No, 4: Mex. 5: PR, 6: Cuban, 7: Yes, other)	2.2	2.2	1.4	1.3
Political Affiliation (1: Very lib, 4: Mod., 7: Very cons.)	3.7	3.4	2.9	3.3

5.2.1 Comparing responses and attributes of the sub-groups within ridehailing group

First note that out of the 148 valid ridehailing responses, roughly a third fell into each of the two extremes of likely (N=47, 32%) and unlikely (N=42, 28%) to purchase an EV next. Interestingly, each of the two sub-groups' mean responses are similar with regard to willingness to pay more for a EV and their perceptions about the upfront cost, fuel and maintenance costs of EVs relative to gasoline vehicles although the former (the likely group) seems to worry a little bit more about credit being a barrier to EV purchase (mean score of 3.7 vs 3.1). The two groups' responses are also similar regarding rentals. For this set of questions the two groups seemed similar, the one exception being with respect to miles driven per week. The likely group drives slightly more than 700 miles per week as opposed to 560 although the standard deviation suggests that the means are not statistically different. Interestingly, the less likely group states that they expect to continue the job or gig a bit longer (mean score 4.3, i.e., > 1 year) relative to the likely group (3.9 which corresponds to less than one year). The differences with respect to charging preferences are a bit more revealing. The unlikely group is relatively more concerned about running out of charge[12] (mean score 6.0 vs 4.8). They believe that charging an EV is harder (mean score 3.3 vs 4.5), and charging time will eat into driving time (mean

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[12] See Table 5A for the coding scheme for the categorical response into numerical scores on a scale 1 to 7. Also note that slightly different categories and coding schemes is used for the different variables

score 5.1 vs 4.0) and therefore, earnings (mean score 4.6 vs 3.7). This means they are less willing to spend time charging (54 minutes vs 73 minutes). The likely sub-group states a greater likelihood of adopting EVs if there exists a widespread network of EV charging café with various amenities even if they do not receive compensation for time spent charging. With respect to the personality traits and environmental preferences, the likely group is slightly more risk taking, although not by much (7.2 vs 6.6), and state slightly, but consistently greater, penchants for pro-social and pro-environmental behavior as evident from Table 4. Finally, when we look at the demographics, there is really not much to differentiate the two sub-groups except that the likely subgroup is younger on average by about 3 years. They have practically the same mean levels of education, annual income, home ownership, gender and whether they are Hispanic or not. Somewhat surprisingly, however, the unlikely sub-group is slightly more liberal than the likely group although the means do not appear statistically different.

5.2.2   Comparing responses and attributes of the sub-groups within comparison group

As with the ridehailing sub-groups, the differences between the likely and unlikely to purchase an EV sub-groups are not very surprising either although there are some interesting differences relative to the ridehailing group's composition. We present a similar summary of differences across the different categories of questions.

Out of the total 396 valid responses within this group, 82 are in the likely category (20%), and 141 (36%) fall under unlikely sub-group. In other words, a smaller share of respondents is enthusiastic while a greater share is less so relative to ridehailing sub-groups. However, the gap in terms of willingness to pay more is wider between the two sub-groups relative to the ridehailing group. The concern about running out of charge is similar for each sub-group relative their ridehailing counterparts and each report a similar level of concern when it comes to charging availability limiting EV use. The comparison of the personality traits and environmental preferences are similar to that for the ridehailing group. Finally, when we look at the demographics, the difference in average age of the two sub-groups is slightly smaller for the comparison group relative to the ridehailing group while the income gap is wider between the two sub-groups (with the likely group being wealthier both relative to the unlikely sub-group within the comparison group and also relative to the likely sub-group within the ridehailing group). The likely sub-group is more liberal than its counterpart in the ridehailing survey while the unlikely sub-group is similarto its counterpart.

5.2.3   Distribution of individual responses to select questions

Please refer the Appendix for histograms of individual responses and other charts.

6   Policy discussion

Our work suggests the following areas for targeted public support as well as support from TNC and fleet owners to help drivers overcome barriers when it comes to adopting EVs. A substantial portion of ridehailing vehicles clock over 3X the miles of the typical household vehicle and possibly even 4X that of the average EV vehicle today. Electrifying these vehicles would then deliver 3X to 4X faster

payback and environmental benefits and greater life cycle cost savings. Owners of these vehicles are lower income relative to the typical EV owner and so the upfront cost barrier looms larger. We suggest the following additional policies and programs to accelerate EV adoption.

Firstly, what ridehailing drivers need is **low interest financing to overcome credit constraints coupled with a subsidy per mile of vehicle**. The subsidy could be in lieu of the upfront vehicle subsidy (they would then need help financing the purchase through a loan or a lease – more on this below) or if the finances permit could be additional to the vehicle subsidy. Given that the federal tax credit may not apply on some vehicles and given the uncertainty with the extension and level of this rebate, barring a compensating increase from the states, ZEV adoption could decline. A per mile subsidy would help overcome this shortfall and direct it to those vehicle users who would benefit the most in the form of fuel and maintenance cost savings and also displace the most amount of fossil fuels and pollution. See Rajagopal and Phadke (2019) for detailed exposition of the practical case for a policy pivot to incentivizing electric vehicle miles travelled (eVMT).

Secondly, a complementary strategy is to increase **financial and programmatic support for leasing EVs.** Leasing helps overcome upfront cost barrier, mitigates credit constraints, and helps adopters benefit from learning-by-using akin to learning-by-doing. Since the ridehailing industry is characterized by rapid driver turn around and low retention rates (the average driver in our survey expects to work less than a year, which is close but still shorter than a 1.5 to 2 year payback to EV) leasing mitigates the risk of an investment in EV turn out to costly in the event of an early exit from ridehailing by a driver. Our survey reveals limited knowledge about the existence of short-term rental including those that offer EVs in LA such as BlueLA and Maven to name just a couple.

Thirdly, the **barriers to charging faced by these vehicle owners are different to those faced typical EV owner** today. Most EV owners today tend to be homeowners and have access to a dedicated parking space with an electrical outlet. In contrast, the majority of ridehailing drivers reported living in rented and multi-unit dwelling. While they do seem to have access to parking space, they may not have access to electrical outlet or not have freedom to install one as a renter. Furthermore, the nature of their vehicle use is such that they would still need access to charging away from home, which is what our survey respondents suggest. Furthermore, the likely adopters state a stronger preference for fast charging in contrast to the typical slower (Level 2 chargers) that seem adequate for most pure private users who own a home.

Fourthly, our surveys reveal a need for **better information and outreach to educate** ridehailing drivers about to allay apprehensions on account of incomplete and outdated information on costs and benefits of EVs relative to gasoline vehicles especially for high mileage users such as themselves, the leasing options (which needs to be expanded as mentioned above) and the various incentives and subsidies available how they could meet and manage their charging needs. To reiterate, educating not just the drivers but also the broader population about short-term rentals specifically those that offer EVs is also recommended.

Fifthly and last but not least, our work highlights the **role of TNCs and private fleet operators the complementing the public investments** and programs in each of the above areas with their own

investments. They have an important role in helping with the procurement and financing of EVs including helping with leasing, investments in charging infrastructure, more aggressively marketing their green fleets including instituting a green premium and credits for selecting greener option and their own information and outreach program. Our surveys show that drivers are open to sharing their battery status information that would allow TNCs and fleet operators to dispatch vehicles more efficiently and also direct them to nearest charging station at the right time and so long as these charging stations are convenient, have access to amenities to help rest and relax themselves, drivers may even be willing to go recharge without monetary compensation for downtime although this would certainly help. To this end, TNCs and fleet operators should themselves be educated to enthusiastically support these efforts in light of their obligation under policies such as the Clean Miles Standard.

7   Conclusion

California has long been a leader in driving adoption of zero emission vehicles for personal transportation and was one of the earliest to mandate targets for Zero Emission Vehicles (ZEV). More recently, the State is once again trying to lead the way in requiring the rapidly growing ridehailing sector (Lyft, Uber and other on-demand transportation and delivery services) through the recently adopted State Bill 1014 – The Clean Miles Standard. And more uniquely, California aims to do so in a socially just and equitable manner through legislations and programs such as SB535, AB1550, SB1275 and the Clean Vehicle Rebate Project (CVRP)). The impressive and comprehensive suite of policies notwithstanding, there is a need for some additional targeted measures aimed at a lower income and high-mileage drivers which is lacking today. The measures we suggest here were quite timely even before the CoVid-19 pandemic hit as the federal incentives for vehicles were slowly drying up for the major EV automakers but also because to of the fact that the current EV owners were not high mileage users anyway. The emergence of the CoVid-19 pandemic and it's economic fallout which is likely to drastically increase scarcity of public and private funds for supporting clean technologies coupled with the precipitous fall in oil prices both due to the collapse of OPEC and decline in oil demand, have all combined to only accentuate further the rationale for these additional policies we suggest. It has become ever more important that policies target EV adoption and provide incentives ever more precisely to those individuals and commercial operations that are not only in real need of support but can also deliver the most environmental benefits to society. In this context, this work provides some of the first data-driven insights on how the lower-income households employed in providing ridehailing services could both benefits economically and also deliver substantial environmental benefits rapidly and more cost-effectively and contribute to the success of California's pollution reduction goals.

BIBLIOGRAPHY

Amirkiaee, S. Y., & Evangelopoulos, N. (2018). Why do people rideshare? An experimental study. *Transportation Research Part F: Traffic Psychology and Behaviour*, *55*, 9–24. https://doi.org/10.1016/j.trf.2018.02.025

Bauer, G. S., A. Phadke, J. B. Greenblatt, D. Rajagopal (2019): Electrifying Ur- ban Ridesourcing Fleets at No Added Cost through Efficient Use of Charging In- frastructure, Transportation Research Part C, 2019 Vol. 105, August 2019 https: //www.sciencedirect.com/science/article/pii/S0968090X19300713

Broadbent, G.H., Drozdzewski, D., Metternicht, G., (2017). Electric vehicle adoption: an analysis of best practice and pitfalls for policy making from experiences of Europe and the US. Geogr. Compass. http://dx.doi.org/10.1111/gec3.12358.

Canepa, K., Hardman, S., & Tal, G. (2019). An early look at plug-in electric vehicle adoption in disadvantaged communities in California. *Transport Policy*, *78*, 19–30. https://doi.org/10.1016/j.tranpol.2019.03.009

Cook, C., Diamond, R., Hall, J., List, J., & Oyer, P. (2018). *The Gender Earnings Gap in the Gig Economy: Evidence from over a Million Rideshare Drivers* (No. w24732; p. w24732). https://doi.org/10.3386/w24732

DoE 2014: A Guide to the Lessons Learned from the Clean Cities Community Electric Vehicle Readiness Projects U.S. Dept of Energy# DOE/CHO-AC02-06CH11357-1301

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*, *48*, 717–729. https://doi.org/10.1016/j.enpol.2012.06.009

Farkas Z., & Shic Shin H. (2018). Environmental Attributes of Electric Vehicle Ownership and Commuting Behavior in Maryland: Public Policy and Equity Considerations. Mid-Atlantic Transportation Sustainability University Transportation Center. Retrieved April 20, 2019

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., & Stannard, J. (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transportation Research Part A: Policy and Practice*, *46*(1), 140–153. https://doi.org/10.1016/j.tra.2011.09.008

Hardman. (2018). A review of consumer preferences of and interactions with electric T vehicle charging infrastructure. Transportation Research, 62, 508-523. Retrieved May 21, 2019, from https://journals-ohiolink-edu.proxy.lib.ohio-state.edu/pg_99?

Hall, J. V., & Krueger, A. B. (2017). An Analysis of the Labor Market for Uber's Driver-Partners in the United States. ILR Review, 71(3), 705-732. doi:10.1177/0019793917717222

Hall, D., Lutsey, N., (2017). Emerging best practices for electric vehicle charging infrastructure. ICCT - Int. Counc. Clean Transp.Hall, J., & Krueger, N. (2017). An Analysis of the Labor Market for Uber's Driver-Partners in the United States. *ILR Review*, *71*(3), 705–732. https://doi.org/10.1177/0019793917717222

Han, L., Wang, S., Zhao, D., & Li, J. (2017). The intention to adopt electric vehicles: Driven by functional and non-functional values. *Transportation Research Part A: Policy and Practice*, *103*, 185–197. https://doi.org/10.1016/j.tra.2017.05.033

John, H., & Alan, K. (n.d.). *AN ANALYSIS OF THE LABOR MARKET FOR UBER'S DRIVER-PARTNERS IN THE UNITED STATES*. Retrieved from https://journals.sagepub.com/doi/pdf/10.1177/0019793917717222

Jenn, A. (2019). Electrifying Ride-Sharing: Transitioning to a Cleaner Future. *UC Davis: National Center for Sustainable Transportation*. Retrieved from https://escholarship.org/uc/item/12s554kd

Ke, J., Cen, X., Yang, H., Chen, X., & Ye, J. (2019). Modelling drivers' working and recharging schedules in a ride-sourcing market with electric vehicles and gasoline vehicles. *Transportation Research Part E: Logistics and Transportation Review*, *125*, 160–180. https://doi.org/10.1016/j.tre.2019.03.010

Li, W., Long, R., Chen, H., & Geng, J. (2017). A review of factors influencing consumer intentions to adopt battery electric vehicles. *Renewable and Sustainable Energy Reviews*, *78*, 318–328. https://doi.org/10.1016/j.rser.2017.04.076

Isaac, E. (2014). Disruptive Innovation: Risk-Shifting and Precarity in the Age of Uber. *Berkeley Roundtable on the International Economy*. Retrieved April 9, 2019, from https://brie.berkeley.edu/sites/default/files/disruptive-innovation.pdf.

Lane, B. W., Dumortier, J., Carley, S., Siddiki, S., Clark-Sutton, K., & Graham, J. D. (2018). All plug-in electric vehicles are not the same: Predictors of preference for a plug-in hybrid versus a battery-electric vehicle. *Transportation Research Part D: Transport and Environment*, *65*, 1–13. https://doi.org/10.1016/j.trd.2018.07.019

McGee, C. (2017, April 20). Only 4 percent of Uber drivers remain after a year says report. Retrieved April 7, 2019, from https://www.cnbc.com/2017/04/20/only-4-percent-of-uber-drivers-remain-after-a-year-says-report.html

Mobile Source Technical Review Sub-committee. (2012). Consumer Acceptance of Electric Vehicles in the US. Retrieved April 14, 2019, from https://www.epa.gov/sites/production/files/2014-09/documents/kodjak121312.pdf

National Academies 2015: Overcoming Barriers to Deployment of Plug-in Electric Vehicles, Report of the National Research Council, National Academies

Need a Car to Earn? (2019). Retrieved April 9, 2019, from https://www.uber.com/

Purchia, R. (2019, January 9). Why electric cars make sense for Uber, Lyft drivers in San Francisco. Retrieved April 7, 2019, from The San Francisco Examiner website: https://www.sfexaminer.com/news/why-electric-cars-make-sense-for-uber-lyft-drivers-in-san-francisco/

Rajagopal, D., A. Phadke (2019): Prioritizing electric miles over electric vehicles will deliver greater benefits at lower cost, Environmental Research Letters, Volume 14, Number 9, 2019 https://iopscience.iop.org/article/10.1088/1748-9326/ab3ab8

Rezvani, Z., Jansson, J., Bodin, J., 2015. Advances in consumer electric vehicle adoption research: a review and research agenda. *Transportation Research* Part D 34, 122–136.

Rosenblat, A. (2016). "How Can Wage Theft Emerge in App-Mediated Work?" *The Rideshare Guy*, August 10, 2016. http://therideshareguy.com/how-can-wage-theft-emerge-in-app-mediated-work/

Rosenblat, A. (2016). "The Truth About How Uber's App Manages Drivers." *Harvard Business Review*, April 6, 2016. https://hbr.org/2016/04/the-truth-about-how-ubers-app-manages-drivers

Rosenblat, A. (2016). "Who are the Uber & Lyft drivers?" *Medium.com*, July 11, 2016.
https://medium.com/uber-screeds/who-are-the-uber-lyft-drivers-e7b746f21665#.bdli5zo1a

Scott, Busco, & Hampshire. (2018). Characteristics and Incentives for EV adoption by Yellow Cab
Columbus. Retrieved May 21, 2019, from
https://kb.osu.edu/bitstream/handle/1811/84852/ENR_AEDE4567_EVAdoptionForYellowCab
_sp2018.pdf?sequence=1

Santini, D. J., and Y. Zhou: Potential to Electrify Miles with Different Plug-in Vehicle Innovation
Paths, 94th Transportation Research Board Annual Meeting, # 15-3263, 2015

Shahan, C. (2019, February 07). Lyft Increases Electric Vehicle Advocacy & Use. Retrieved April 24,
2019, from https://cleantechnica.com/2019/02/06/lyft-increases-ev-advocacy-more-
efficient-driving/

Shaheen, S., N. Chan and L. Rayle: Ridesourcing's Impact and Role in Urban Transportation, Access
Magazine, Spring 2017, Accessible at https://www.accessmagazine.org/spring-
2017/ridesourcings-impact-and-role-in-urban-transportation/

Sperling, D. Three Revolutions. Steering Automated, Shared, and Electric Vehicles to a Better Future,
Island Press 2017

Spurlock, C. A., Sears, J., Wong-Parodi, G., Walker, V., Jin, L., Taylor, M., … Todd, A. (2019).
Describing the users: Understanding adoption of and interest in shared, electrified, and
automated transportation in the San Francisco Bay Area. *Transportation Research Part D:
Transport and Environment*. https://doi.org/10.1016/j.trd.2019.01.014

Tal, G. (2013). Who Is Buying Electric Cars in California? Exploring Household and Vehicle Fleet
Characteristics of New Plug-In Vehicle Owners. Retrieved April 14, 2019, from
https://merritt.cdlib.org/d/ark:/13030/m56692z3/1/producer/2013-UCD-ITS-RR-13-02.pdf

U.S. Census Bureau. (2018). Retrieved from
https://www.census.gov/quickfacts/fact/table/US/PST045218

White, L. V., & Sintov, N. D. (2017). You are what you drive: Environmentalist and social innovator
symbolism drives electric vehicle adoption intentions. *Transportation Research Part A: Policy
and Practice*, *99*, 94–113. https://doi.org/10.1016/j.tra.2017.03.008

Williams, B. and J. Anderson: Electric Vehicle Rebates in Disadvantaged Communities: Evaluating
Progress with Appropriate Comparisons, Evaluation 2016 (AEA), 26 October 2016, Atlanta
Accessible online at https://cleanvehiclerebate.org/

Young, & Ernst. (2017). Gauging interest for plug-in hybrid and electric vehicles in select markets.
Retrieved May 21, 2019, from https://www.ey.com/Publication/vwLUAssets/EY-
gauging_interest_for_plug-in_hybrid_and_electric_vehicles_in_select_markets

Zarazua de Rubens, G. (2019). Who will buy electric vehicles after early adopters? Using machine
learning to identify the electric vehicle mainstream market. *Energy*, *172*, 243–254.
https://doi.org/10.1016/j.energy.2019.01.114

Zoepf, S. M., Chen, S., Adu, P., & Pozo, G. (2018). The Economics of Ride-Hailing: Driver Revenue,
Expenses and Taxes. *MIT Center for Energy and Environmental Policy Research.* Retrieved
from https://teamstersafety.org/wp-content/uploads/2018/03/2018-005-Brief.pdf

APPENDIX

### A. Distribution of individual responses of ridehailing drivers to select questions
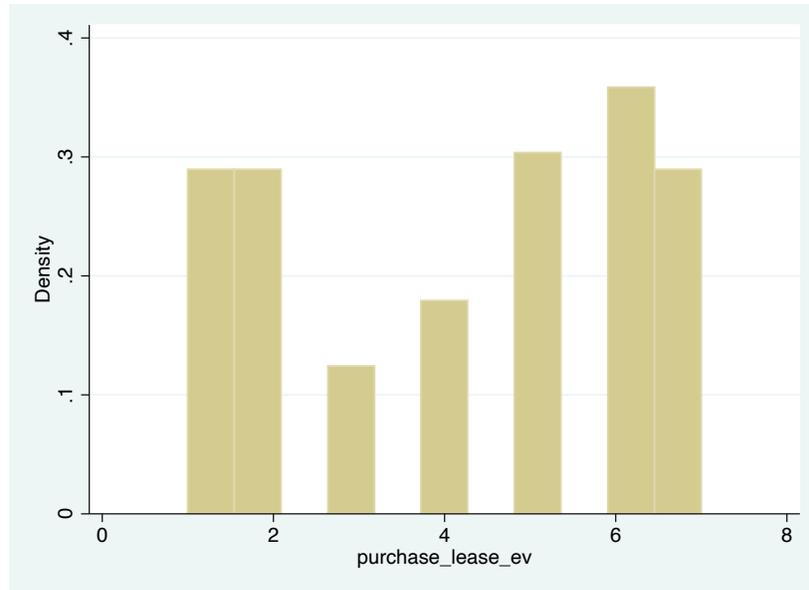
Figure A1: Response of ridehailing drivers to question as to whether next purchase is likely an EV. Numerical codes are as follows: (1) Extremely unlikely, (2) Moderately unlikely, (3) Slightly unlikely, (4) Neither likely nor unlikely, (5) Slightly likely, (6) Moderately likely, (7) Extremely likely
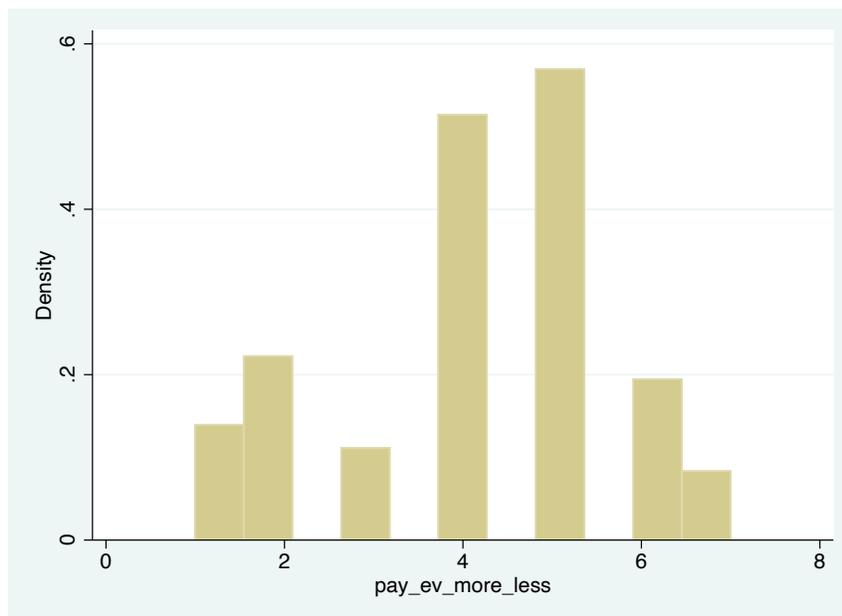

Figure A2: Response of ridehailing drivers to question as to whether one is willing to pay more or less for EV. Numerical codes are as follows: (1) Much less, (2) Less, (3) Somewhat less, (4) No more or less, (5) Somewhat more, (6) More, (7) Much more
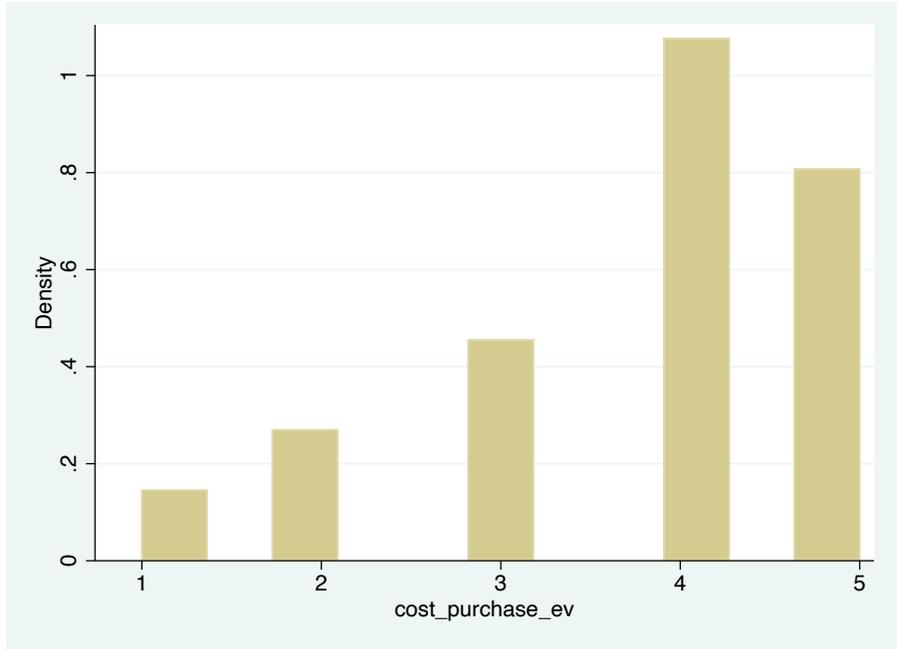
Figure A3: Response of ridehailing drivers to question as to whether EV is costlier or cheaper upfront today relative to a gasoline. Numerical codes are as follows: (1) Much less, (2) Less, (3) Somewhat less, (4) No more or less, (5) Somewhat more, (6) More, (7) Much more
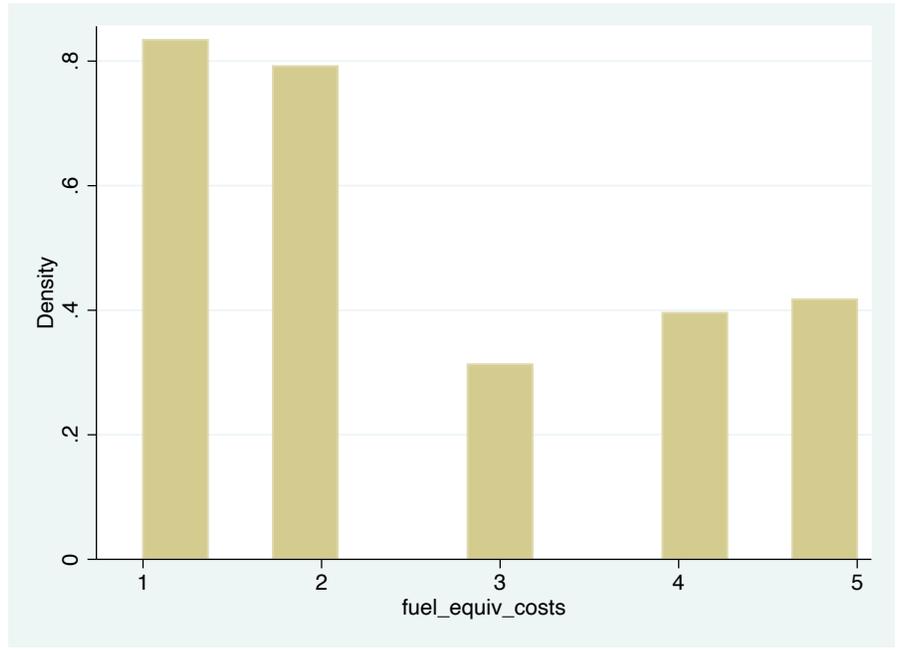
Figure A4: Response of ridehailing drivers to question as to whether EV is costlier or cheaper to fuel relative to a gasoline. Numerical codes are as follows: (1) Much less, (2) Less, (3) Somewhat less, (4) No more or less, (5) Somewhat more, (6) More, (7) Much more
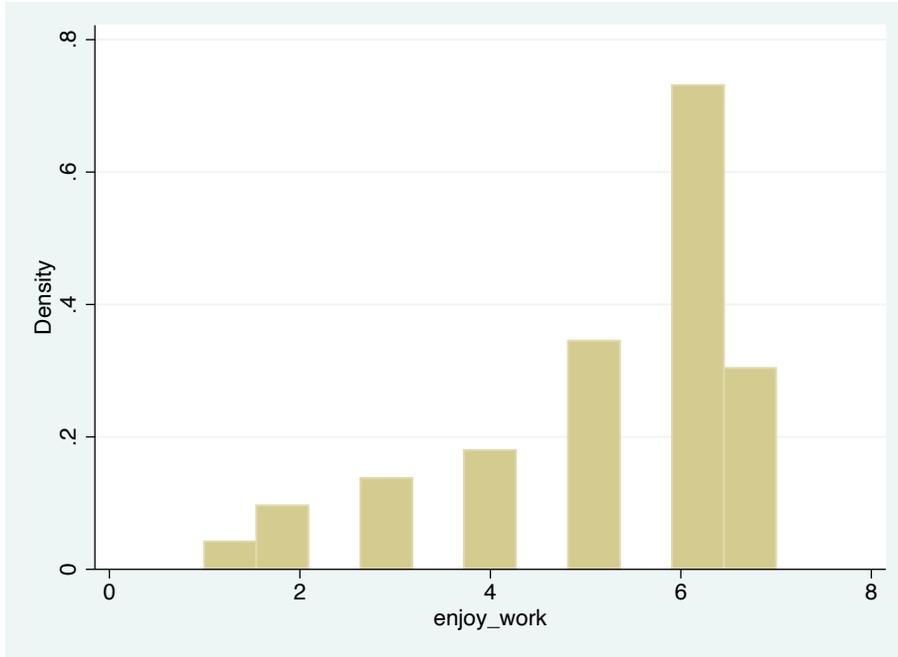
Figure A5: Response of ridehailing drivers as to how much they enjoy driving for the Lyft or Uber. Numerical codes are as follows: (1) Strongly disagree, (2) Disagree , (3) Somewhat disagree, (4)Neither agree nor disagree, (5) Somewhat Agree, (6) Agree, (7) Strongly agree
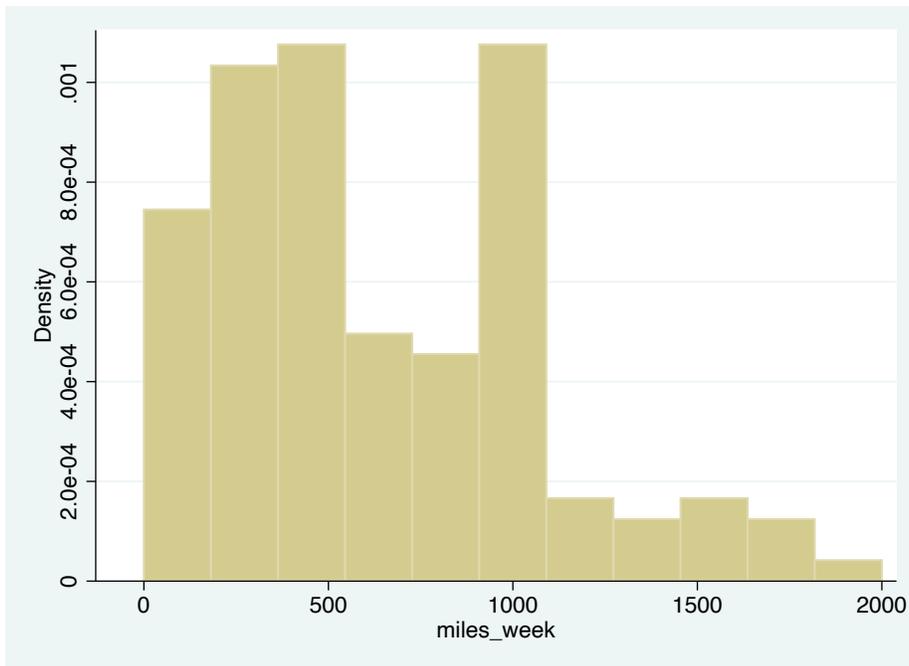
Figure A6: Response of ridehailing drivers on how many miles they drive per week on total (including personal miles).
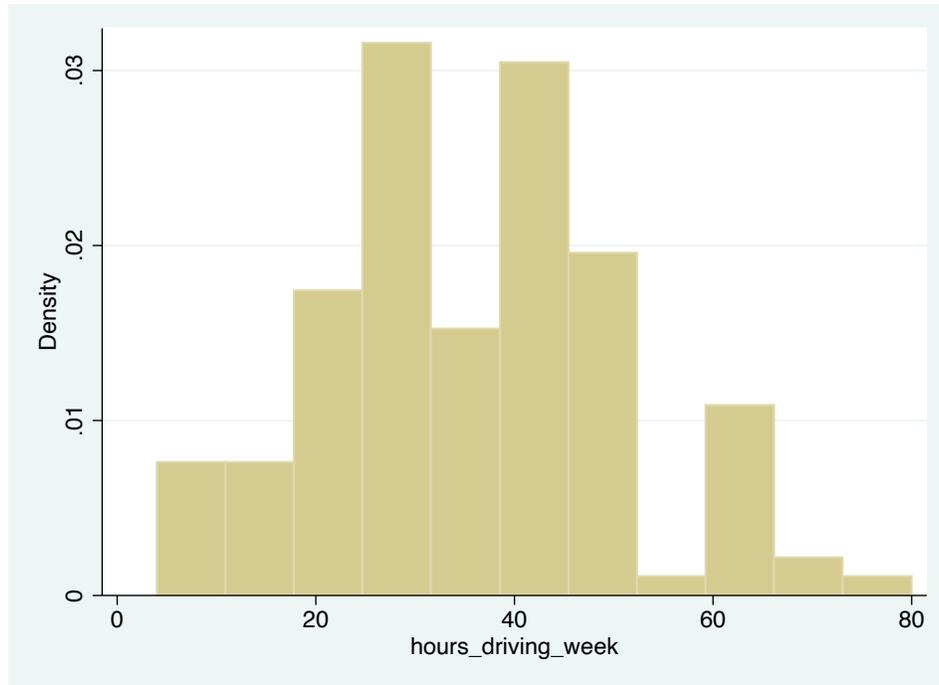
Figure A7: Response of ridehailing drivers on how many hours per week they drive on the Lyft or Uber platform.
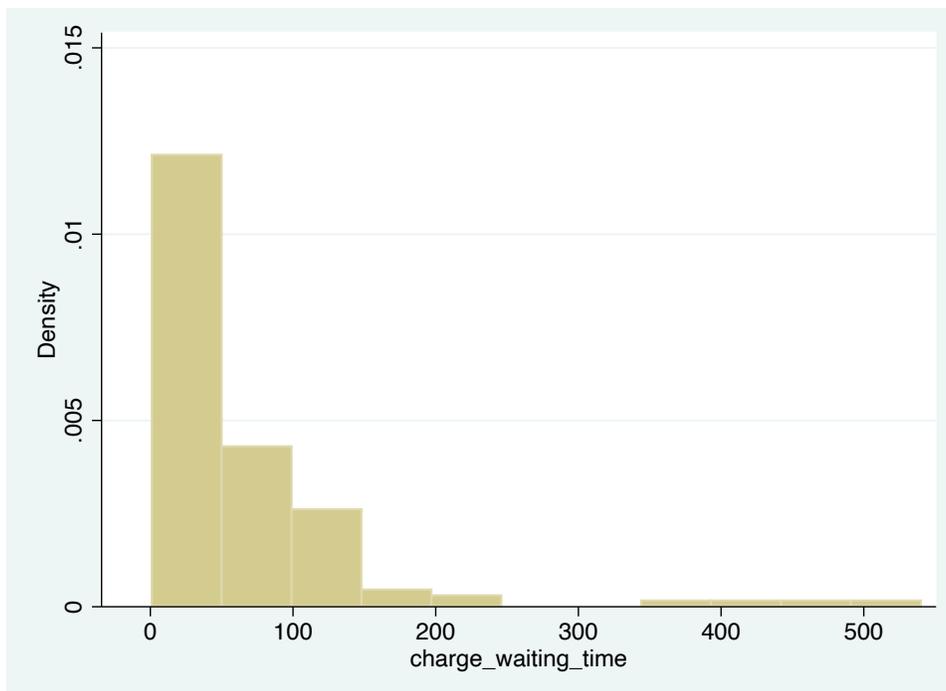
Figure A8: Response of ridehailing drivers on how many minutes are they willing to wait to charge uptheir EV battery.
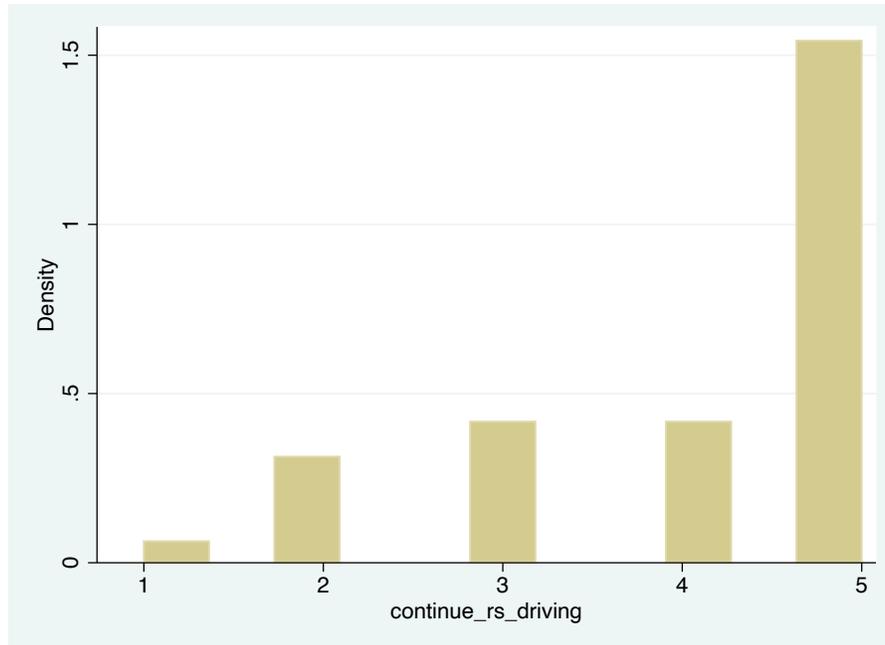
Figure A8: Response of ridehailing drivers as to how long they expect to continue driving for Lyft or Uber. Numerical encoding is follows: (1) less than 1 month, (2) 1 to 3 months, (3) 4-6 months, (4) 7-12 months, (5) more than 1 yearr)

B. Questionnaire for Lyft and Uber drivers

University of California, Los Angeles
CONSENT TO PARTICIPATE IN RESEARCH
Electric Vehicles in Ridesharing Applications

Dr. Deepak Rajagopal from the IOES department at the University of California, Los Angeles (UCLA) and Dr. Nicole Sintov from the School of Environment and Natural Resources at The Ohio State University are conducting a research study.

You were selected as a possible participant in this study because we are interested in better understanding the experiences and beliefs of ridesourcing drivers. Your participation in this research study is voluntary.

Why is this study being done?

Electric vehicles (EVs) are typically less costly to operate than gasoline cars. We would like to know what ridesourcing drivers think about them. We will use this information to better understand what barriers to EV adoption exist among ridesourcing drivers, and develop incentives or other programs to overcome these barriers.

What will happen if I take part in this research study?

If you volunteer to participate in this study, you will be asked to respond to a survey that consists of multiple choice and short answer questions regarding your experience working as a ridesourcing driver and your beliefs about EVs. This survey will be conducted during this rideshare trip in the comfort of your vehicle and you will receive monetary compensation upon survey completion.

How long will I be in the research study?

Participation will take a total of about 8-10 minutes and will conclude after the survey is completed.

Are there any potential risks or discomforts that I can expect from this study?

There are no anticipated risks of discomforts.

Are there any potential benefits if I participate?

You will not directly benefit from your participation in the research. However, your participation might ultimately allow researchers and practitioners to better understand driver needs for increased EV adoption in rideshare and help develop infrastructure to support these needs.

Will I be paid for participating?

You will receive $10 in the form of cash at the time the survey is completed.

Will information about me and my participation be kept confidential?

Your participation is entirely anonymous. That means we will not be collecting any information that can link the information provided to you specifically. Additionally, any information that is obtained in connection with this study will remain confidential. It will be disclosed only with your permission or as required by law. To minimize any risks of confidentiality breach, interview notes will be stored on an encrypted survey platform commonly used in University research that is password protected and accessible only by the research team. When the research is complete, we may save survey results for use in future research. We will retain these records for up to 3 years after the study is over.

What are my rights if I take part in this study?

You can choose whether or not you want to be in this study, and you may withdraw your consent and discontinue participation at any time. Whatever decision you make, there will be no penalty to you, and no loss of benefits to which you are otherwise entitled. You may refuse to answer any questions that you do not want to answer and still remain in the study.

Who can I contact if I have questions about this study? The research team:

If you have any questions, comments or concerns about the research, you can talk to one of the researchers.
Please feel free to contact Dr. Deepak Rajagopal at rdeepak@ioes.ucla.edu or Dr. Nicole Sintov at
sintov.2@osu.edu.

UCLA Office of the Human Research Protection Program (OHRPP):

If you have questions about your rights as a research subject, or you have concerns or suggestions and you want to talk to someone other than the researchers, you may contact the UCLA OHRPP by phone: (310) 206-2040; by email: participants@research.ucla.edu or by mail: Box 951406, Los Angeles, CA 90095-1406.

_____ Signature

_____ Date

Demographics

In what year were you born?

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┌────────────────────────────────────────────────────────────┐
│                                                            │
└────────────────────────────────────────────────────────────┘
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Which most closely represents your gender identity?

Man   Woman   Other

○   ○   ○

How would you describe your primary residence?
- ○ Single-family home (detached or free-standing residence)
- ○ Multi-family homes (apartment, condo)
- ○ Duplex, tri-plex, or 4-plex
- ○ Townhouse
- ○ Mobile Home
- ○ Other

Do you own or rent this residence?

Own   Rent   Other

○   ○   ○

Do you have a dedicated parking spot at your primary residence?
- ○ Yes
- ○ No

Do you have access to an electrical outlet where your car is parked in your primary residence?
- ○ Yes
- ○ No

What is the zip code of this residence?

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┌────────────────────────────────────────────────────────────┐
│                                                            │
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Many of the following questions ask about electric vehicles. When we ask about electric vehicles (EVs), we are referring to all-electric vehicles powered by plugging into a specialized outlet and using electricity to charge a battery pack, with no gasoline engine. A Nissan Leaf is an example of an EV. When we refer to the range of an EV, we refer to the distance that the vehicle can drive on a single battery charge. EV does not refer to hybrid electric vehicles. A Toyota Prius is an example of a hybrid.

Think about your next vehicle purchase or lease. How likely are you to purchase of lease an EV?
- ○ Extremely unlikely
- ○ Moderately unlikely
- ○ Slightly unlikely
- ○ Neither likely nor unlikely
- ○ Slightly likely
- ○ Moderately likely
- ○ Extremely likely

Please indicate the extent you agree or disagree with the following statement:

I am planning on owning an EV within the next 5 years.

- ○ Strongly disagree
- ○ Disagree
- ○ Somewhat disagree
- ○ Neither disagree nor agree
- ○ Somewhat agree
- ○ Agree
- ○ Strongly Agree

Compared to a gasoline vehicle, how much would you be willing to pay to purchase or lease an equivalent EV?

- ○ Much Less
- ○ Less
- ○ Somewhat less
- ○ No more or less
- ○ Somewhat more
- ○ More
- ○ Much more

You may have heard about short-term vehicle rental pograms. These rental programs generally allow flexibility around rental time periods (hourly, daily, weekly) and come with insurance and unlimited mileage. They typically require an up-front, fully refundable deposit to cover gas and damage to the vehicle. Uber and Lyft have partnered with many of these programs to offer incentives, such as a cash bonus for completing a given number of rides in a week. Please indicate your level of familiarity with the following such programs.

	Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar
BlueLA	○	○	○	○	○
Maven	○	○	○	○	○
Keys	○	○	○	○	○
Fair	○	○	○	○	○
GetAround	○	○	○	○	○
Hertz	○	○	○	○	○
Express Drive	○	○	○	○	○
FlexDrive	○	○	○	○	○
Whirl	○	○	○	○	○

How likely are you to rent:

	Extremely unlikely	Moderately unlikely	Slightly unlikely	Neither likely nor unlikely	Slightly likely	Moderately likely	Extremely likely
A car through one or more of these short-term rental programs?	○	○	○	○	○	○	○
An EV through one or more of these short-term rental programs?	○	○	○	○	○	○	○

Approximately how long do you intend to continue working as a ride-share driver?

No more than 1 month	1-3 months	4-6 months	7-12 months	1 year or more
○	○	○	○	○

Approximately how many hours per week do you work as a ride-share driver?

<div style="border:1px solid black; height:60px;"></div>

Approximately how many total miles per week do you drive in a car that you own or lease? Include trips made for ride-sharing, other work, school, shopping, errands, entertainment, etc.

<div style="border:1px solid black; height:60px;"></div>

Approximately what percentage of total miles per week is for:

Ride-sharing	
Other work or personal use	
Total	

Please indicate the extent to which you agree or disagree with the following statement:

In general, I enjoy working as a rideshare driver.

- ○ Strongly disagree
- ○ Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Agree

Individual Differences

How do you see yourself: Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?

Not at all willing to take risks					Moderately willing to take risks					Very willing to take risks
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Please indicate the extent to which you agree or disagree with the following statements:

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Acting environmentally friendly is an important part of who I am.	○	○	○	○	○	○	○
Using cutting edge technology is an important part of who I am.	○	○	○	○	○	○	○
Please select "disagree" as your response to this item.	○	○	○	○	○	○	○
I think of myself as someone concerned about society.	○	○	○	○	○	○	○

Symbolic Attributes

Please indicate the extent to which you agree or disagree with the following statement

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Driving an EV means that I care about the environment.	O	O	O	O	O	O	O
Driving an EV signifies to others that I am environmentally conscious.	O	O	O	O	O	O	O
Driving an EV shows others that I am at the cutting edge of technological transport innovation.	O	O	O	O	O	O	O
Driving an EV means that I'm tech savvy	O	O	O	O	O	O	O
Driving an EV means that I am a good community member.	O	O	O	O	O	O	O
Driving an EV demonstrates to others that I am socially responsible.	O	O	O	O	O	O	O

UCLA Institute of the **Environment & Sustainability**

Acquisition and Cost Barriers

Compared to a gasoline vehicle of the same type and size, do you think that:

	Much Less	Somewhat Less	About the same	Somewhat More	Much more
The cost to purchase/lease an EV is	○	○	○	○	○
The fuel-equivalent costs of an EV are	○	○	○	○	○
The maintenance and repair costs of an EV are	○	○	○	○	○

Please indicate the extent to which you agree or disagree with the following statement:

I am worried my credit could prevent me from purchasing or leasing an EV.
- ○ Strongly disagree
- ○ Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Agree Strongly Agree

Please indicate whether this statement is true or false:

The year is 2019.
- ○ True
- ○ False

Charging Barriers

When we refer to the range of an EV in several questions below, we refer to the distance that the vehicle can drive on a single battery charge.

Please indicate the extent to which you agree or disagree with the following statement:

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
If I owned an EV, I would often be worried about running out of charge.	○	○	○	○	○	○	○

How important is the availability of an easily accessible charger in your considerations to use an EV?
- ○ Extremely unimportant
- ○ Unimportant
- ○ Somewhat unimportant
- ○ Neither important nor unimportant
- ○ Somewhat important
- ○ Important
- ○ Extremely important

Charging an EV would be
- ○ Extremely difficult
- ○ Moderately difficult
- ○ Slightly difficult
- ○ Neither easy nor difficult
- ○ Slightly easy
- ○ Moderately easy
- ○ Extremely easy

The time it takes to fully charge the battery would limit my use of the EV.
- ○ Strongly disagree
- ○ Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Agree
- ○ Strongly agree

How important is speed of charging in your considerations to use an EV?
- ○ Extremely unimportant
- ○ Unimportant
- ○ Somewhat unimportant
- ○ Neither important nor unimportant
- ○ Somewhat important
- ○ Important
- ○ Extremely important

Approximately how many minutes would you be willing to wait while charging?

Having to charge an EV would limit my earning potential as a ride-share driver.
- ○ Strongly disagree
- ○ Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Agree
- ○ Strongly agree

Imagine that you are driving an EV as a ride-share driver. The Transportation Network Company (TNC for short -- e.g. Uber, Lyft) you are working for can dispatch you to an available nearby charging station at the right time if it can track the battery charge state of your EV. How likely would you be to allow your EV to share information about battery charge status with the TNC while the app is on?

- ○ Extremely unlikely
- ○ Moderately unlikely
- ○ Slightly unlikely
- ○ Neither likely nor unlikely
- ○ Slightly likely
- ○ Moderately likely
- ○ Extremely likely

Where should EV chargers be sited (e.g. any particular locations in LA or Southern California more broadly? Or any particular types of locations such as gas stations, airports, grocery stores, restaurants, etc.)?

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[blank response box]
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Possible Incentives

Imagine that there is a network of EV "re-charging cafes" throughout the southern CA region, where ride-share drivers can stop, re-charge their vehicles, and re-charge themselves. The cafes offer lounge space, restrooms with showers, a marketplace, beverages, and food. They can only be accessed by rideshare drivers who drive EVs and only during your ride-sharing shift. Drivers do not get paid while stopped at a café.

How valuable would this be for you?
- ○ Not at all valuable
- ○ Somewhat valuable
- ○ Valuable
- ○ Very valuable

If this network of cafes existed, how likely would you to be rent, lease, or purchase an EV?
- ○ Extremely unlikely
- ○ Moderately unlikely
- ○ Slightly unlikely
- ○ Neither likely nor unlikely
- ○ Slightly likely
- ○ Moderately likely
- ○ Extremely likely

Imagine that TNCs offered EV drivers a "Green Premium" of an additional $0.05 compensation per mile. If this existed, how likely would you be to rent, lease, or purchase an EV?

○ Extremely likely
○ Moderately likely
○ Slightly likely
○ Neither likely nor unlikely
○ Slightly unlikely
○ Moderately unlikely
○ Extremely unlikely

What other policy or TNC incentives would make you more likely to drive an EV?

Demographics-Sensitive

Please indicate your highest level of education (include degree you are currently working on if applicable)
- ◯ Did not complete high school
- ◯ High school/GED
- ◯ Some college/associate's degree
- ◯ 4-year college degree
- ◯ Graduate degree

What is your annual household income?
- ◯ Less than $10,000
- ◯ $10,000 to $14,999
- ◯ $15,000 to $24,999
- ◯ $25,000 to $34,999
- ◯ $35,000 to $49,999
- ◯ $50,000 to $74,999
- ◯ $75,000 to $99,999
- ◯ $100,000 to $149,999
- ◯ $150,000 to $199,999
- ◯ $200,000 or more

Do you have another source of household income in addition to your ride-share income?
- ◯ Yes
- ◯ No

If yes, approximately what percentage of your annual household income comes from ride-sharing vs. other sources?

Ride-sharing

Other source (s)

Total

Are you Hispanic, Latino, or Spanish in origin?
- ◯ No, not of Hispanic, Latino, or Spanish origin
- ◯ Yes, Mexican, Mexican American or Chicano origin
- ◯ Yes, Puerto Rican
- ◯ Yes, Cuban
- ◯ Yes, another Hispanic, Latino, or Spanish origin

What is your race? Please check all that apply
- ○ White
- ○ Black or African American
- ○ Native American or Alaska Native
- ○ Asian (including Asian Indian)
- ○ Native Hawaiian or Pacific Islander
- ○ Other

Please indicate which of the following most closely represents your political affiliation
- ○ Very liberal
- ○ Liberal
- ○ Somewhat liberal
- ○ Moderate
- ○ Somewhat conservative
- ○ Conservative
- ○ Very conservative

Please review the cost and technical details provided on the two vehicle below.

A

Electric Vehicle	
Price	$29,990
Fuel	Electric Energy
Range	150 miles
CO2 emissions	0 g/km

B

Gasoline Vehicle	
Price	$21,845
Fuel	Gasoline
Range	425 miles
CO2 emissions	172 g/km

*Range refers to the distance the car can travel before needing to refuel

5-year Estimated Costs

	Electric Vehicle	Gasoline Vehicle
Fuel	$9,206	$20,660
Repairs	$773	$1,183
Maintenance	$3,405	$4,438
Insurance	$7,850	$6,966
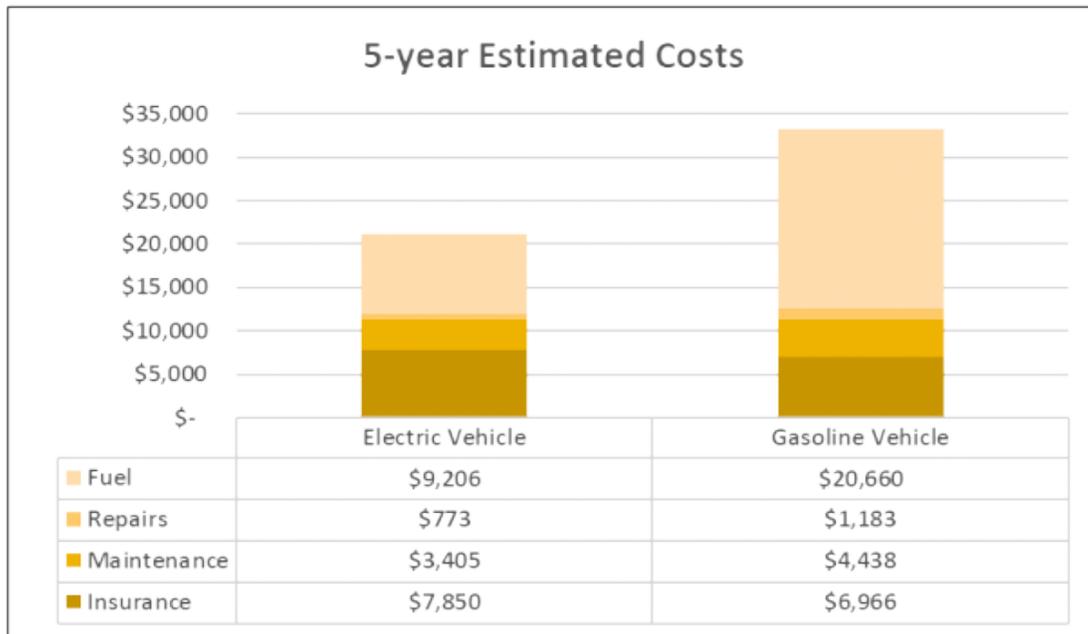
The graph above shows the estimated 5-year costs of owning each vehicle. These include the cost of fuel, repairs, maintenance and insurance.

Please review the cost and technical details provided on the two vehicles above. If given the choice, which of these two vehicles would you be more likely to lease or purchase?

○ Vehicle A – the electric vehicle
○ Vehicle B – the gasoline powered vehicle