Overview
Plug-in electric vehicles (PEVs) in ride-hailing services have grown rapidly over the last few years. This coupling has enormous potential to mitigate greenhouse gases for future mobility from transportation network companies (TNC). This work employs high-resolution data from both charging service providers and TNCs to provide novel insights into the use of PEVs in ride-hailing. We also find that emissions benefits are approximately 3 times higher for electric vehicles being used in ride-hailing compared to regular usage. Simultaneously, we find that the charging behavior of TNC drivers have decreased the utilization of regular electric vehicle users in the DC fast charging networks by about 25%.

Research Approach
The two primary sources of data are trip data provided by Lyft and charging profile data from several charging network providers. The trip data include individual trip distances with corresponding time stamps, low resolution pickup and dropoff locations, service type descriptions, and anonymous IDs to match key FOB IDs for charging events. The charging data include all charging events for full-time TNC drivers since their introduction in early 2017. These data consist of the time of charge, the duration of charge, the rate of charge, as well as location information for the chargers (latitude, longitude, and address).

Calculating the emissions benefit of electrification in shared-use fleets requires several pieces of knowledge: emissions associated with the specific electric vehicle compared against the emissions resulting from a counterfactual conventional gasoline vehicle. For the emissions of the electric vehicle, its daily driving distances can be used to develop a model of charging requirements, which allows for the calculation of associated emissions.

We analyze the charging patterns of drivers from the service provider dataset in order to understand the usage, turnover, and locational aspects of chargers. In addition, we examine the substitution patterns of charging events as Lyft vehicles become increasingly integrated into the fleet of electric vehicles on the road. In particular, we are interested in the response of other charger users to the high demand from Lyft drivers.

Sample Results
We can calculate the associated emissions for each charging event based on the amount of energy demand and the time of the event. The upstream emissions resulting from plugging in an electric vehicle depends on the time of charging because different power plants are responding to increase in charging demand at different times of the day. We calculate the average marginal emissions in California on an hourly basis from the California Independent System Operator Greenhouse Gas Emission Tracking Reports that allow us to understand how clean/dirty the electric grid is at different times of the day. Due to the high availability of solar power, the emissions during the day are lower than the nighttime emissions, though California as a whole has a relatively cleaner grid compared to the remainder of the United States.

How much emissions have been saved from the use of PEVs in ride-hailing services? If we assume that the PEVs were all instead relatively fuel-efficient gasoline vehicles (35 MPG), we can calculate the difference in emissions across all miles traveled as captured by the charging infrastructure (left panel, Figure 1). The daily emission savings averages at 36.5 kg of CO₂ for electrifying the ride-hailing service. Across all ~1,000 PEVs from the beginning of 2017 through May 2018, this has resulted in a total savings of 1,142 tons of CO₂, the equivalent of removing approximately 260 gasoline vehicles off the road (note that this is true unless the electric vehicles themselves change the demand for ride-hailing services). When we compare these savings against replacing average gasoline vehicles (not in ride-hailing services) with electric vehicles, the emissions reductions are nearly three times lower (right panel, Figure 1).
Figure 1 A histogram of the comparative emission savings for switching a ride-hailing vehicle from a gasoline vehicle (assuming 35 MPG) to a Chevrolet Bolt (based on TNC PEV travel behavior) versus switching an average gasoline vehicle in California (assuming 27 MPG) to a Chevrolet Bolt (based on CHTS travel behavior). We find the emissions savings to be nearly three times higher for electrifying ride-share versus electrifying the average California driver.

Conclusions

Electric vehicle use in new mobility ride-hailing services has grown rapidly over the last year and a half and there is still tremendous potential for further expansion. Understanding the ramifications of this new vehicle technology coupled with new mobility options, such as Lyft and Uber, is critical to ensuring these two revolutions in transportation can maximize social welfare. In this study we observe both large benefits in the form of emissions reductions but also challenges that must be overcome for charging infrastructure development and use.

The emissions benefits are immediately apparent: due to the higher travel intensity of vehicles participating in ride-hailing programs, using electric vehicles extends the per-mile benefits of this technology over a greater number of miles. One of the concerns for electric vehicles in these services is their ability to provide comparable services due to potential issues with electric range. While we do not perform a direct comparison with ride-hailing service vehicle travel, we do observe that the PEVs in the TNC service are able to drive upwards of 190 miles a day on average (compared to 20-30 miles a day for a typical driver) and can top 300 miles a day in several instances. The travel often exceeds the range of the battery and at least demonstrates with 200+ mile range battery a technical capability with the availability of DC fast chargers (though not necessarily an economic feasibility). From a purely emissions standpoint, we find that even in the most pessimistic scenario, replacing a full-time ride-hailing service vehicle with a battery electric vehicle yields an emissions reduction three times higher than replacing an average gasoline vehicle in California. If policy promoting adoption of electric vehicles begins to move away from a “number of vehicles” focus to a more electric miles focus, strong consideration should be placed on the large potential in electrifying the growing ride-hailing services.