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Electric vehicles in multi-vehicle households

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ABSTRACT
This paper uses U.S. nationally representative data from the 2017 National Household Travel Survey to present a series of facts about electric vehicles (EVs) in multi-vehicle households. First, as of the time of the survey, 89% of households with an EV also had a non-electric vehicle in addition to the EV. Second, 60% of households with an EV also had a non-electric SUV, truck, or minivan. Third, 66% of households with an EV also had a non-electric vehicle that was driven more miles per year. The paper argues that these patterns have significant implications for the environmental impact of EVs and underscore the importance of better understanding how multi-vehicle households substitute between vehicles.

KEYWORDS
Carbon dioxide emissions; vehicle miles traveled; range anxiety; gasoline tax

JEL CLASSIFICATION
D12; L62; Q41; Q54; Q55

1. Introduction

Economists have long argued that the best way to address externalities is to price them directly. For reducing carbon dioxide emissions from transportation this would take the form of a carbon tax, or equivalently, a gasoline tax. The advantage of this approach is that it induces efficient choices along all margins, for example, encouraging households to buy more fuel efficient vehicles and to drive them fewer miles per year.

Instead, many countries have subsidies for EVs.[1] Mostly missed in analyses of EV subsidies, however, is the potential for multi-vehicle households to substitute between electric and non-electric vehicles. Being encouraged to buy an EV may change the other vehicles that a household chooses to buy. In addition, households may choose to use their vehicles differently, for example, preferring non-EVs for long trips.

Within-household substitution only matters to the degree that there are a significant number of such multi-vehicle households. This paper uses U.S. nationally representative data from the 2017 *National Household Travel Survey* (NHTS) to present a series of facts about EVs in multi-vehicle households. Prior to the latest wave of the NHTS there were few EVs on the road, so these data provide one of the first opportunities to examine EVs at a national level within the broader context of household vehicle portfolios.

The paper complements a growing broader literature on the economics of EVs. Previous studies examine, for example, the importance of local factors in determining environmental impacts (Zivin, Kotchen, and Mansur 2014; Holland et al. 2016), the effectiveness of EV subsidies (Muehlegger and Rapson 2020), EV charging infrastructure (Li et al. 2017; Li 2019; Springel 2021), and the economics of banning gasoline vehicles (Holland, Mansur, and Yates 2021).

2. Empirical evidence

2.1 Number of vehicles

Fact 1: As of the time of the survey, 89% of U.S. households with an EV also had a gasoline or diesel vehicle.

Figure 1 describes the number of vehicles per household. Only 10% of U.S. households with an EV are single-vehicle households, compared to 37% of all U.S. households. Thus, households with an EV are almost four times *less* likely to be single-vehicle households. Households with EVs are much more likely to have 2-, 3-, and 4+ vehicles,

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[1]The International Energy Agency 'Global EV Outlook 2021' describes EV subsidies in the United States, Canada, European Union, India, Japan, and China.

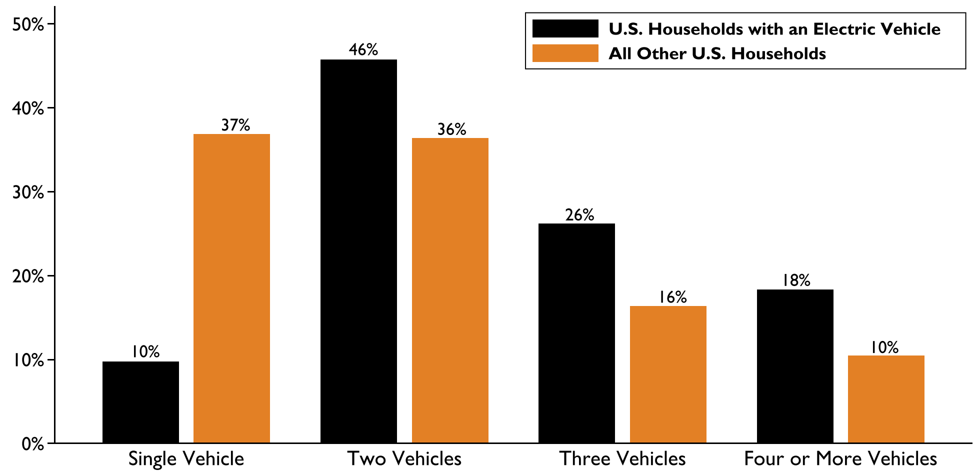

Figure 1. Number of vehicles in the household.
Note: All statistics throughout are calculated using NHTS sampling weights. EVs include both all-electric and plug-in hybrids and the calculations for 'All U.S. Households' exclude a small number of households (<5%) with zero vehicles.

and, overall, U.S. households with an EV have an average of 2.7 vehicles, compared to an average of 2.1 vehicles for all U.S. households.

2.2 Vehicle categories

Fact 2: As of the time of the survey, 60% of U.S. households with an EV also had a non-electric SUV, truck, or minivan.

Table 1 describes the other vehicles in U.S. households with an EV. Among U.S. households with an EV, 55% also have a non-electric 'car', i.e. a sedan, hatchback, or station wagon. Of U.S. households with an EV, 42% also have a non-electric sports utility vehicle (SUV). Many households with an EV also have non-electric trucks (13%) and minivans (12%). These larger vehicles provide differentiation with regard to seating capacity, cargo area, and other factors, but tend to be less fuel efficient.

2.3 Driving intensity

Fact 3: As of the time of the survey, 66% of U.S. households with an EV had a non-electric vehicle that was driven more.

Table 2 reports information about driving intensity. NHTS respondents report the current odometer reading for all vehicles in the household. To calculate the average annual miles travelled for each vehicle, these odometer readings were divided by vehicle age.

Most U.S households with an EV have some other non-electric vehicle that they drive more miles per year. Larger vehicles tend to be used particularly intensively and, overall, 46% of U.S. households with an EV have a non-electric large vehicle that they drive more miles per year. These findings provide additional context for previous research which has shown that EVs tend to be driven less than other vehicles (Davis 2019; Burlig et al. 2021).

Table 1. Other vehicles.

Among U.S. households with an EV, what percentage also have?	
Another vehicle of any type	90%
A non-electric vehicle of any type	89%
A non-electric car (e.g. Honda Civic, Toyota Camry)	55%
A non-electric SUV (e.g. Porsche Cayenne, Toyota Highlander)	42%
A non-electric truck (e.g. Ford F-Series, Toyota Tacoma)	13%
A non-electric minivan (e.g. Honda Odyssey, Toyota Sienna)	12%
A non-electric SUV, truck, or minivan	60%

Table 2. Driving intensity.

Among U.S. households with an EV, what percentage have?	
A non-electric vehicle that is driven more than the EV	66%
A non-electric car that is driven more than the EV	33%
A non-electric SUV that is driven more than the EV	33%
A non-electric truck that is driven more than the EV	7%
A non-electric minivan that is driven more than the EV	9%
A non-electric SUV, truck or minivan that is driven more than the EV	46%

3. Discussion

3.1 Why multi-vehicle households?

A potential explanation for these patterns is that EVs are attractive to multi-vehicle households because they can substitute attributes across vehicles. Archsmith et al. (2020) describes a model in which multi-vehicle households derive utility from the characteristics of each individual vehicle, as well as from the *combination* of attributes in the vehicle portfolio.

For example, a household might want one vehicle for commuting, as well another larger vehicle for trips that require carrying more passengers or cargo. This differentiation increases household utility, making it more likely that a household has an appropriate vehicle for any necessary trip and purpose. With EVs many households perceive range limitations to be a significant challenge. However, the ability to substitute between vehicles makes range limitations less of a challenge for multi-vehicle households.

Adopting an EV may also impact the subsequent vehicles acquired by the household. In the model described by Archsmith et al. (2020), households make vehicle purchase decisions taking into account how that additional vehicle will change the overall portfolio. If the household already has a smaller EV, it may want to diversify when acquiring its next vehicle with a non-electric larger vehicle. Archsmith et al. (2020) discuss how such substitution can erode the environmental benefits of programmes like 'Cash-for-Clunkers', but the same can be said of EV subsidies.

3.2 Why fewer miles?

Why do two-thirds of households with an EV have a non-electric vehicle that is driven more miles per year? This is somewhat surprising because EVs cost less to drive per mile than gasoline- and diesel-powered vehicles (Rapson and Muehlegger 2021), so there is a financial incentive for households to use EVs intensively. One possible explanation is range limitations. Multi-vehicle households may choose to deploy non-electric vehicle for longer trips.

The 2017 NHTS is already several years old and it is worth noting that earlier EVs tended to have limited range. The first generation Nissan Leaf, for example, had a range of less than 80 miles, making it impractical for medium-length trips. In contrast, the current Nissan Leaf has a 150+ mile range, almost twice the range as the original version. Moreover, manufacturers have now introduced dozens of new EV models with significantly higher range. An important priority for future work is to re-examine these patterns with newer data once available.

4. Conclusion

Thus the evidence shows that, at least for this early wave of EV adoption in the United States, EVs tend overwhelmingly to be in multi-vehicle households. These households tend to also have at least one large non-electric vehicle like an SUV, and they tend to have at least one non-electric vehicle that is driven more miles per year than their EV.

This evidence suggests that the environmental benefits of EVs may be smaller than previously believed. Multi-vehicle households are able to choose larger and less fuel-efficient vehicles to complement their EVs. Moreover, within-household substitution may lead to EVs being driven less intensively than non-electric vehicles.

These results underscore the importance of better understanding how multi-vehicle households substitute between vehicles. This within-household substitution plays a particularly important role with EVs and policymakers need better information about these behaviours if they are to craft effective subsidies and other policies aimed at reducing carbon dioxide emissions from transportation.

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Disclosure statement

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