EconoFact Chats: The Economics of EV Adoption
David Rapson, University of California, Davis
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I'm Michael Klein, executive editor of EconoFact, a non-partisan, web-based publication of the Fletcher School at Tufts University. At EconoFact, we bring key facts and incisive analysis to the national debate on economic and social policies, publishing work from leading economists across the country. You can learn more about us and see our work at www.econofact.org.

Michael Klein
An important source of climate change is greenhouse gas emissions, and an important source of these emissions is the use of fossil fuels for transportation. Electric vehicles are thought to represent a partial, but important, solution. Towards this end, the European Union, China, Japan, South Korea, and several U.S. states have declared the intention to ban gasoline and diesel cars. How realistic is it to move to a fully electric vehicle fleet? How desirable is this goal? And what are the challenges in achieving this? To address these questions, I am pleased to welcome to EconoFact Chats Professor David Rapson of the University of California at Davis. Dave also serves as an Economic Policy Advisor to the Federal Reserve Bank of Dallas. He has written extensively about energy and the environment, including a prior EconoFact memo on electric vehicles. Dave welcome to EconoFact Chats.

David Rapson
Thanks, Michael. It's great to be here, and you do a lot of important work here at EconoFact, so I appreciate being invited. Before we get going, I just need to give a disclaimer, the views that I'm sharing today are my views alone, and not the views of the Federal Reserve Bank of Dallas or the Fed system.

Michael Klein
Okay, my views aren't those of the Fed system either, so that makes two of us.

Michael Klein
Dave, I remember when I would be surprised to see a Tesla on the road. At that time, it was, to my knowledge, the only fully electric vehicle. Now it's commonplace to see Teslas, [Rivians], and electric vehicles from Audi, Ford, Mercedes-Benz, and many other manufacturers. What are the statistics behind this? What's been the increase in electric vehicles?

David Rapson
Well, in 2023, over 16% of new cars sold in the U.S. were plug-ins – where about 80% of those are battery electric, and 20% are plug-in hybrid electric. So it's not surprising to me that, especially you being in Boston, that you're encountering a lot of these cars. In places like Boston, and where I live in California, these are very popular. So it's even a much larger market share of new vehicle sales where we live. But of course, it takes a long time for new vehicle sales to be reflected in the overall transportation, the car fleet. So right now, EVs are about 1% of the total light-duty fleet nationwide. But yeah, where you and I live, that fraction is much higher. In California, it's about 5%. And this is up dramatically over the last several years. Just when I

started studying electric vehicles about a decade ago in 2014, they were a minuscule market share, and there were almost none of them on the road.

Michael Klein
So you mentioned around Boston and in California where you are, there are a lot more electric vehicles. Does that reflect the fact that these are relatively affluent parts of the country? Because these are really expensive cars. How does the price of electric vehicles as compared to gas or diesel vehicles hamper the expansion of the market?

David Rapson
Well, yeah, I think there's actually two questions in there. One is, you know, why do we see EVs in the places where we live? And I think part of it is that these are affluent areas of the country. But also, there's a very strong political divide that you see when you look at patterns of EV purchases. And there was a nice paper by Lucas Davis and co-authors that was showing how strong political affiliation is as a predictor of who's buying EVs. But yes, you're absolutely right. Electric vehicles are relatively expensive. Last year, over half of the EVs sold in the US were Teslas. And I don't know whether you've ever driven a Tesla, Michael, but they're really fancy, amazing cars. The best car I've ever driven, I would say for sure. And, you know, I make pretty good money, but I've never bought a car that's anywhere close to that expensive.

Michael Klein
Yeah, it's a sweet ride, as they say.

David Rapson
It is.

Michael Klein
I guess what you're saying is you wouldn't expect certain bumper stickers to show up on Teslas as compared to, I don't know, a pickup truck or something like that.

David Rapson
Yeah, it does seem like a different population. And, you know, for EVs to be widespread, the costs are going to have to come down. And the options in the marketplace are going to have to include many more low-cost EVs that are going to be affordable to the average car buyer in America. And, you know, I think we're going to talk soon a little bit about the tariffs on Chinese imports. But, you know, there are a lot of cheap EVs being produced worldwide. We just don't really sell them here in the US yet.

Michael Klein
Yeah, that's what I was going to bring up next. The President has recently directed increases on the tariff on Chinese electric vehicles from 25% to 100% in 2024—and this effectively keeps them from being sold in the United States. I guess it would have been relatively inexpensive. So does this illustrate one type of tension between competing goals, that of, say, protecting American auto jobs, and on the other hand, trying to do something for the environment?

David Rapson
Yeah, there's a real tension at work here, Michael, for sure. And it feels to me like we've entered a new era of global geopolitics and trade. You know, a decade ago, this type of tariff would have, I think, met widespread resistance, whereas now it has more or less widespread bipartisan support. And I think that's reflective of, as you say, competing priorities around national security, the need for cheap and reliable energy services, economic growth, climate goals, political considerations, all of these are tugging in different directions. And, you know, sometimes the national security goals might, or energy security goals, might win out over the climate goals. And it certainly seems like in this case, you know, these tariffs are not pro-climate tariffs.

Michael Klein
The president has also called for higher tariffs on lithium-ion batteries, battery parts, and graphite—which is used in batteries. This too will add to the cost of electric vehicles. But isn't one of the big stories with regard to electric vehicles the decline in the cost of their batteries?

David Rapson
Yeah, absolutely. Battery prices have fallen by about 90% in the last decade, which is just an incredible decline. And it has allowed electric vehicles to become much more affordable, even though, you know, the ones that we see on the road are still quite expensive. Batteries are about, for let's say a Tesla Model 3, they're going to be about $8,000 to $11,000 right now, the battery component of that car. So that's, you know, about 20% of MSRP. It changes, you know, that number changes from time to time. But the key here is that these battery price declines are a result of China dominating this industry and every part of the supply chain, and essentially expanding capacity for battery production, so much that there's abundant supply and the prices have really declined. And right now, the issue is that the US doesn't want to be reliant on China for this supply chain. The US and its allies are seeking to build their own Western battery supply chain. And right now, it's just impossible for the Western supply chain to compete with China. That's how dominant China's position is. And so these tariffs are an attempt to allow some headroom for the domestic supply chain to take a foothold.

Michael Klein
Well, the tariffs are an effort to do that, but the batteries for electric vehicles, at least of now, require minerals and metals that are not widely available. How much of a constraint to the expansion of electric vehicle production and ownership does this represent?

David Rapson
Well, a lot of people are really worried about this. And certainly, I would say that if we are getting our supplies from China and China decides to cut off those supplies, that would be an issue. But I'm a little bit less worried about this than other people. As it turns out, we're really good at finding sources of supply for things that we need. And this is kind of an almost magical talent that our economy has that operates through the price signal. So when things get scarce, when prices go up, high prices are going to have two main effects that are going to solve this problem for us. One is when prices get high, we're going to consume fewer of these goods, and we're going to look for substitutes. So in the battery context, that's, for example, a shift away from nickel-magnesium-cobalt batteries to LFP batteries, lithium iron phosphate batteries, which are much cheaper. Iron and phosphate are more abundant and cheap than nickel and cobalt are.

And so this is, I think, the type of thing that's going to allow us to navigate the resource scarcity in this market.

Michael Klein
Of course, one of the reasons that people are wanting to promote electric vehicles is for climate change. And there's some discussion out there about the relative efficiency of electric vehicles as compared to internal combustion engine vehicles, where internal combustion engine vehicles waste a lot of the energy. You can tell by the way the engines heat up, for example. And electric vehicles are more efficient. But this isn't the whole story, is it, about energy efficiency?

David Rapson
When you look at energy efficiency of these two competing technologies, you really have to look at the entire life cycle of these vehicles. And really, it's not just the energy that we care about. Usually, people are looking at the life cycle footprints of these vehicles through the lens of the pollution that they're creating. But no matter how you slice it, you've got the emissions that are happening from the use of the vehicle. And there, for electric vehicles, there's almost no emissions at the tailpipe, right? Because all of the emissions have happened upstream in the energy production. And so I think often, when I hear people talking about the relative efficiency of electric vehicles, that's what they're talking about. But it misses the upstream components that are really important. The electricity has to be generated somehow. And right now, 60% of the US grid is fossil generation. And actually, 60% of the global grid is as well, just with a different mix of coal and gas. So there's still a lot of emissions coming out of electricity production. And another big component for electric vehicles is the mining and production [and] of refining of nickel, which is very energy-intensive and emits a lot of pollutants as well. So I think it's complicated to really look at the relative energy use or emissions of these two technologies is quite complicated. I recently actually saw a paper presented just last week, Jeremy Michalek from Carnegie Mellon was here. He had done an analysis looking at the relative footprints of these technologies. And from his assessment, which is a couple years old, a large battery electric vehicle actually produced more pollution than a gasoline combustion car. So it's complicated.

Michael Klein
So it's complicated. But nonetheless, there's a government push to address climate change through the adoption of electric vehicles. And towards this end, there have been government subsidies and tax breaks. Is this good public policy?

David Rapson
Well, first, I think there needs to be an understanding that subsidizing electric vehicles is going to produce a very different vehicle population than if instead we had taxed gasoline cars. I am concerned that if we pursue a subsidy-based approach, which really is, you know, the Inflation Reduction Act is very subsidy-based. If we pursue that as the main approach, that expands demand for vehicles, we're going to be buying a lot more electric vehicles because they're subsidized. But it doesn't really contract demand for gasoline cars…or certainly doesn't produce an incentive to use gasoline cars less. So from an emissions perspective, I have a real fear that we're going to look back 10 years from now, having deployed so much subsidy resources towards EVs and find that actually we're still burning much more gasoline and emitting a lot more carbon than we had hoped to at that point.

Michael Klein
Yeah, your EconoFact memo, that I mentioned in the introduction, talks about people buying electric vehicles, but then still holding on to their gas cars. And I guess that's exactly the point you're making here, right?

David Rapson
Yeah, so I'm actually going to come out with a paper, hopefully in the next few months, that documents, and estimates actually the average change in vehicle portfolios for households that buy electric vehicles. And yeah, we are finding that people who buy electric vehicles are holding on to more gasoline cars than people who buy gasoline cars. So it's like there's a little bit of hedging going on there.

Michael Klein
So in terms of people's choice, we've been talking about the upfront cost of electric cars, but they're cheaper to operate and maintain than gas powered cars. Do you think this has been an important contributor to the expansion in the sales and adoption of EVs?

David Rapson
Well, I mean, the conventional belief is that EVs are cheaper to operate and maintain, but I'm actually not sure that that is completely true. So for the operating side of things, we know how much gasoline costs, we know how much electricity costs in a given place, we know the efficiency of the vehicle. So the cost of traveling a mile can be easily compared on the operation side of things. And what we see is in most of the country, it's certainly true that EVs are going to be cheaper to operate because electricity prices are so cheap relative to gasoline prices. And you know, when you do all the conversions, it just turns out that way. But that's not necessarily the case everywhere. In California, a lot of EV owners are paying very high electricity prices. And it's not necessarily cheaper for all of these EV users. Now, you also mentioned maintenance. And, you know, I'd heard for a long time as well that EVs have lower maintenance costs. But I've recently seen more stories that this isn't true. And, you know, these are along the lines of people bringing their EV into the shop, and then having to wait, sometimes several weeks, for a replacement part to arrive. So, you know, maybe this is just a supply chain issue that's going to iron out as EVs become a larger part of the fleet. But, you know, if they're cheaper, they're not a lot cheaper than gasoline cars to maintain at the moment.

Michael Klein
Another issue with the expense is the upfront cost of creating a charging station or the challenge of not being able to have a charging station. For example, if you live in a multi-unit dwelling in an apartment. How does this affect the adoption of electric vehicles?

David Rapson
Well, one of the main benefits of an EV is that you can charge it at home. And you don't have to go to gasoline stations. But obviously, that's only available to you if you have, you know, a parking lot or a driveway or a garage and a charger that you can get out to the car. So a lot of people who live in multi-unit dwellings, they're not going to have that available. And they're going to be relying on charging infrastructure that's public. And the economics of these commercial charging stations is not great. I mean, it was a surprise to me, and I think quite

revealing that just recently Tesla, which has the dominant fast-charging network in America, laid off its entire smart charger team. And they appear to be now dramatically slowing their build-out of commercial chargers. And this, by the way, is after they had basically won the battle to become the standard in that market. So I think the economics of commercial chargers is not great. I think that's what I take from that is, you know, if Tesla was making money hand over fist from their supercharger network, then I don't think they would be slow rolling it like this. But yeah, there are lots of issues relating to charging. And it's one of the big challenges. How do we figure out how to make chargers available to people who don't live in single-family homes?

Michael Klein
Dave, I'd like to sort of look at a broader point now. I learned a lot from a recent review article that you co-authored with James Bushnell in the *Review of Environmental Economics and Policy*. One of the interesting points you bring up in that article is that economists think differently about the issue of the adoption of electric vehicles than many other analysts. You write that, "the dominant policy framing, based on engineering or natural science, focuses on quantitative targets like say net zero emissions." But economists try to match benefits versus costs, or more precisely, marginal benefit versus marginal cost, for those who have had even a principles of economics course. Can you explain this difference and discuss its implications for policy?

David Rapson
Sure. So let's think about just the example of electric vehicles. In the early stages of adoption, the people who want electric vehicles, they're very wealthy, they have a strong preference to be pro-climate, and they're getting a lot of benefits from buying and using electric vehicles, and maybe being seen to use electric vehicles that cause them to be willing to pay a high price for these cars. But as you start having more and more people adopting, the next people buying electric vehicles are going to probably be a little bit more pragmatic. They want to see, well, which of these cars is going to meet my needs the best? And if the marginal benefit to them is lower than the marginal cost, then they're not going to buy the car. Now, you can think of this from a policy perspective too, just zooming out. What is the optimal amount of electric vehicles on the road? Well, electric vehicles have costs and benefits, and we want to maximize the net benefits to society. This includes both the private benefits of people enjoying transportation services, but also the pollution reduction that happens from, say, driving an EV that's charged with renewable energy. And economists would like to maximize those net benefits, which might imply that we're not going to get to 100% EVs for example. It might be the case that the costs of going more electric rise steeply at some point on the adoption curve. And at that point, we want to consider, well, do we want to have further adoption of EVs?

Michael Klein
Another really interesting point in that review article is that electric vehicles are not likely to be what you call the 'dominant technology.' Can you explain what you meant by that and why you came to this conclusion?

David Rapson
Yeah, so people in the EV industry and often in climate policy in general have in the back of their mind the framework of the 'S adoption curve'. So this is an adoption curve with time on the x-axis, and the fraction of the population that has adopted this technology on the y-axis. And it looks often like an 'S', where you have early adopters are going to be slowly increasing the market share until some critical mass is achieved. And then it's going to really steepen the adoption curve, and then flatten out as you get to really high levels. Now, for some technologies like smartphones and flat-screen TVs, you end up plateauing at around 99%. That's just to say almost everybody's using these technologies because they're superior in the mix of attributes that they're offering, including price. So the question is, is this going to happen for electric vehicles? And I don't think there's really any reason to think that it will plateau at 99% or 100%. It could easily be the case that at some point on this adoption curve, the costs of going farther are going to outweigh the benefits at some unknown market share. We don't know what that is, but yeah, it's quite possible that the equilibrium we're going to end up with is one that has both gasoline cars on the road, and battery electric cars on the road. And by the way, I think that plug-in hybrids are probably going to be very popular over the next decade.

Michael Klein
So in terms of policy, I guess this is saying that you don't want this policy that's pressing for everybody to have an electric vehicle. That's not necessarily the best policy. It does not recognize that there are costs as well as benefits to having electric vehicles.

David Rapson
Maybe the way I described it before might have been taking it from the wrong direction. So let me take another stab at that. You know, one way to think about the costs of going to 100% electric vehicles is let's say that 90% of people are driving electric vehicles, and the only people who are left drive massive Ford F-150 trucks that actually use them to haul heavy construction equipment around. You know, it turns out that right now, gasoline cars are just better at that type of activity. When you use a battery electric, let's say the Ford Lightning, to haul around heavy construction equipment, the range on that car diminishes really, really quickly. So this is an example of the marginal benefit of moving to electric dramatically declining, or, put differently, the benefit to these consumers of sticking with their gasoline Ford F-150 is very high. Now, do we want to force them to go electric anyway? I think the case for that would be if we have a completely green grid and the damages from that incremental amount of pollution are so high that we're going to prioritize reducing those emissions over the private benefits of using a truck that has better services for them. That would be the rationale. I think at some point we're going to reach a level of EV penetration where the next buyers just really prefer to have their gasoline cars.

Michael Klein
So I'm going to conclude by asking you, Dave, what kind of car do you drive?

David Rapson
Well, right now, let me just rewind actually because I in 2017 leased a hydrogen car. So this was my kind of foray into the frontier of these new technology vehicles. And this was an amazing car. It was a Toyota Mirai and I really enjoyed the experience when I was driving it. But overall,

it had the worst consumer experience that I've ever had because I couldn't find fuel for it about half the time. And this is for a variety of reasons. Hydrogen charging stations are technologically very difficult to operate because of the temperature of the hydrogen and the fragility of the components and whatnot. But also one of the hydrogen production facilities in California blew up in the middle of my lease. And so there just wasn't enough hydrogen to go around. But after that experience, Michael, I just decided I'm going to go for this other technology that has really reliable supply and that I know I'll be able to fuel up anytime. And it's called a gasoline car. So I currently drive a Volvo sedan, a used one from 2013. And I'm very much enjoying it.

Michael Klein
Okay, well, I'll contact the people at Volvo, you'd make a good ad for them—for what remains of their gas-powered fleet. Dave, thanks for joining me today on EconoFact Chats and discussing this really important topic, and one that has really captured the public's attention.

David Rapson
My pleasure, Michael. Thanks for having me.

Michael Klein
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