The chicken-and-egg problem of electric cars

For consumers to adopt electric cars widely, a network of charging stations must be present. However, the development of charging stations is also dependent on the wide circulation of electric cars. Additionally, consumers worry about the tendency for electric vehicles to have a lower driving range than traditional cars. ***Kevin Remmy*** *built an empirical framework that models consumers' new car purchase decisions, car producers' price and range decisions, and charging station entry. He writes that policymakers must understand strategic price and range reactions to subsidies and how they interact with indirect network effects.*

LSE Environment Week
19-23 September 2022

Road transport accounts for nearly 11 per cent of global greenhouse gas emissions. One of the most promising tools to decarbonise this sector are electric cars. Accordingly, governments worldwide subsidise electric car purchases to the tune of nearly $30 billion in 2021 alone. However, significant barriers preventing widespread electric car adoption exist. First, electric car diffusion requires the development of a network of charging stations whose value in turn depends on the number of electric cars circulating. These indirect network effects create a "chicken-and-egg" problem in which neither side of the market will develop without the other. Second, the driving range of electric cars is lower compared to gasoline or diesel cars, making range an important quality factor for consumers. Moreover, firms can adjust the range relatively easily. These barriers then pose an issue to policymakers: How to effectively design electric car subsidies considering this chicken-and-egg problem that interacts with car makers adjusting both prices and driving range in response to subsidies?

To answer this question, I built an empirical framework that models new car purchase decisions of consumers, price and range decisions of car producers, and charging station entry. Consumers decide which car to buy based on the purchase price and attributes such as the fuel economy, horsepower, and -if the car is electric- the driving range and the size of the local public charging network. Firms set the prices of all their cars and the range of their electric cars, considering both subsidies and potential charging station entry. Lastly, charging station providers make entry decisions that depend on how many electric cars are driving around and the level of subsidies they receive for setting up chargers. I estimate the model using data on new car purchases and charging station entry from Germany.

I find significant complementarities between electric car adoption and charging station entry. These findings are in line with studies by Li, Tong, Xing, and Zhou (2017) and Springel (2021), who quantify indirect network effects in electric car markets. Compared to these studies, I also model strategic supply-side reactions in price and range to these indirect network effects: Car makers face strong incentives to reduce the price of electric cars to generate charging station entry that generates additional electric car sales. In consequence, indirect network effects lower the margins earnt on electric cars by 16 per cent on average. Indirect network effects also lead to negative cross-price elasticities: If firm A increases the price of its electric car, its own sales will decrease, but the sales of all other electric cars will also decline.

These indirect network effects and their interaction with car producers' price and range decisions have important implications for policymakers who want to subsidise electric cars and charging station entry. I analyse these implications in two steps. In the first step, I assess a German support scheme consisting of a €2,000 purchase subsidy for electric cars and an €8,000 subsidy for charging points. I find that this scheme doubled electric car sales and increased charging station entry by some 80 per cent. When looking at the impact of either subsidy in isolation, I find that the purchase subsidy led to substantial price and range distortions that impact both the type of electric cars available and the substitution patterns they generate. Car makers reacted to the subsidy by reducing both the price and the range of electric cars. The station subsidy led to fewer distortions and did most of the heavy lifting in terms of increasing electric car sales, expanding the charging network, and reducing CO_2 emissions from new car sales. Consumers also benefited more from the charging station subsidy.

The second step is a comparison of all possible purchase and charging station subsidy combinations, holding the total spending fixed at its 2018 level. I also allow the purchase subsidy to depend on the range, which for instance was the case in China. This analysis reveals that policymakers face a trade-off in which policy objectives to optimise: Increasing the purchase subsidy by half its amount and decreasing the charging station subsidy a bit less than half its amount maximise electric car sales. Reducing the charging station subsidy by a similar amount but indexing the purchase subsidy on the range minimises CO2 emissions from new car sales. Spending the whole budget on charging station subsidies would maximise total welfare and leave consumers best off. The main drivers behind these findings are the price and range distortions caused by the subsidies and how these distortions shape substitution patterns between electric and combustion engine cars.

A scheme with a higher purchase and lower charging station subsidy compared to the observed scheme generates maximal substitution towards electric cars as it induces strong indirect network effects on both sides. This scheme also causes substantial distortions leading to cheap but low-range electric cars. Selling as many electric cars as possible does not necessarily minimise CO2 emissions from new car sales, however. Ideally, electric cars attract consumers who would have bought a very polluting car otherwise. Incentivising range provision by indexing the purchase subsidy on range strikes a balance between inducing many electric car sales and replacing very polluting cars to achieve minimal CO2 emissions. Finally, consumers prefer a scheme only subsidising charging station entry, which minimises price and range distortions. Such a scheme delivers high-range electric cars and a large charging station network, which consumers value.

These findings highlight that policymakers must understand strategic price and range reactions to subsidies and how they interact with indirect network effects. These reactions can lead to strong price and range distortions that shape substitution patterns between electric and combustion cars, which in turn shape policy outcomes. In particular, focusing on maximising electric car sales may come at the expense of range improvements and charging station network development.

♣♣♣

Notes:

- *This blog post is based on the author's presentation Adjustable product attributes, indirect network effects, and subsidy design: the case of electric cars, at LSE Environment Week.*
- *The post represents the views of its author(s), not the position of LSE Business Review or the London School of Economics.*
- *Featured image by J Dean on Unsplash*
- *When you leave a comment, you're agreeing to our Comment Policy.*