Timm Hoefer

DRIVING CHANGE: EXPLORING THE POTENTIAL OF CARBON PRICING TO ACCELERATE ELECTRIC VEHICLE ADOPTION

Timm Hoefer, Chair of Management Accounting, TUM School of Management
Technical University Munich, Arcisstrasse 21, 80333 Munich, Germany
Phone: +49 (0) 175 3189020, e-mail: timm.hoefer@tum.de

Overview

The shift to electric vehicles (EVs) is a key climate change mitigation measure, as recently emphasized by the IPCC's sixth assessment report. Existing research also reveals that the adoption of EVs was strongly driven by governmental subsidies or tax credits.

Several subsidies are now being abolished (e.g., China) or phased out (e.g., Germany, Korea, UK, Norway) as EVs and internal combustion engine vehicles (ICEVs) are close to purchase price parity. However, financial incentivization from both initial cost and total cost of ownership (TCO) perspectives remain key drivers to influence customer perception and accelerate adoption – and ultimately reach ambitious transport decarbonization targets set across regions (e.g., EU ICEV ban in 2035+, USA 50% EV sales share in 2030). Also, recent research and initial real-world observations reveal a high risk of slumping EV sales with cancelled subsidies.

While the positive effect of subsidies on EV adoption is well studied, the literature lacks an investigation of the potential performance of alternative financial incentivization – with lower public burden and market intervention. When considering the application of carbon pricing from a vehicle life cycle perspective, existing instruments apply mainly to the use phase (i.e., tailpipe emissions). Extending carbon prices to full vehicle lifetime emissions and increasing the cost per ton of CO_2, can have an advantageous TCO effect for EVs as they have lower operating emissions than ICEVs. However, electricity needed for charging EVs may be sourced from the grid, resulting in country-specific emissions from carbon-intensive power generation. This makes an evaluation of CO_2-bound financial incentivization with the aim of accelerating EV adoption worth studying more closely. Specifically, the following research question should be answered: *Can extended and increased carbon pricing accelerate the EV adoption curve and help decarbonize the transport sector?*

Methods

To evaluate the effect of extending and increasing carbon prices on EV adoption, the generalized adoption curve model by Bass (1994) is used. It is fitted with a pricing factor that is calculated based on the TCO difference between EVs and ICEVs and corresponding customer price elasticities observed in the literature. Regions studied include the US, Europe, and China as the main EV markets.

Quantification of vehicle emissions builds on an existing life-cycle-analysis (LCA) model, that is modified in its electricity-bound emissions while adopting material efficiency, manufacturing, usage, and recycling data. Instead of using emissions from the average regional electricity mix as many other studies do, an econometric model is used that considers the marginal emissions from electricity use. While renewables such as solar are not always available and cannot be readily ramped up, conventional power plants can increase their capacity, meeting marginal electricity demand from EVs while causing additional CO2 emissions. In the near-term of a ~10-year EV lifetime, the share of renewables is also not expected to grow so high as to completely change turn this around. Calculated life cycle emissions are then multiplied with a region- and time-specific carbon price, resulting in the TCO delta and its price elasticity effects to customer adoption.

Results

Extending carbon pricing to the entire vehicle lifecycle offers relative TCO advantages for electric vehicles. However, those are significantly influenced by the source of marginal electricity used. In China and Germany emissions stemming from such marginal electricity appear to be higher than in the US, at least before 2030.

It is to be noted that an extended and increased carbon price – building on existing ETS schemes – could potentially harm customer adoption of EVs, as more fossil sources are used to cover the additional electricity demand the average electricity price for customers increases. Therefore, carbon pricing becomes particularly effective in its EV adoption effect when renewable energy can cover both most of the existing energy demand, as well as the marginal electricity needs from additional EVs on the roads.

Conclusions

This paper contributes to existing research on accelerating the diffusion of electric vehicles (EVs) by providing insights into the potential impact of extending and increasing carbon prices on the adoption of EVs and decarbonize the transport sector. Considering the concept of marginal electricity needs, region-specific and dynamic carbon pricing instruments tied to the uptake of renewables in electricity generation are recommended. Results can guide policymakers on how to design carbon pricing in road transport, including its point of regulation, scope, and transition over time. As EV and ICEV purchase prices are at par, financial incentives focusing on the full vehicle costs become even more relevant to drive adoption, especially as customer awareness of TCO increases.

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