Operational Learning Effects of Charging Processes at Public Charging Stations in Germany

Dustin Sperling[1], David Hardt[2], Peter Letmathe[3]

[1] *sperling@controlling.rwth-aachen.de, Chair of Management Accounting, RWTH Aachen University, Templergraben 64, 52062 Aachen, Germany*
[2] *Research Unit International Economics, RWTH Aachen University, Templergraben 64, 52062 Aachen, Germany*
[3] *Chair of Management Accounting, RWTH Aachen University, Templergraben 64, 52062 Aachen, Germany*

Research field: **x Economics**, ☐ Technology, ☐ Politics, ☐ Social Aspects
Preferred Presentation Type: **x Oral** ☐ Poster

Abstract

Battery electric vehicles (BEV) currently face challenges in gaining widespread adoption in Germany. In addition to the still high procurement costs, there is a lack of reliable public charging infrastructure. Recent project data allow to investigate the operational learning effects during BEV charging sessions at public charging stations. Two emerging questions were posed: To what extent do learning effects occur during the public charging process in Germany? Which learning drivers are effective in the public charging process? An empirical analysis was conducted using data from approximately 4 million charging sessions at almost 17,000 charging points. The results show that an increase in the number of successful sessions leads to a significant reduction in downtime, while errors increase it. In addition, public fast charging has less downtime than slow charging because of the higher utilization rate required for profitability.

Introduction and Motivation

BEVs play a crucial role in the transition to a cleaner transport sector. However, they still face challenges such as higher procurement costs and insufficient charging infrastructure, both of which hinder the widespread adoption of BEVs (1, 2). Unreliable charging infrastructure (CIS) makes consumers uncertain about their decision to purchase an electric vehicle and leads to lower BEV sales. In addition, failures and downtime reduce the profitability of charge point operators' investments. The current study investigates the operational learning effects of charging BEVs at public CIS in Germany. The extent to which successful charging sessions are improved by repeated charging can be determined by applying learning curve theory. Learning should lead to increased reliability, reduced downtime and fewer failures. Emerging research questions are 1.) To what extent do learning effects occur during the charging process of electric cars at public charging stations in Germany? 2.) Which learning drivers are effective in the charging process of electric cars?

Applied Method

An empirical analysis of the extent of the learning effects of charging processes and the potential drivers of these effects was conducted using a dataset that includes data on approximately 4 million charging sessions at nearly 17,000 charging points from most charge point operators (CPOs) in Germany. The methodology includes multiple regression models based on panel data analysis to estimate the relationship between performance and learning. Several control variables were included to account for differences in company size, operating hours and technological aspects of the charging stations.

Results

The results indicate that increased repetition of successful charging sessions leads to a statistically significant reduction in average charging point downtime - approximately 1.6% for each doubling of completed charging sessions. However, the number of errors in the charging process significantly increases downtime - approximately 1.35% increase in downtime for each percentage increase in errors. The level of experience of the CPOs did not show a consistent positive effect on learning outcomes. The interaction between failed and successful charging sessions showed that higher error rates may enhance learning by prompting CPOs to investigate issues more thoroughly, leading to improved operational practices over time. In addition, public DC fast chargers had lower average downtime than AC chargers due to the higher utilization rates required for profitability.

Conclusions

This study concludes that while repetition plays a critical role in reducing inefficiencies at public charging stations for BEVs, challenges remain due to persistent errors that negatively impact overall performance. The findings suggest that addressing these errors through proactive management can unlock further potential for improvement beyond what can be achieved through repetition alone. In addition, it highlights that simply increasing the experience level of CPOs may not inherently lead to better performance unless coupled with targeted strategies aimed at optimizing sessions based on identified weaknesses or issues encountered during service delivery.

References

1. Biresselioglu ME, Demirbag Kaplan M, Yilmaz BK. Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes. Transportation Research Part A: Policy and Practice. 2018;109:1-13.
2. Kühl N, Goutier M, Ensslen A, Jochem P. Literature vs. Twitter: Empirical insights on customer needs in e-mobility. Journal of Cleaner Production. 2019;213:508-20.