***WILLING TO PAY? SPATIAL HETEROGENEITY OF E-VEHICLE CHARGING PREFERENCES IN GERMANY***

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## Overview

In economics, electric vehicle (EV) charging spots – a spatial combination of parking and refueling – are rival goods (Wolbertus et al. 2018). A better fit of EV charging supply to user expectations, needs, and behavior has yet to be found (Daina et al. 2017; Wolbertus et al. 2018). This, in turn, hinders the uptake of EV diffusion (chicken-and-egg problem). Further, users’ *actual* EV charging spot usage may differ from previously anticipated *perceived* usage. Thus, the efficient alignment between the spatially heterogeneous supply of EV charging spots and (perceived) demand calls for a better understanding of private EV users’ *expected* as well as *actual* recharging behavior. In Germany, a ratio of 1.5 EVs per charging spot seems sufficient for reducing range anxiety to an acceptable level. Yet, these charging spots are not evenly distributed across regions. This study attempts to find out the perceived usage of charging infrastructure service as well as the willingness to pay (WTP) for them according to the number of currently available charging spots.

Few studies have so far determined the spatial development of and need for charging infrastructure. Wolbertus et al. (2018) analyze the determinants of charging session length while differentiating between connection time and total occupancy time (dwelling time) in the Netherlands. Depending on the EV range, Chakraborty et al. (2019) determine home and at-work charging to be the most requested charging locations. Interestingly, the density of charging spots plays a minor role compared to duration (Globisch et al. 2019). The demand side – determined by the EV charging behavior – has been analyzed for Germany by Soylu et al. (2016), Gnann et al. (2018), Wirges et al. (2012), Hardman et al. (2018), Funke et al. (2019), and Wolff and Madlener (2019) but has not been contrasted with the actual supply of charging infrastructure and recent trends.

## Methods

Our three research questions are: (1) Does the number of existing charging spots affect the EV charging preferences? (2) Depending on the number of charging spots, what is the WTP for certain attributes of the EV charging process? For example, how much is 1 minute less in charging duration worth? Following from that: (3) What are the implications for charging infrastructure policy and planning with consideration of the spread of charging infrastructure?

Due to the low share of current EV users in Germany, investigating consumers’ EV charging infrastructure preferences and their WTP for it based on real usage data is challenging. Therefore, we conducted a Discrete Choice Experiment to assess (current and future potential) EV drivers’ valuation of six different attributes of the charging process: charging speed, location, share of renewables, waiting time for an available charging station, charging technology, and price. From the choice experiment, we derived the WTP for EV charging options and spatially map it against the availability of public charging spots.

## Results

We matched *N* = 4,101 respondents living in 1,718 cities with 10,732 public charging spots in those cities. Subsequently, we obtained the WTP for the charging attributes when interacting with charging spots. A reduction of the charging duration by 1 min is worth 0.15-0.17 €/month to consumers – depending on the number of charging spots in situ.

For the charging locations, we find marked spatial heterogeneity in the willingness to pay subject to the number of available public charging spots: with every additional public charging spot, respondents are more likely to charge away from home. This holds until the number of charging spots has reached a tipping point at which respondents become indifferent between home and work charging. When the tipping point is exceeded, respondents rather charge at work than at home. Thus, with increasing numbers of charging spots, public chargers near home are less relevant than those near work. Eventually, public chargers away from home become more attractive.

Also, with increasing numbers of charging spots our results reveal a fivefold greater willingness to pay for reducing waiting time (for a charging spot to become available) than for accelerating charging speed. Thus, charging point operators could surcharge by implementing a booking scheme than by implementing fast-charging.

## Conclusions

We find charging preferences and the WTP for them in relation to charging infrastructure awareness. Our results show spatial heterogeneity, i.e. respondents’ choices depend on the quantity of public charging spots available to them. Non-availability of public charging spots in the vicinity has a larger effect on the choice probability than 1, 2, or 3 charging spots have. This could be evidence for charging infrastructure awareness.

From the findings, we derive implications for charging infrastructure policy, business model design, and infrastructure planning. Thus, our results seem very useful for charging infrastructure operators such as car manufacturers, state, government (or some governmental agency), municipalities, or energy companies, e.g. regarding the expected break-even points for rolling out charging infrastructure and the provision of green energy.

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