CUSTOMERS' VALUATION OF GRID RESILIENCE TO EXTREME EVENTS: WILLINGNESS TO PAY AND PREFERENCE HETEROGENEITY

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Overview

The need to replace existing infrastructure and the aim to connect an increasing share of renewable energies and distributed generation to the grid will drive major investments in electricity transmission and distribution networks in the coming decades (Ofgem, 2014). However, if the capital costs of the marginal improvement in grid infrastructure exceed the marginal present value of ongoing cost savings for the investors (e.g. the network operators), then the investment is only economically viable, if the customers' aggregated valuation exceeds this difference. As transmission and distribution networks are natural monopolies, though, there is no real market for the related services and hence no market price to signal their value. Since the 1990s regulators of infrastructure industries around the globe have therefore implemented incentive regulation models that mimic market mechanisms to promote efficiency in such natural monopolies (Jamasb et al., 2012). These require the estimation of marginal cost and demand (i.e. consumers' WTP). Choice modelling is broadly regarded as the most suitable method for estimating consumers' WTP for quality improvements. In fact, the estimation of WTP via stated choice experiments is an important part of price review processes of electricity market regulators such as Ofgem in the UK. Usually standard multinomial logit (MNL) models are employed to elicit consumer preferences and determine the amount that transmission and distribution companies can levy on users of their system. Such models assume homogeneous preferences or pre-impose specific customer segments.

We present an alternative, more refined choice modelling approach to explore customer preferences and WTP for resilience of the electricity grid to extreme events. We demonstrate the methodological and practical relevance of this approach using the example of the UK's incentive regulation scheme for distribution network operators (DNOs). Our analysis is based on a discrete choice experiment that informed the fifth distribution price control review (DPCR5) in the UK, but the approach is equally applicable to any other stated choice experiment set up to inform incentive regulation. In our application grid resilience to extreme events is measured via three attributes: the amount of undergrounding of overhead lines per annum, the number of customers affected by major storms and the number of major electricity sites across the UK exposed to potential flood risk. The valuations of undergrounding of overhead lines and the resilience to storms are in focus. In contrast to the existing manner to inform incentive rates, we broadly account for preference heterogeneity in the population, allow for scale heterogeneity (i.e. heterogeneity in the randomness of choice) and exploit individual posterior distributions. We show that changes in the assumptions on heterogeneity in the population can have significant implications for the price controls. Our approach is easy to implement, can deliver more reasonable WTP estimates and could foster more efficient incentive setting.

Methods

While the concepts of preference and scale heterogeneity are established in the academic literature, they are rarely considered in practice. In context of the price review process, Ofgem uses a standard multinomial logit (MNL) model for example that relies on the assumption of homogeneous preferences within DNOs. We estimate a number of models that exclude demographics, but differ in the manner in which unobserved heterogeneity is accommodated. To avoid confoundedness of our WTP estimates with scale heterogeneity, we estimate the models in WTP space rather than in preference space. This allows us to impose distributional assumptions directly on the individual WTPs and has been proven to result in more plausible estimates of the full WTP distributions than when deriving the WTP from the utility parameters in preference space (e.g. Hole and Kolstad, 2010). On the other hand, there has been evidence that models in preference space fit the data better than models in WTP space (e.g. Train and Weeks, 2004 and Sonnier et al., 2007). We acknowledge and combine these considerations: we estimate the flexible generalised multinomial logit (GMNL) model as suggested by Fiebig et al. (2010) in WTP space and perform posterior analysis to improve the estimates. We then examine how the currently employed models perform in comparison to ours and investigate the implications of refined estimation strategies for the price controls.

Results

Our estimates of interest are all significant and have the expected signs: while customers ask for compensation for deterioration of resilience, they are willing to pay for services that improve resilience such as the undergrounding of overhead lines or the reduction of the number of customers affected by blackouts due to storms. We also find significant differences between WTP and WTA for a given attribute: ceteris paribus customers require a higher compensation for deterioration of the service than they would be willing to pay for an equivalent improvement.

We demonstrate, though, that the assumptions on preference and scale heterogeneity can impact the estimated valuations of grid resilience to extreme events remarkably. We calculate the implied incentive rates and show that they vary substantially across models that differ with respect to the restrictions imposed on the heterogeneity parameters. Models that flexibly allow for parameter heterogeneity reflect customer preferences more realistically. In line with previous literature (e.g. Hensher and Greene, 2011), the estimation of models in WTP space proves to provide more reasonable WTP distributions than estimation in preference space. Since our results suggest significant scale heterogeneity, the models that incorporate a scale parameter fit the stated choice data best. In particular in applications in which customers have little experience with the object of interest and are hence likely to choose more randomly (as it is the case with extreme events), the consideration of scale is critical. It significantly impacts the estimates and yields more realistic valuations. The estimates can be improved further by exploiting the posterior distributions. While the posterior means lie very close to the estimated means, the posterior standard deviations are smaller and the ranges of valuations consequently more bounded. The posterior preference correlations are also more meaningful than those revealed by the unconditionally estimated Cholesky marices.

Conclusions

Our results suggest that models which accommodate scale heterogeneity and are estimated in WTP space improve the estimates of customers' valuation of grid resilience to extreme events, not only on the individual, but also on the aggregated level. We show that posterior analysis can tame the WTP distributions and reveals more intuitive preference correlations than the initially estimated distributions. The assumptions on heterogeneity in the population can thus have significant implications for the price controls.

We conclude that the current models to evaluate customers' WTP for grid resilience are too simplistic. They are likely to result in too generous allowances and therefore in an oversupply of resilience services. We agree with Ofgem that incentives should be tailored for the DNOs individually, but recommend to also take heterogeneity within the customer base of any DNO into account. Our suggested approach is easy to implement, could improve policy evaluations and foster more efficient incentive setting.

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