Resource and Energy Economics 45 (2016) 124–143

Contents lists available at ScienceDirect

Resource and Energy Economics

journal homepage: www.elsevier.com/locate/ree

Linking the value of energy reliability to the acceptance of energy infrastructure: Evidence from the EU

Jed J. Cohen[a], Klaus Moeltner[a,*], Johannes Reichl[b], Michael Schmidthaler[b]

[a] Department of Agricultural and Applied Economics, Virginia Tech, 208 Hutcheson Hall, Blacksburg, VA 24061, United States
[b] Energy Institute at the Johannes Kepler University, Altenberger Strasse 69, A-4040 Linz, Austria

ARTICLE INFO

Article history:
Received 4 June 2014
Received in revised form 9 May 2016
Accepted 3 June 2016
Available online 11 June 2016

Keywords:
Power outages
Energy infrastructure
Acceptability
Bayesian estimation
NIMBY

ABSTRACT

Existing studies on the acceptability of energy-related infrastructure have centered around how to overcome the Not-In-My-Backyard phenomenon amongst local stakeholders, focusing primarily on drivers such as community participation and direct economic benefits to impacted areas. To date, none of these contributions have related the acceptability question to the value of power reliability to the same stakeholders. We fill this gap by combining an analysis of outage vulnerability with an examination of infrastructure acceptability using a unique data set from 15 EU countries with household-level information on both aspects of power provision. We find only limited evidence of a positive relationship between local residents' sensitivity to outages and their acceptability of new energy infrastructure projects. This stresses the importance of creating awareness amongst stakeholders on how planned infrastructure expansions relate to energy security for their own household.

1. Introduction

The European Union (EU) has the ambitious goal of reducing greenhouse gas emissions by over 80% compared to 1990 levels by 2050 (European Commission, 2012). This has significant and wide-ranging implications for the energy sector. Most importantly, the EU aims for a share of total energy supply produced by renewable sources (RESs) of 25% by 2030, and 40–60% by 2050. Virtually all of electricity consumption is to be covered by RESs by 2050.

This requires rapid growth in RES installations, such as wind turbines and solar panel arrays, across the entire EU region. The decentralized nature of these facilities, and the corresponding need for inter-regional transfer and trade of electricity creates a new sense of urgency for the construction of transmission lines and pylons. The near-term goal is to increase interconnection capacity between regions by 40% by 2020 (European Commission, 2012). This is also consistent with the parallel objectives of enhancing the security of energy supply across all member nations and of working toward a completely unified energy market with a seamless exchange of electricity across all members (European Commission, 2012).

However, new energy projects are frequently met with opposition by local stakeholders. The EU "Roadmap 2050" report explicitly acknowledges this fact as one of the main barriers to implementation: "*The current trend, in which nearly every energy technology is disputed and its use or deployment delayed, raises serious problems for investors and puts energy system changes at risk*" (European Commission, 2012, p. 17).

* Corresponding author.
E-mail addresses: jedcohen@vt.edu (J.J. Cohen), moeltner@vt.edu (K. Moeltner), reichl@energieinstitut-linz.at (J. Reichl), schmidthaler@energieinstitut-linz.at (M. Schmidthaler).

http://dx.doi.org/10.1016/j.reseneeco.2016.06.003
0928-7655/

In Europe and elsewhere, local opposition to public infrastructure is often referred to as the "Not-In-My-Backyard" (NIMBY) syndrome. There is a rich academic literature that has examined the drivers of NIMBY and possible remedies with respect to energy infrastructure for a variety of case studies and geographic regions (for a recent review see Cohen et al., 2014). Suggestions to facilitate acceptance include transparency of process, stakeholder involvement, and allowing locals to benefit economically from new installations (e.g. van der Horst, 2007; Soini et al., 2011; Cotton and Devine Wright, 2013; Devine-Wright and Batel, 2013).

There also exist economic contributions that have attempted to place a currency value on the disamenity effect of electricity infrastructure, either via stated preference methods (Navrud et al., 2008; Groothuis et al., 2008; Soini et al., 2011; Strazzera et al., 2012), or via property valuation methods (Colwell, 1990; Rosiers, 2002; Sims and Dent, 2005). A related branch of the literature has examined the cost of power outages, or, alternatively put, residents' willingness-to-pay (WTP) to avoid service interruptions (Layton and Moeltner, 2005; Carlsson and Martinsson, 2007, 2008; de Nooij et al., 2007; Baarsma and Hop, 2009; Reichl et al., 2013). Most of these contributions find that residents experience negative benefits from both the proximity to power infrastructure and from power interruptions.

However, and somewhat surprisingly, the two concepts of vulnerability to outages and acceptability of energy infrastructure have to date not been brought into direct comparison, let alone examined jointly. Yet there exist plausible reasons why local residents *should* associate new infrastructure with enhanced reliability. For example, for the case of high-voltage transmission lines, which are the focus of this study, recent history has shown that failures in interconnected transmission grids can have widespread and cascading effects, leading to prolonged outages over large areas (UCTE, 2007; Buldyrev et al., 2010). The European Network of Transmission System Operators (ENTSOE) has long advocated the "$N-1$" criteria for transmission grid reliability, calling for backup infrastructure for any single element in the system in case of failure. It lists supply security as a major reason for the proposed grid expansion in its recent network development plan (ENTSO-E, 2012).[1] Therefore, it is important to understand if customers are aware of this linkage between a reinforced grid and the reliability of supply, and to what extent this awareness affects their stance on new energy projects.

This study fills this gap by eliciting the WTP to avoid interruptions and the propensity to oppose new energy infrastructure from the *same* sample of stakeholders. We apply our estimation framework to a large sample of European households from 15 EU nations. Our data set is unprecedented in geographic scope, as existing valuation studies related to energy provision have exclusively focused on specific regions within a single country. While it probably falls short of capturing all relevant household-level details related to power provision at the local level, it does allow for a first comparison of values for power reliability and attitudes toward new transmission lines for the "typical residential customer" across multiple nations.

Our results indicate strong heterogeneity across countries with respect to both their WTP to avoid *specific* outage scenarios, and their acceptance of new infrastructure. In addition, we find only limited evidence of a positive linkage between a typical household's WTP to avoid interruptions and their propensity to have a positive disposition toward new power lines. We take this as a signal that an information campaign enhancing stakeholders' awareness of the implications of new large-scale infrastructure improvements on power reliability at the local level may be needed to overcome the NIMBY phenomenon.

Econometrically, our study presents an extension of the "recursive" bivariate probit model with a single endogenous regressor (Greene, 2012, Chapter 17) along multiple dimensions. Specifically, we consider a system of five correlated binary equations, the last of which includes the observed responses for the other four as endogenous covariates. Since variances are identified in our case for all but the last equation, we can also incorporate equation-specific heteroskedasticity into our framework. To our knowledge this is the first such high-dimensional recursive binary response model considered in the applied economics literature.

The following section provides an outline of the conceptual and econometric estimation framework. Section 3 introduces the data and presents estimation results. This is followed by concluding remarks in Section 4.

2. Estimation framework

In the outage cost part of our survey each respondent $i=1\ldots N$ is presented with $s=1\ldots S$ choice menus. Each menu contains two choice options – to tolerate the stipulated outage scenario s or to pay the offered bid P_{si} and prevent the interruption.

The corresponding indirect utilities are given as

$$\begin{aligned} \tilde{U}^*_{si} &= -d_s * \mathbf{x}_i'\boldsymbol{\beta}^*_s + \gamma m_i + \tilde{\epsilon}^*_{si} \\ \tilde{U}^*_{1i} &= \gamma(m_i - P_{si}) + \tilde{\epsilon}^*_{1i}, \end{aligned} \tag{1}$$

where $\tilde{U}^*_{si}$ is the indirect utility under occurrence of the interruption, and $\tilde{U}_{1i}$ is the indirect utility under payment and avoidance. The former is a function of outage duration d_s, household characteristics $\mathbf{x}_i$, income m_i, and an error term $\tilde{\epsilon}^*_{si}$ that captures unobservables. For ease of interpretation after differencing utilities we let d_s enter with a negative sign. If the outage is avoided payment P_{si} is subtracted from income, as shown in the second equation.

[1] The notion of enhancing electricity reliability by adding backup capacities and redundancies to all parts of a power grid is also supported by the engineering literature – see e.g. Ren et al. (2008).