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Price volatility and residential electricity decisions: Experimental evidence on the convergence of energy generating source

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ABSTRACT

The recent trend in most developed countries has been toward greater reliance on renewable or "green" energy sources. This paper investigates how price volatility in residential electricity rates impacts consumers' preferences for green power. Using a choice-based experiment, we present respondents with choice scenarios that feature two electric utility plans: (i) a *conventional* plan where electricity is generated from either coal or natural gas, and (ii) a *green* plan where electricity is generated renewably from either wind or solar. We then systematically vary the monthly price volatility of each plan across choice scenarios. Our results suggest that price volatility in monthly rates significantly impacts respondents' plan choices and, specifically, their decision to adopt the green power plan. In particular, increased volatility in the green power plan reduces the likelihood of respondents choosing the green plan, while increased volatility in the conventional plan increases the likelihood of respondents choosing the green plan. Moreover, the documented effects of price volatility are robust across different price premiums for the green power plan.

Renewable power is good. More renewable power is not always better.
[(The Economist, December 2015, p. 7)]

1. Introduction

As an economy grows and develops, the mix of energy sources used to satisfy the demand for energy adapts. In the U.S., as well as in many other developed nations, the recent trend has been toward greater reliance on renewable or "green" energy sources. While the EIA (U.S. Energy Information Administration, http://www.eia.gov) reports that approximately 80% of current domestic energy production continues to be hydrocarbon based (e.g., coal, natural gas, and crude oil), there has also been a steady increase in production of renewable energy over the last decade from about 8% to upwards of 12%. This increase has likely been a result of the combination of shifts in energy policy aimed at stimulating renewable energy, as described by the American Wind Energy Association (http://www.awea.org/advocacy/), as well as increases in the demand for renewable energy stemming from its environmental benefits and sustainability. The convergence of the energy mix to an optimal or steady state depends on a number of factors, not the least of which is consumer demand.

The current study investigates how price volatility in residential electricity rates impacts consumers' preferences over how that electricity is generated; specifically, consumers' preferences for electric utility plans where the electric power is either generated from a conventional hydrocarbon-fossil fuel source or a renewable energy source. Conventionally, the bulk of residential electric power has been predominately generated from the combustion of coal or natural gas — the EIA reports that nearly half of the production in the electric power sector is coal based. However, in recent years residential consumers have been increasingly offered the option to purchase electric power that is, at least partially, generated from renewable and more "green" sources like solar and wind (Bird and Sumner, 2010). As a result, electric power generated from renewable sources accounted for 13.5% of the total generation in 2014, as reported by the EIA. While part of this increase in the provision of green power has been driven by regulatory reform and government policies, increasing consumer demand for green energy has also played an important role. In fact, there has been ample research documenting that residential consumers are willing to pay a premium, typically in the range of $5–$15 per month, to purchase electric power generated from green sources (see the survey by Sundt and Rehdanz, 2015 for a review).

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Much of the prior research relating to residential demand for renewable electric power has focused on the impact of retail price differences between electricity generated by conventional sources (hydrocarbon or fossil fuel-based) and green sources on residential demand for green electric power.[1] Not surprisingly, the price premium associated with green power is an important determinant in consumers' decisions to purchase green power plans. In this paper, we take a complementary approach by considering how volatility in the price of plans for both conventional and green power impacts residential demand for green power. We view this as an important extension for several reasons. First, green power generation (especially wind and solar power) is susceptible to intermittency problems that can result in substantial variability in costs (Zeineldin et al., 2009; Denholm et al., 2010) and, ultimately, more volatility in green power prices. Second, uncertainty regarding future regulatory changes in subsidies and incentives for producers and consumers of green energy could lead to either lower or higher prices, thereby inducing substantial volatility in the retail price of green electric power (Kaplan, 2008). Third, technological innovation, which is inherently uncertain and unpredictable, could significantly increase the efficiency of green power generation and minimize the intermittency problems with green power; thus lowering the effective price of green power.[2] Fourth, variability in the price of fossil fuels used to generate electricity has been well documented (e.g., Ewing et al., 2002), which can induce substantial volatility in the current and future prices that consumers face regarding the retail price of electricity generated from conventional power sources (Kaplan, 2008).

Volatility in the price of retail electricity plans (assuming a constant expected price) would not be expected to directly impact plan choice of consumers under the assumption that consumers behaved in a risk-neutral manner. However, it is well-known that price volatility, in general, can impact economic decision making in important ways[3]; specifically, over the past several decades a plethora of research has documented decision making inconsistent with risk-neutrality.[4] Most notably, if consumers are risk-averse, then increases in price volatility of a given electric utility plan would make that plan less attractive to consumers. In addition to risk preferences, other behavioral biases could influence how consumers respond to the increased price volatility of various plan offerings. For example, consumers may exhibit saliency bias (Bordalo et al., 2012, 2013), where either very low or very high possible prices are more salient to consumers when they are making their plan choice; thus, plans with more pricing volatility may either be more or less attractive to consumers depending on the strength of how salient these outlying prices may be. Consumers may also exhibit projection bias (Loewenstein et al., 2003) and, as a result, either overestimate or underestimate their future electricity usage.[5] Again, this could lead consumers to become more or less attracted to plans with greater price volatility. If consumers exhibit non risk-neutral behavior and/or various behavioral biases, which is likely to be true in the aggregate across residential consumers, then there is scope for price volatility to impact consumers' decisions regarding their preferred electric utility plan. Accordingly, we examine the specific case of price volatility in the context of electric utility plan choices.

The EIA reports that in 2014, the residential sector accounted for about 22% of U.S. energy consumption, and Brounen et al. (2013) note that about 20% of the global energy demand stems from residential energy demand. That being said, it is of great importance to better understand consumer preferences for residential power generated from green power, and the possible factors that influence consumers' adoption of green power. In this paper, we implement a choice-based experiment, administered via survey, to investigate how price volatility in residential electricity rates impacts consumers' preferences over how the electric power was generated. In the survey, individuals are presented information on two hypothetical electric power plans that they can choose to purchase. We systematically vary several attributes of these electric power plans including: (i) the source by which the electricity is generated — conventional or green, (ii) the expected price difference between the two plans (i.e., the price premium associated with the green plan), and (iii) the volatility of monthly prices of each plan. The information obtained from the survey allows us to examine the causal link between price volatility and consumers' demand for green power. We also investigate how price dispersion across both the green and conventional power plans impacts plan choice. Lastly, we consider how personal attitudes toward the environment and green energy, as well as other socio-demographic measures impact plan choice.

Based on results from 832 respondents to 9108 plan choice scenarios, we find that price volatility significantly impacts plan choice. Specifically, as the monthly price volatility of the green energy plan increases (holding the expected monthly price constant), respondents are significantly less likely to choose the green energy plan. Similarly, as the price volatility of the conventional plan increases (holding the expected monthly price constant), respondents are much more likely to choose the green energy plan. Importantly, our main results regarding the impact of price volatility are robust across three different levels of monthly price premium for the green energy plan. Moreover, not only do we show that price volatility of monthly rates impacts plan choice, we also show that price dispersion matters; respondents are significantly more likely to choose the green plan the more dispersed the distribution of possible monthly prices (holding the level of variance constant). Lastly, in line with prior studies, we document that respondents with a greater overall concern for the environment are more likely to choose the green power plan.

The paper proceeds by briefly discussing the prior literature relating to the residential adoption of green electricity in Section 2. In Section 3 we introduce the choice-based experiment and describe the survey procedure. Section 4 describes the conceptual framework. Section 5 presents the empirical results, and Section 6 concludes with discussion of the possible implication of our main findings and areas of future research.

2. Review of related literature

As of late, there has been a growing trend toward renewable energy generation both in the U.S. and globally. For example, the U.S. Department of Energy reported that in 2014, renewable electricity in the U.S. grew to 15.5% of installed capacity and 13.5% of total generation, and these rates have been steadily increasing over the last decade; moreover, renewable electricity accounted for 52% of the new capacity additions in 2014. The increasing importance of renewable energy as a significant component of the overall energy mix has spurred substantial research relating to consumption of renewable energy. Most closely related to our study is the existing literature examining residential adoption of green power.

Not surprisingly, much of this prior research has focused on estimating residential consumers' willingness to pay (WTP) to purchase green

[1] We postpone our review of this literature and other related literature until Section 2.

[2] An example would be innovation in energy storage technologies that enable electric power grids that rely heavily on renewable energy power sources like wind and solar to operate more efficiently and mitigate problems of intermittency; we refer readers to a report by Denholm et al. (2010) for a more detailed discussion of topics relating to energy storage in renewable electricity generation.

[3] For example, a recent paper by Cardella and Kitchens (2016) documents experimental evidence that volatility in court awards can impact settlement negotiations, as well as provides a more general review of this literature.

[4] We will not attempt to cite all relevant studies in this extensive body of literature. Rather, we reference Cox and Harrison (2008), Dave et al. (2010), and Charness et al. (2013) who provide comprehensive, although not exhaustive, reviews of this extensive body of literature, especially in the domain of experimental evidence.

[5] While not specifically in the context of electricity usage, several papers have documented empirical evidence of individuals exhibiting projection bias. Examples include DellaVigna and Malmendier (2006), Conlin et al. (2007), and Busse et al. (2015).

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