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Analysis

Risk preferences and purchase of energy-efficient technologies in the residential sector

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ABSTRACT

Perceived risk in future energy cost savings of energy efficient technologies has been well identified as a major barrier to the adoption of such technologies. However, direct empirical evidence of the impact of consumer risk aversion on the adoption of energy efficient technologies has been limited. In this paper, we elicit consumer risk preferences using a multiple price list experiment tailored to household energy decisions. We then use the elicited risk preferences to explain consumers' self-reported historical purchase of energy efficient appliances and installation of energy efficiency retrofitting technologies. Using data from 432 homeowners from Arizona and California, USA, results show that more risk averse consumers are less likely to adopt energy efficient technologies (except for the case of energy efficient air-conditioners). In addition, the findings provide evidence that households' perceived mobility as measured by the probability of moving within five years, can amplify the negative impact of risk aversion on the adoption of energy efficiency retrofitting technologies. Overall, the results provide implications for policy makers and companies involved in promoting energy efficient technologies.

1. Introduction

Energy efficiency is widely regarded as the most cost-effective approach for addressing energy challenges and climate change (McKinsey and Company, 2009). Recently, the U.S. government has increasingly focused on improving energy efficiency in end-use sectors such as transportation, lighting, and space heating and cooling (Gillingham and Palmer, 2014). Improving energy efficiency in the residential sector, which in 2012 was responsible for 11% of total U.S. energy consumption (EIA, 2013), has the potential to slow or even offset the projected increases in residential energy demand over the next 30 years. Federal, state, and local government agencies and utilities have been promoting the adoption of energy efficient technologies in the residential sector through various programs and measures such as rebates, tax credits and information programs. Current mass-market energy-efficient technologies available to the residential sector are wide-ranging from energy-efficient consumer appliances such as compact fluorescent light bulbs (CFLs) and efficient refrigerators, to building technologies such as efficient heating, ventilation and air conditioning (HVAC) systems.

Despite the apparent economic benefits of adopting many energy-efficient technologies as well as government subsidies to partially defer the cost, their diffusion has been slow. This is the well-known "efficiency paradox" problem — "cost-effective energy efficient technologies based on simple net present value calculations at current prices enjoy only limited market success" (Brown, 2001; Hirst and Brown, 1990; Jaffe and Stavins, 1994; Sanstad and Howarth, 1994; Weber, 1997). Hirst and Brown (1990) find that behavioral factors such as perceived risk of the return on energy efficiency investments and attitudes towards energy efficiency can cause the slow diffusion of energy saving technologies. Jaffe and Stavins (1994) conclude that market failures such as principal–agent problems and factors such as high implied discount rates can cause the energy efficiency paradox. Sanstad and Howarth (1994) find that consumer behavioral issues such as bounded rationality could cause the realized outcomes to deviate from the optimal. Weber (1997) summarizes that institutional, market-related, organizational and behavioral barriers can explain the slow diffusion of energy efficiency. Brown (2001) concludes that government interventions are necessary to address the issue of the energy efficiency paradox. In sum, common barriers to the diffusion of energy efficient technologies include: information asymmetry, lack of

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financial support, perceived technological risks, institutional and regulatory barriers, market barriers/market failures, and behavioral factors (Reddy and Painuly, 2004).

There is abundant existing literature analyzing consumer time preferences and the adoption of energy efficient technologies. Based on the theory of inter-temporal choices, consumers should discount their future benefits or costs at the market interest rate (Verboven, 1999). Existing studies have found a wide range of implicit discount rates for consumers purchasing energy efficient appliances, ranging from 5 to 100% (Dubin and McFadden, 1984; Hausman, 1979; Sanstad et al., 1995; Train, 1985; Verboven, 1999). Some of the implied discount rates are significantly higher than the market interest rate, indicating that consumers are myopic in terms of energy efficiency investments. Andreoni and Sprenger (2012) show that risk preferences and time preferences are different. Thus, it is important to also look at how risk preferences influence consumers' adoption of energy efficient technologies.

This paper builds upon the existing literature (e.g., Gillingham et al., 2009; Maréchal, 2010; Min et al., 2014; Schleich, 2009; Stern, 1985) exploring the role of consumer behavior in impeding the adoption of energy efficient technologies and in explaining the efficiency paradox. Specifically, the objective of this paper is to investigate the relationship between homeowner risk preferences and the decision to improve the energy efficiency of a home. While a common barrier for the diffusion of efficient technologies is the high upfront cost, there is also uncertainty about the benefits an individual will ultimately obtain from adoption. Hassett and Metcalf (1993) consider the option value of delaying adoption of energy efficient technology when faced with uncertain future energy prices and show that this option can slow the diffusion of energy efficient technologies. Building upon this work, Baker (2012) considers the role of uncertainty and irreversibility on the diffusion of energy efficient technologies by considering consumers' decisions about when to buy which new product. While the results of Baker (2012) may cloud the significance of the option value in driving the energy efficiency gap, they indicate that risk and uncertainty play a role. Providing empirical evidence on the direction of the impact of risk on the adoption of energy efficiency will be a useful addition to the literature. Policies that aim solely to address the price barrier by providing rebates to lower purchase costs do not address the buyer's willingness to accept the risk of adopting a new technology. Risk can take several forms including a technology's true efficiency in the field, whether a homeowner will be able to recoup the cost before leaving or losing their home and other possible unknown negative risks. This study is designed to illuminate the role that individual risk perception plays in the decision to adopt efficient technologies.

Perceived risk towards future energy cost savings of energy efficient technologies has been well identified as a major barrier to the adoption of such technologies (Christie et al., 2011; Hirst and Brown, 1990; Shama, 1983). The return on energy efficiency depends on future energy use patterns, future energy prices, and reliability of the technology, all of which are unknown. Thus, consumers' risk preferences should play an important role in the adoption of energy efficient technologies. Some of the strongest evidence of risk preferences influencing technology adoption comes from the agricultural economics literature focusing on farmer decision making (e.g., De Pinto et al., 2013; Flaten et al., 2005; Greiner and Patterson, 2009; Koundouri et al., 2006; Marra and Pannell, 2003; Serra and Zilberman, 2008). In the context of adoption of home energy related technologies, few studies have considered the influence of risk preferences.

Eliashberg and Hauser (1985) estimate the impact of risk preferences on the adoption of residential heating technology by estimating a von Neumann–Morgenstern utility function to model consumer risk preferences and choice between solar and oil heating systems. Farsi (2010) conducts a choice experiment among apartment tenants in Switzerland. By estimating the curvature of the utility function, Farsi (2010) concludes that when consumers decide whether to adopt energy efficient systems, risk consideration is central and that willingness to pay (WTP) estimates could be biased if the same risk attitudes towards efficient and conventional technologies are assumed. However, Eliashberg and Hauser (1985) and Farsi (2010) do not explore the heterogeneity in risk aversion across the respondents. Erdem et al. (2010) conduct a survey in Turkey to elicit consumers' WTP for hybrid vehicles and find that risk-seeking consumers are willing to pay a higher price. However, Erdem et al. (2010) elicit consumers' risk attitudes by asking them to self-assess their own risk attitude on a scale of 1 to 5 (where 1 is risk averse and 5 is risk loving), rather than directly elicit and measure risk attitudes on a quantifiable scale. Bocqueho and Jacquet (2010) use a theoretical model and simulation approach to find that risk attitudes play a crucial role in farmers' adoption of lignocellulosic biomass, an important feedstock for renewable energy production.

This paper contributes to the nascent literature on risk preferences and the adoption of energy efficient technologies in several regards. First, this paper uses a well-established experimental technique from Holt and Laury (2002) to better elicit consumers' risk preferences. These measures of risk preferences are used to explore the relationship with homeowners' historical energy efficiency investments. Second, compared with existing papers that estimate the average curvature of assumed utility functions of choosing energy efficient technologies for all consumers, this paper explores the heterogeneity of risk preferences of different consumers by directly eliciting individual consumers' risk aversion coefficient.

Data for the analysis are collected via an online survey of 432 homeowners in Arizona and California in April, 2013. The survey participants are representative in terms of socio demographic characteristics (e.g., income, education, occupation, age). The risk elicitation experiment design used in this study is based upon Holt and Laury (2002) but is tailored to the purchase decision of energy efficient appliances. We use a constant relative risk aversion utility function to estimate the risk factor of each individual consumer. In addition to the risk experiment, homeowners were surveyed regarding their past purchases of energy efficient appliances and home energy retrofits. Using the measures of homeowner risk preferences and the survey data on past household energy improvements, the relationship between risk attitudes and energy efficient home technology adoption is assessed controlling for other factors.

Employing a series of probit models and count data models, the results suggest that risk is indeed a deterrent to homeowners improving the energy efficiency of their home. More risk averse homeowners are less likely to have conducted energy efficiency retrofits or purchased energy efficient appliances (except for the case of energy efficient air-conditioners). For the adoption of energy efficient AC however, no statistically significant impact of risk preferences is found. Further, the magnitude of the influence of risk attitudes on energy efficient technology adoption is found to be magnified or dampened, depending upon the type of energy improvement, with the likelihood of homeowners moving in the future and the length of their residence in their current home. As we discuss, these results have several implications for the design of policies to foster residential energy efficiency improvements.

The remaining part of this paper is organized as follows. Section 2 describes the methodology and survey of homeowners. Section 3 describes homeowner survey responses, risk attitudes, and perceptions of barriers to improving home energy efficiency. Section 4 presents regression analysis exploring the role of risk attitudes influencing home energy improvements. Section 5 discusses the results and implications for policies to improve residential energy efficiency. Section 6 is a brief conclusion.

2. Material and Methods

An online survey of 1000 homeowners who are 21 years or older in Arizona (AZ) and California (CA) was conducted in April 2013. The response rate was about 43% yielding 432 usable homeowner surveys.