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Free riding and rebates for residential energy efficiency upgrades: A multi-country contingent valuation experiment

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ABSTRACT

The cost-effectiveness of energy technology upgrade programs critically depends on free riding. This paper assesses ex ante the effects of free riding on the cost-effectiveness of a rebate program that promotes the adoption of energy-efficient heating systems, relying on contingent valuation choice experiments carried out through identical representative surveys in eight EU Members States. The analysis distinguishes between strong and weak free riders: strong free riders already plan to adopt a new heating system in the next five years; weak free riders decide to purchase once propositioned with an attractive technology package (and therefore do not require a rebate to adopt). The reservation rebates for incentivized adopters (those who decide to adopt because of a rebate) differ substantially across countries. On average, they amount to approximately 40% of the heating system's purchasing price, suggesting generally high opportunity costs for premature upgrades. The reservation rebate and weak free-ridership vary with income, risk and time preferences, and environmental identity. At a rebate level that corresponds to half the purchase price of the offered heating system, the estimated share of free riders exceeded 50% for most countries, with a typically higher share of weak free riders than strong free riders. Specific rebate cost estimates (in €/tCO_2) differ considerably across countries, suggesting that cooperation can yield budgetary benefits.

1. Introduction

Subsidies that incentivize the adoption of energy efficient technologies are commonly used by governments and energy companies to reach energy savings or greenhouse gas emission goals (de la Rue du Can et al., 2011, 2014; Galarraga et al., 2013, 2016). Surveys of the empirical literature typically conclude that subsidies, such as rebates and subsidized loans, spur the adoption of energy efficient technologies (e.g. Markandya et al., 2014; Datta and Filippini, 2016). Subsidies may also help accelerate the replacement of energy-using technologies, such as appliances or heating systems, before they reach the natural end of their working life. Such premature technology upgrades may be required to meet ambitious climate policy targets, particularly for the residential building sector, which is generally considered to represent high potential for energy savings (IEA, 2016). In practice, subsidies are often combined with information and communication programs that help customers overcome a lack of information on available efficiency upgrades, prohibitive transaction costs, or a lack of awareness (e.g., Stern et al., 1986; Blumstein, 2010; Allcott and Taubinsky, 2015; Gillingham and Palmer, 2014).

The design and evaluation of subsidy programs that promote energy efficient technologies are generally complicated by self-selection, rebound effects, moral hazard (consumers deferring adoption to wait for a financial incentive program), and free riding (Hartman, 1988; Gillingham et al., 2006; Alberini et al., 2014). Failure to account for these issues results in an overestimation of policy effectiveness (e.g. Joskow and Marron, 1992). Free riding, the focus of this study, occurs when subsidies are paid to customers who would have purchased the technology even without the subsidy. Free-ridership has been estimated in a variety of ways in previous ex post studies of utility demand side management (DSM) and tax credit programs for residential energy efficiency upgrades in North America (Joskow and Marron, 1992; Malm, 1996; Loughran and Kulick, 2004; Boomhower and Davis, 2014) and Europe (Grösche and Vance, 2009; Nauleau, 2014; Alberini et al., 2014). These studies find that free-rider shares among program beneficiaries range from 50% to 90%. For governments and utilities, it is rarely feasible to distinguish among beneficiaries who needed or did not need the subsidy to engage in energy efficient behavior. Similarly, the economic evaluation literature presumes a non-discrimination principle of incentive allocation: those who allocate the rebate cannot - if not for ethical reasons then for reasons of prohibitive administrative costs - distinguish between free riders and non-free riders when granting subsidies to consumers who purchase eligible efficiency upgrades. In

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addition, when subsidies are part of a policy package (usually also involving accompanying information programs), evaluations typically cannot identify the effects of individual policies on program effectiveness and program costs. For example, program evaluations typically do not distinguish customers who were planning to invest in an energy efficient technology anyway from customers who were not originally planning to invest in such a technology but decided to do so after being informed.

The overall objective of this paper is to do an ex ante assessment of the effects of free riding on the cost-effectiveness of a rebate program that incentivizes the premature adoption of energy-efficient heating systems in eight EU Member States. Unlike previous studies, we distinguish the effects of two types of free riders, which we name strong and weak free riders respectively. Strong free riders are households that were planning to invest in a new heating system anyway; weak free riders are households that were not originally planning to invest in a heating system but decided to do so after receiving information about an attractive technology package (and therefore only needed awareness of technology, not of the rebate). We effectively separate the effects of providing information from the effects of offering rebates. Further, we explore the factors explaining weak free-ridership and the rebate level required to adopt a new heating system. Our findings allow for an analysis of the cost-effectiveness of rebate programs across countries, and assess the relevance of each type of free riding for differences in cost-effectiveness across countries.

Our empirical analysis relies on contingent valuation choice experiments carried out through representative surveys of around 15,000 households in eight EU Members States (France, Germany, Italy, Poland, Romania, Spain, Sweden, and the United Kingdom (UK)). Together, these eight countries account for about 80% of EU population, energy use, and greenhouse gas emissions. Respondents' choices are used to estimate (for each country) the probability that households upgrade their heating system as a function of the rebate offered, and to construct curves for the specific rebate costs (in €/tCO_2) based on free-rider shares, which are compared across countries.

The remainder of the paper is organized as follows. Section 2 presents the methodology, describing an analytical model to evaluate the effectiveness of a rebate policy distinguishing between strong and weak free riders, the multi-country survey, and the choice experiment. Section 3 presents the results, showing findings for rebate levels across countries and for the determinants of the rebate level and weak free-ridership. Section 3 also includes simulation analyses on the effects of strong and weak free riding on the cost-effectiveness of rebates across countries. Finally, Section 4 summarizes and discusses our main findings and identifies policy implications.

2. Methodology

In this section, we first present a simple analytical model for evaluating the effectiveness of a rebate policy while distinguishing between strong and weak free riders. Then, we describe our survey, our choice experiment, and the econometric model that we employed to estimate the rebate level and to conduct simulations. Finally, we present the data by including the descriptive statistics of the choice experiment and the household and respondent characteristics used as covariates in our econometric model.

2.1. Analytical model of rebate effectiveness and free riding

The model presented in this section will later be parameterized with econometric estimates based on a contingent valuation survey. Constructing specific rebate cost curves as a function of the rebate level allows us to simulate the effects of free riding on the cost-effectiveness of the rebate program for premature adoption of an energy efficient technology (here: heating).

The specific rebate c costs are the average CO_2 abatement costs of the rebate program:

$$c = C/\Delta E \tag{1}$$

C captures total program costs, i.e. the total expenditure for rebate payments, and ΔE is the total additional CO_2 emissions saved by the rebate program. The non-discrimination principle implies that all adopters receive the rebate:

$$C = N_{adopt} \times R = \left(N_{ia} + N_{wfr} + N_{sfr}\right) \times R \tag{2}$$

where R stands for the rebate offered and N_{adopt} is the total number of households adopting, comprised of (i) the number of incentivized adopters N_{ia}, i.e. those adopting only if $R > 0$; (ii) the number of weak free riders N_{wfr}, i.e. those adopting once made aware of an attractive technology package; and (iii) the number of strong free riders N_{sfr}, i.e. those adopting independent of a rebate or additional information. Let the number of strong free riders be defined as:

$$N_{sfr} = N_{pop} \times a \tag{3}$$

where N_{pop} is the total number of households in the population, and a is the share of strong free riders. Similarly, we denote the number of incentivized adopters:

$$N_{ia}(R) = N_{pop} \times b(R), \text{for } R > 0 \tag{4}$$

where $b(R)$ is the probability of adoption, i.e. Pr(adoption|R); $b(R)$ is a function of the rebate R with $b'(R) > 0$ (for $R > 0$). The number of weak free riders is then:

$$N_{wfr} = N_{pop} \times b(0) \tag{5}$$

where $b(0)$ defines the share of weak free riders in the population. Program costs are:

$$C = R \times N_{pop}[a + b(0) + b(R)] \tag{6}$$

The additional CO_2 emissions saved by incentivized adopters can be written as:

$$\Delta E = N_{ia}(R) \times \Delta e \times \gamma = b(R) \times N_{pop} \times \Delta e \times \gamma \tag{7}$$

where Δe is end-use energy savings per replacement, and γ is the CO_2 emissions per unit of energy. We may then rewrite the specific rebate costs from Eq. (1) as:

$$c = \frac{C}{\Delta E} = \frac{R \times [a + b(0) + b(R)]}{b(R) \times \Delta e \times \gamma} \tag{8}$$

As further detailed in Section 2.4, we employ a double-bounded willingness-to-accept choice experiment and interval data model estimation to predict the probability of adoption and to estimate $b(R)$ and $b(0)$.

2.2. Survey

The survey was implemented by Ipsos GmbH (a German polling company) via computer assisted web interviews (CAWI), using existing household panels from Ipsos. A total of 15,055 participants from eight EU countries (France, Germany, Italy, Poland, Romania, Spain, Sweden, UK) completed the survey. In each country, participants were selected via quota sampling to be representative for the country in terms of gender, age (between 18 and 65 years), and region; only respondents who said that they were involved in their household's investment decisions for utilities, heating, and household appliances were qualified for the survey. Interviews were carried out between July and August 2016.