BEHAVIOUR, CONTEXT AND ELECTRICY USE: EXPLORING THE EFFECTS OF REAL-TIME FEEDBACK IN THE SWEDISH RESIDENTIAL SECTOR

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Overview

Increased energy efficiency is a fundamental pillar to foster resource-efficient economies and low-carbon energy systems. To that end, policies and measures to promote energy conservation and energy efficiency technologies are becoming, increasingly popular to reduce or correct market and behavioural failures that have historically prevented the diffusion and adoption of profitable efficient technologies – a policy challenge often called as the 'Energy Efficiency Gap' (Jaffe and Stavins, 1994).

With the aim to address information-related barriers that prevent increased energy efficiency improvements, the roll out of Smart Meters (SMs) in the residential sector has gained considerable policy attention in the European Union (EU) lately.[1] SMs enable real-time feedback to residents about their electricity use and, depending on the specific technology design, also about related economic costs. A key tenet of SMs is that the provision of information encourages residential end-users to change their behaviour and make 'rational' choices about their electricity use and demand for energy services. That is, policy choices about the adoption of SMs are based on an 'information-deficit model' that assumes a more rational behaviour by consumers if information asymmetries are reduced.

This paper provides an empirical analysis about the effectiveness of real-time feedback technology on Swedish households. Taking core theoretical elements of behavioural economics to frame the research, the study aims to increase our understanding of how and to what extend psychological, moral and contextual variables affect behavioural electricity use. Research on behavioural economics relies on empirical studies to infer actual behaviour of individuals, rather than to derive self-evident outcomes from theoretical analysis. As such, a key departure point for our study is the very limited understanding about the actual effectiveness of SMs and underlying factors affecting the performance of SMs in the Swedish residential sector. In addition, and considering the size of our intervention and control groups (details in next section), the study also aims to contribute with knowledge on behavioural aspects associated with large-scale trials of SMs.

Methods

To fulfil the objective, a mix of different quantitative and qualitative methods for data collection and analysis were used to elicit scientific outcomes and policy recommendations.

In terms of data collection, monthly electricity use data from nearly 4 700 users over four years was used for the research. The data included electricity use from January 2011 to April 2015. The size of the intervention group (i.e. people subject to SMs) was 2 751 households. A survey addressing numerous behavioural, moral and contextual factors regarding electricity use was submitted to 2 173 households within this intervention group. The level of response reached 543 households. To determine baselines or counterfactuals associated to the level of effectiveness of SMs in reducing electricity use (or increasing energy efficiency) a control group composed by 2 048 households was used during the research. From a theoretical point of view, and also to support the development of our survey, a literature review was carried out to provide an understanding and framework about behavioural and contextual factors affecting or driving decisions about electricity use.

When it comes to methods for data analysis, engineering and econometrics approaches were deployed. The former aimed to estimate baselines (i.e. what would have happened in the absence of SMs) and thus generate values to assess the level of effectiveness of SMs in reducing electricity use. These engineering approaches considered climatic correction, control and intervention groups, and also different time periods under analysis. Then, econometric models were used to explore behavioural and contextual determinants of electricity use and the role and effects of real-time feedback. Model specification and testing lead to the development of different but complementary models aimed to explain electricity use, electricity savings, and the actual level of effectiveness of

[1] A total of 16 EU Member States will proceed with large-scale rollout of SMs by 2020 or earlier. Three Member States have opted for selective rollouts to some customers.

SMs. Building upon the Theory of Planned Behaviour (TPB) (Ajzen, 1991) and Value-Belief-Norm (VBN) (Stern, 2000), independent variables included attitudes, subjective norms, perceived behavioural control, awareness of consequences, and ascribed responsibility to act. Contextual and socio-economic variables such as age, education, income, living area and household size were also taken into account. A stepwise regression analysis and different statistical tests and metrics supported the overall quantitative exercise.

Results

Preliminary results strongly suggest that the effectiveness and thus effects of real-time feedback are rather limited if implemented in isolation. Estimates show electricity savings in the range of 1.4-1.9% for Swedish residential units. This result is consistent with previous studies that found average savings in the proximity of 1.6% from a study of 19 SMs interventions (c.f. Bager and Mundaca, 2015). However, our results seem to be much lower compared to other real-time feedback studies that suggested electricity savings up to 15% (c.f. Darby, 2006; Ehrhardt-Martinez et al., 2010). Discrepancies can be largely explained by how feedback is actually designed, the size of the studies, accessibility to real-time feedback as such, supportive interventions aiming to complement real-time feedback (e.g. energy audits, suggested technology improvements) and the intervention period. For the later, our results show that responses to and thus effectiveness of SMs are higher during the time closest to the beginning of the intervention, and lower as time goes by. This finding is consistent with the existing literature (Ehrhardt-Martinez et al., 2010).

From a behavioural and contextual point of view, econometric results show that contextual rather than behavioural (psychological and normative) aspects better explain electricity use and marginal savings under the presence of real-time feedback. Variables such as living area, income and in particular household size (i.e. number of persons living in the property) explain up to 17.6% of electricity use variability. Result from one of the tested models indicate that perceived behavioural control and personal norms were statistically significant predictors (16.7%) for how well Swedish households consider that real-time feedback can help them to reduce electricity use. In fact, and despite the estimated marginal electricity savings, partial correlations tests indicate that those households that have greater perceived behavioural control and feelings of moral obligations were the ones that actually reduced their total electricity use. Our results are inconclusive as to whether higher education levels correlate with more energy conservation behaviour and energy efficiency technology improvements.

Conclusions

It is concluded that the implementation of SMs *per se* is likely to be insufficient to foster increased efficient use of electricity if this provided in isolation. Therefore, the findings strongly suggest the adoption and implementation of other policy instruments and measures, such as electricity pricing, awareness raising, expert advice and tailored education campaigns to deliver expected policy outcomes. Complementary policies and measures seem to be critical to counterbalance the lower response to real-time feedback in the long term. Contextual factors seem to have a greater implication than behavioural aspects in determining the effects of real-time feedback and resulting electricity use. Our results also confirm that much greater attention must be given to the use and application of behavioural economics to support and offer new perspectives (e.g. design and framing of feedback) to the development of energy and environmental policies.

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