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Nudging electricity consumption using TOU pricing and feedback: evidence from Irish households ☆

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ABSTRACT

This paper analyses the electricity usage of 5000 Irish residential consumers in response to the introduction of Time Of Use (TOU) tariffs and three different forms of financial feedback: immediate feedback from in-home displays (IHD), monthly billing and bimonthly billing. Half-hourly data on consumption collected during the trial indicated that TOU tariffs reduced consumption at peak, with some reductions lasting beyond the end of the peak period and post-peak spikes in usage were not observed. IHD feedback resulted in the most reliable reductions and bimonthly billing the least. Moreover, consumers slightly increase the electricity usage during the first hours of the night and early in the morning. Households with greater education react to the information associated to the TOU tariffs slightly more than the average.

1. Introduction

Balancing electricity demand and supply is difficult and expensive. Traditionally system operators have used supply-side techniques, such as reserves, to make sure that there is always enough generation to meet a fairly inelastic demand as demand fluctuates.[1]

Recently there has greater interest in the potential of demand-side tools to balance energy markets as highlighted by Feuerriegel and Neumann (2016). In particular, there are considerable advantages in increasing the sensitivity of electricity demand to its generation costs. First of all, higher electricity generation costs are largely driven by higher demand.[2] Principally, peak demand requires increased electricity generation at times when it is most costly, so the cost savings of reducing peak demand are greater than proportional to the decrease in demand. A second advantage concerns environmental impact of peak demand. Power plants that are brought online to supply electricity at peak times tend to run on fossil fuels and be less efficient, causing greater greenhouse gas emissions per unit of electricity generated. A third advantage concerns energy efficiency.

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[1] Short-term demand is inelastic in part because retail prices have historically been fixed for long periods of time. See for Ireland (Eirgrid, 2009).

[2] On average, peak load for the Irish system is about 25% greater than the average day demand.

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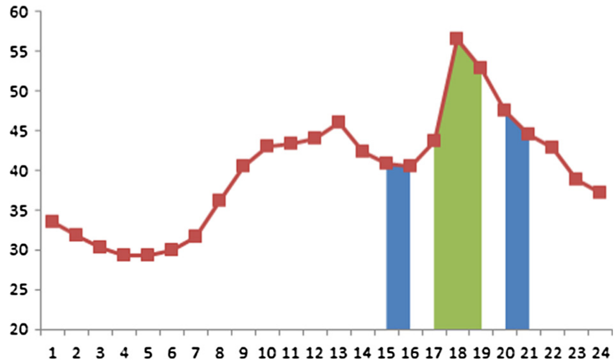

Fig. 1. Plot of estimated coefficients at half hourly intervals before, during and after the peak pricing period, by feedback stimulus and tariff for houses in the Higher Ed category only. See Figure \ref{fig:whole_results} for an explanation of symbols.

Reducing peak demand increases energy efficiency by ensuring more complete usage of current energy resources and reducing required investments in electricity generation, transmission and distribution in the medium to long term, leading to savings for the system as a whole. All EU countries must reduce emissions and energy consumption by 2020 to comply with EU energy efficiency targets (2009/28/EC).[3] Reducing peak electricity demand also helps meet this target. Reduction of peak demand need not require consumers to reduce the use of electricity; they can also redistribute the usage of some appliances (dishwashers, washing machines) among different times of the day and night. Of these alternative times, redirecting electricity demand from peak times to the night hours presents several benefits, both for consumers and for the system.[4] Consumption during the night hours is cheaper than during the day and the peak hours, as shown by Fig. 1.

As shown in Fig. 1, in the hours highlighted in blue, immediately before and after the peak time (highlighted in green), the wholesale price of electricity is lower than in the peak hours. The basic idea behind the installation of smart meters is that rational consumers facing real-time prices may postpone or anticipate the use of electricity to benefit from lower electricity prices. Night-time consumption also takes advantage of increased availability of renewable generation like wind generation, that comes on stream during the night as highlighted by Finn, OĆonnell, and Fitzpatrick (2013) and Eirgrid (2014). Finally, increasing the demand elasticity encourages greater competition between generators, as shown by Walsh, Malaguzzi Valeri, and Di Cosmo (2016).

The current study investigated whether pricing schemes and pricing feedback provided to the consumer change the consumption during peak hours and lead to a shift in consumption from peak hours to other times of day. In examining shifts in consumption, we were particularly concerned to establish whether short-term redistribution, such as earlier usage just prior to the peak pricing period or postponement of usage until the end of the peak pricing period would give rise to a new peaks in the hours immediately before or after the peak pricing period. Moreover, we analysed whether households with different educational level react to the change in tariffs and information differently from the whole sample.

Previous work have discussed how consumers react to a change of the electricity price mechanism when flat tariffs are switched to Time of Use (TOU) or continuous pricing schemes. For instance, a number of experiments in the US (see Faruqui & Sergici, 2010) and in Europe (see Aubin, Fougare, Husson, & Ivaldi, 1995; Filippini, 1995) have investigated whether consumption reacts more to prices when the cost of electricity follows wholesale costs more closely. The experiments in the US (Faruqui, Harris, & Hledik, 2010) confirm that higher prices during congested hours lead to a slight change in the electricity consumption, but the magnitude of the effect is not constant across experiments. Moreover, the authors find that customers may take advantage of lower night time tariffs by shifting their electricity usage to night-time storage heaters and water heaters on a timer. Faruqui and Sergici (2010) analysed 15 pricing experiments using TOU pricing and found that customers responded to higher prices during the peak hours by reducing peak hour electricity usage and/or shifting it to less expensive off-peak periods. On average, TOU rates induced a reduction in peak demand from 3–6% in the 15 pricing experiments. In some cases, consumers do not significantly change consumption as prices change. There are a number of reasons why this might occur. Consumers have bounded capacity to reduce or reallocate electricity usage and it is possible that they do not fully reassess their optimal consumption when the price of electricity increases. Alternatively, the opportunity cost of changing behaviour may be too high for the consumers (i.e. the time spent monitoring prices constantly is not used for other productive activities).

Gabaix and Laibson (2006) found that consumers often express uncertainty on the relationship between inputs and outputs, such as how heating a room translates into energy usage or how a use of the washing machine translates into cost. Other authors such as Allcott (2011), Jessoe and Rapson (2014) and Di Cosmo, Lyons, and Nolan (2014) have investigated

[3] Directive 2009/28/EC of the European Parliament and of the Council (2009) on the promotion of the use of energy from renewable sources and amending and subsequently repealing directives 2001/77/EC and 2003/30/EC, Official Journal of the European Union.

[4] See, as examples, Commission (2015) and Joskow (2012).