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A novel machine learning approach for identifying the drivers of domestic electricity users' price responsiveness

EPRG Working Paper 1824

Cambridge Working Paper in Economics 1844

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Abstract

Time-based pricing programs for domestic electricity users have been effective in reducing peak demand and facilitating renewables integration. Nevertheless, high cost, price non-responsiveness and adverse selection may create the possible challenges. To overcome these challenges, it can be fruitful to investigate the 'high-potential' users, which are more responsive to price changes and apply time-based pricing to these users. Few studies have investigated how to identify which users are more price-responsive. We aim to fill this gap by comprehensively identifying the drivers of domestic users' price responsiveness, in order to facilitate the selection of the high-potential users. We adopt a novel data-driven approach, first by a feed forward neural network model to accurately determine the baseline monthly peak consumption of individual households, followed by an integrated machine-learning variable selection methodology to identify the drivers of price responsiveness applied to Irish smart meter data from 2009-10 as part of a national Time of Use trial. This methodology substantially outperforms traditional variable selection methods by combining three advanced machine-learning techniques. Our results show that the response of energy users to price change is affected by a number of factors, ranging from demographic and dwelling characteristics, psychological factors, historical electricity consumption, to appliance ownership. In particular, historical electricity consumption, income, the number of occupants, perceived behavioural control, and adoption of specific appliances, including immersion water heater and dishwasher, are found to be significant drivers of price responsiveness. We also observe that continual price increase within a moderate range does not drive additional peak demand reduction, and that there is an intention-behaviour gap, whereby stated intention does not lead to actual peak reduction behavior. Based on our findings, we have conducted scenario analysis to demonstrate the feasibility of selecting the high potential users to achieve significant peak reduction.

Keywords Time-based electricity pricing, price responsiveness, high-potential users, variable selection, Time of Use, machine learning

JEL Classification Q41, C55

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Publication August 2018
Financial Support Research Grants Council of Hong Kong [Grant No. RGC-GRF-17403614]

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