Unlocking households' flexibility potential - on the barriers to real-time pricing

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Overview

The lack of flexibility in electricity grids can cause frequent price spikes, elevated grid management costs, and in severe situations, could lead to rationing and power outages. Fortunately, many countries intend to electrify most of their energy consumption in the near future, which will raise the flexibility of electricity consumption significantly. However, consumers are only incentivised to utilise this flexibility potential when appropriate price signals exist. Passing on wholesale prices, which mirror contemporaneous supply and demand conditions, could provide such signals and is commonly known as real-time pricing (RTP). In this paper, we explore the potential complementarities of RTP with flexible consumption and identify barriers to its adoption. To do so, we extend on the stylised electricity market model of Borenstein and Holland (2005) and solve for the partial equilibrium analytically. Our results identify multiple barriers to the adoption of RTP; some of which are already known in the existing literature while others have not been previously discussed. As expected, limited consumption flexibility reduces the adoption of RTP as consumers cannot easily adjust their consumption according to prices. Additionally, our model suggests that market power among retailers as well as elevated grid fees play a significant role for the attractiveness of RTP to consumers. If such frictions are large, RTP contract remain unattractive to consumers even if consumption flexibility increases. Lastly, we provide policy suggestions depending on the underlying barrier.

Methods

Our analysis is based on the electricity market model of Borenstein and Holland (2005), which we extend in two ways. First, we introduce utility-maximising consumers, who are flexible in their consumption. We model this by treating electricity consumption at different times as substitutable. If electricity at different times becomes more substitutable, this results in greater flexibility of consumption. Specifically, we use the widely used quality-augmented quadratic utility function of Sutton (1997). In a second step, we introduce frictions in the retail market and move away from the perfect competition framework of the original model. We focus our attention on two common frictions in the electricity retail market: market power and grid distribution costs. By deriving the partial equilibrium of the model analytically, we can identify how different model parameters affect prices, welfare and the adoption decision of consumers.

Results

Our results indicate notable synergies between flexible consumption and RTP. If flexibility is low, consumers cannot easily adjust their consumption according to prices, rendering RTP unattractive. However, as flexibility rises, consumers can more effectively shift consumption across time, increasing the consumers' benefits of RTP contracts and thus adoption. Additionally, increased flexibility accelerates the alignment of real-time prices and significantly reduces the fixed price as more consumers adopt RTP. However, if the share of RTP consumers remains low, increased flexibility may also lead to an adverse outcome, causing a divergence in real-time prices and an increase in the fixed price. This model prediction has already materialised in some regions, where EV charging had to be prohibited during peak hours (see DSO Stedin in the Netherlands), because many consumers shifted their flexible consumption to the peak period.

Furthermore, high grid distribution costs or market power renders RTP contracts unattractive to consumers. In either case, retail prices include a considerable markup on top of the wholesale electricity prices. Such markups do not only raise the average retail prices for consumers, they also lead to a decrease in the real-time price disparities as off-peak prices increase by relative more than peak prices. Since RTP functions as an 'arbitrage opportunity' to exploit existing price discrepancies, a reduction in these discrepancies lowers the attractiveness of RTP to consumers and consequently adoption. Our results were computed for a specific parametric framework but remain robust as long as (i) the industry marginal cost of generating electricity is non-concave and (ii) demand in peak

periods is relatively more elastic than in off-peak periods; both common assumptions in the peak-load pricing literature (Crew et al., 1995).

Conclusions

Real-time pricing (RTP) can be viewed as a classic public goods problem. It offers considerable welfare gains through efficient pricing, improved grid stability and indirect promotion of renewables. Nonetheless, individual consumers might only marginally benefit from adopting such contracts, resulting in insufficient adoption. In this paper, we identify multiple mechanism for the limited adoption of RTP and provide policy suggestions to overcome them. Since RTP and consumption flexibility exhibit significant synergies, an effective policy approach would connect policy tools that promote flexible consumption and the adoption of RTP simultaneously. For example, many countries offer subsidies for heat pumps and EVs independent of the consumers' electricity contracts. Instead, subsidies could be made conditional upon adopting RTP contracts.

On the other hand, if distribution costs are significant, policymakers could mandate that distribution costs are collected as a value-added 'tax' instead of lump-sum. This approach would mimic RTP's effect by discouraging consumption when prices are high encouraging it when prices are low. If market power is the source of considerable markups, policymakers should adopt strategies to enhance market competitiveness. This can be achieved by reducing barriers to entry, minimising searching and switching costs as well as enhancing price transparency

Our paper shows that there can be numerous sources for the limited adoption of RTP. An increase in demand flexibility is thus far from self-fulfilling and may need government intervention. It is thus crucial to identify the prominent mechanism driving consumers' choices to introduce the correct policy instrument and achieve demand flexibility during the energy transition.

References

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