Energy Policy 106 (2017) 244–254

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Perceived price complexity of dynamic energy tariffs: An investigation of antecedents and consequences

Patrick Layer[a], Sven Feurer[b,*], Patrick Jochem[c]

[a] Daimler AG, Stuttgart, Germany
[b] Postdoctoral Researcher at the Institute of Information Systems and Marketing (IISM), Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany
[c] Postdoctoral Researcher at the Institute for Industrial Production (IIP), Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany

ARTICLE INFO

Keywords:
Dynamic tariffs
Price complexity
Information processing
Consumer
Perceptions

ABSTRACT

Dynamic tariffs have the potential to contribute to a successful shift from conventional to renewable energies, but tapping this potential in Europe ultimately depends on residential consumers selecting them. This study proposes and finds that consumer reactions to dynamic tariffs depend on the level of perceived price complexity that represents the cognitive effort consumers must engage in to compute the overall bill amount. An online experiment conducted with a representative sample of 664 German residential energy consumers examines how salient characteristics of dynamic tariffs contribute to perceived price complexity. Subsequently, a structural equation model (SEM) reveals that the depth of information processing is central to understand how price complexity relates to consumers' behavioral intentions. The results suggest that it will be challenging to convince European consumers to select complex dynamic tariffs under the current legal framework. Policymakers will need to find ways to make these tariffs more attractive.

1. Introduction

In response to climate change, many national governments have started to shift electricity generation from fossil fuels to renewable energy sources (RES) or nuclear power (EC, 2010; Mills and Schleich, 2012). These efforts have been reinforced by the 2015 United Nations Climate Change Conference in Paris at which large parts of the world implicitly committed to nearly carbon-free electricity generation by the middle of this century. However, the euphoria about this remarkable multilateral achievement cannot hide the fact that decarbonization of the electricity system is and will continue to be a challenging endeavor for energy providers, policymakers, and society as a whole.

The feed-in of RES-based technologies occurs mainly on decentralized grid levels and, in the case of photovoltaic and wind, the controllability of feed-in is limited to the largely inefficient curtailment (Loisel et al., 2010). Hence, if no unexpected leaps in storage technologies and electricity exchange with neighboring countries occur, decarbonization processes will rely on increased demand-side flexibility (Breukers et al., 2011; Grünewald et al., 2015). One promising way to achieve this flexibility at relatively low cost is by means of dynamic tariffs (Grünewald et al., 2015; Roscoe and Ault, 2010). In dynamic tariff schemes, residential consumers pay different prices per kWh, depending on the time of use and/or on the current load at household level (Dütschke and Paetz, 2013). In contrast, static tariffs consist of a fixed connection charge per time period and one consumption-dependent charge per kWh, resulting in peak demand being relatively underpriced (Hall et al., 2016; Simshauser and Downer, 2014). The idea is that dynamic tariffs financially incentivize consumers to react to the status of the electricity system by shifting consumption from peak to non-peak periods of the residual load, hereby supporting the integration of RES (Darby and Pisica, 2013; Dupont et al., 2014; Grünewald et al., 2015). Data from field tests conducted mainly in the US confirm that dynamic tariffs can lead to substantial peak load reductions (e.g., Faruqui and Sergici, 2010).

Given this evident potential, European politics and lawmakers are generally supportive of dynamic electricity tariffs. For example, German law requires power suppliers to offer at least one dynamic tariff (EnWG §40), and the European Commission strongly recommends their application (EC, COM(2015) 339 final). The key difference to the US legislation is that in most European countries dynamic tariffs are not provided by default but only as an opt-in option (Faruqui et al., 2010). Unlike in the US, the potential of dynamic tariffs to contribute to a successful decarbonization in Europe ultimately depends on residential consumers selecting them (Salies, 2013).

Unfortunately, the prior literature on demand side management (DSM) suggests that consumers show adverse reactions to the inherent

* Corresponding author.
E-mail address: sven.feurer@kit.edu (S. Feurer).

http://dx.doi.org/10.1016/j.enpol.2017.02.051
Received 13 July 2016; Received in revised form 20 February 2017; Accepted 26 February 2017
Available online 04 April 2017

complexity of dynamic tariffs (e.g., Breukers and Mourik, 2013; Dütschke and Paetz, 2013; Gordon et al., 2006; Stenner et al., 2015). For example, Dütschke and Paetz (2013) note that "consumers are open to dynamic prices, but prefer simple programs to complex and highly dynamic ones" (p. 226). In a similar vein, Dupont et al. (2014) stress the importance of "social acceptability" and conclude that "a tariff should be simple" (p. 346). While there is apparently consensus on this general notion, very little is known about the underlying process by which consumers evaluate dynamic tariffs, and the role complexity plays in it. A profound understanding of these processes is crucial to design dynamic tariffs that overcome the conflict between supply-demand balancing and consumer acceptance.

The overarching goal of this study is to close this research gap and to examine antecedents and consequences of consumers' perceived price complexity of dynamic tariffs. To do so, we draw on research in the domains of marketing, especially behavioral pricing, and psychology. In line with Homburg et al. (2014), we define price complexity as the extent to which a price or tariff[1] poses a high cognitive burden on the consumer in his/her effort to make sense of the price components and to mathematically arrive at the final bill amount. The term "cognitive burden" has a negative valence, reflecting the common conception that consumers are cognitive misers who naturally avoid their limited information-processing resources to be exploited (Fiske and Taylor, 1991; Miller, 1956).

Based on our conceptualization, all prices that consumers are confronted with are perceived as complex *to a certain degree*. Most prices in everyday shopping situations (e.g., for consumer goods) have low levels of inherent complexity because they involve one single number and, at most, an additional discount to take into account. However, we expect dynamic tariffs to be perceived as relatively complex by nature because determining the correct bill amount requires consumers to apply different mathematical operations, for example, multiplying consumption-dependent price components with anticipated consumption, adding the resulting values together, etc. (Homburg et al., 2014). All these operations should contribute to a relatively high cognitive burden and hence perceived price complexity.

The pricing literature supports the initial findings in the realm of DSM regarding consumer reactions to complex tariffs. For example, in an influential article, Lambrecht and Skiera (2006) examine tariffs of internet service providers and find evidence that many consumers choose flat-rate tariffs over pay-per-use tariffs even if the pay-per-use tariff is economically favorable. In fact, in service industry practice, there is a trend toward simple flat-rate tariffs (e.g., for mobile phone, internet or health club services) in which no mathematical operations are necessary. As dynamic tariffs imply the exact opposite, it is critical to examine the level of price complexity that consumers associate with salient aspects of dynamic tariffs. A review of actual tariffs suggests that dynamic tariffs not only have varying numbers of price components, but they also typically include a discount for new customers and frequently use odd numbers that are more difficult to process. This leads to the first research question:

RQ1: To what extent do these characteristics of dynamic tariffs lead to perceived price complexity?

Furthermore, our research seeks to illuminate the process by which perceived price complexity leads to behavioral reactions. We start with the observation that, from a consumer standpoint, energy represents a domain that is highly relevant for every household but typically evokes only little consumer awareness or involvement (Fischer, 2008; Hargreaves et al., 2010). In this context, consumers likely not only differ in their cognitive ability but also in their motivation to engage in the cognitive effort that a high price complexity implies. To the best of our knowledge, prior research on price complexity has neglected the focal context. The absence of motivation and/or ability typically decreases the depth of information processing, that is, consumers base the tariff evaluation on simple heuristics (e.g., Chaiken et al., 1989; Haugtvedt et al., 1992). Prior pricing research suggests that relying on heuristics can substantially distort consumer price evaluations (Morwitz et al., 1998), but research in the realm of dynamic electricity tariffs is lacking. This leads to our second research question:

RQ2: (a) How does perceived price complexity affect the depth of information processing, and (b) how does the depth of information processing in turn affect behavioral intentions to select a dynamic tariff?

The remainder of this article is structured as follows. In the next section, we provide a brief review of the literature on consumer reactions to dynamic energy tariffs and the role of dynamic tariffs for DSM. Subsequently, we develop our conceptual model and hypotheses. It is a process model covering antecedents and consequences of perceived price complexity. Sections 4 and 5 provide an outline of our method and analytic procedure, as well as the results and a discussion. Finally, we elaborate on contributions and implications and provide avenues for further research.

2. Literature review

As discussed in prior research (e.g., Dütschke and Paetz, 2013; Faruqui et al., 2010), the literature on dynamic tariffs distinguishes three major types of dynamic tariffs: time-of-use (TOU), critical peak pricing (CPP), and real time pricing (RTP). TOU tariffs are considered the least dynamic of the dynamic tariffs. They usually consist of a connection charge and consumption-dependent charges under a fixed timetable for a long period. CPP tariffs include extraordinary events or interruptible rates that penalize consumers heavily for consumption during critical peak periods. RTP tariffs are considered the most dynamic with charges following actual market prices. Note that different combinations of these characteristics are possible (e.g., Dütschke and Paetz, 2013; Fell et al., 2015).

Research on these dynamic tariffs can be ascribed to two major research streams: (1) research on the effectiveness of dynamic tariffs as a strategy to reduce peak demand in the realm of DSM, and (2) research on consumer acceptance of dynamic tariffs. Regarding the former, research seeks to illuminate which, and to what extent, tariffs are *effective* in reducing peak demand. Whereas initial research finds that price elasticity is "fairly low" for private consumers (Lijesen, 2007, p. 249), a different conclusion can be drawn from more recent research that accounts for different tariffs and circumstances (for comprehensive overviews see Faruqui and Sergici, 2010; Newsham and Bowker, 2010; Quillinan, 2011). For example, Newsham and Bowker (2010) highlight the efficacy of such tariffs in pilots and conclude that reasonable expectations for peak load reductions are 5% for TOU tariffs and at least 30% for CPP tariffs. As Quillinan (2011) notes, it seems not so much the question whether dynamic tariffs are effective, but how managers can overcome the challenges that relate to marketing these tariffs to consumers.

In line with this notion, the second stream of research takes on a more consumer-oriented stance. In an influential article, Faruqui et al. (2010) point to the huge savings potential from smart meters in the EU if only barriers to consumers adopting dynamic tariffs can be overcome. In response, an increasing number of articles investigate consumer acceptance of dynamic tariffs. Notably, most evidence stems from focus groups, attitudinal surveys and pilots (Quillinan, 2011). For instance, Paetz et al. (2012) conduct focus group interviews indicating that consumers who recognize the importance of dynamic tariffs are willing to "consider" (p. 32) dynamic tariffs in the near future in order to save money, conserve electricity, and contribute to environmental

[1] We use the terms price and tariff interchangeably throughout this article.