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

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A B S T R A C T

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 flexibil-ity (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,

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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-depen-dent 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 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[2] 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

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

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 comprehen-sive 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 market-ing 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 over-come. 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 benefits. However, more recent research finds that consumers are put off by the inherent complexity of highly dynamic tariff types. Dütschke and Paetz (2013) conduct a conjoint analysis and find that consumers prefer TOU to RTP tariffs. Darby and Pisica (2013) analyze material from six focus group and find that more simple tariffs are preferred. Stenner et al. (2015) conduct a large-scale experimental study with an Australian sample and find that consumers prefer the flat rate tariff to all other tariffs and simpler tariffs seem to be more attractive. Whereas consumers with higher education or renters are more likely to choose a dynamic tariff in general, CPP is most attractive for people in lower income classes. An important reason for the preference for simple tariffs is that a higher complexity implies a higher perceived risk (Darby and Pisica, 2013; Dütschke and Paetz, 2013; Stenner et al., 2015). This notion is in line with Fell et al. (2015) who find that trust in the electricity supplier positively increases the attractiveness of dynamic tariffs, whereas privacy concerns show the opposite influence. Our study takes a different approach and focuses directly on the construct of perceived price complexity.

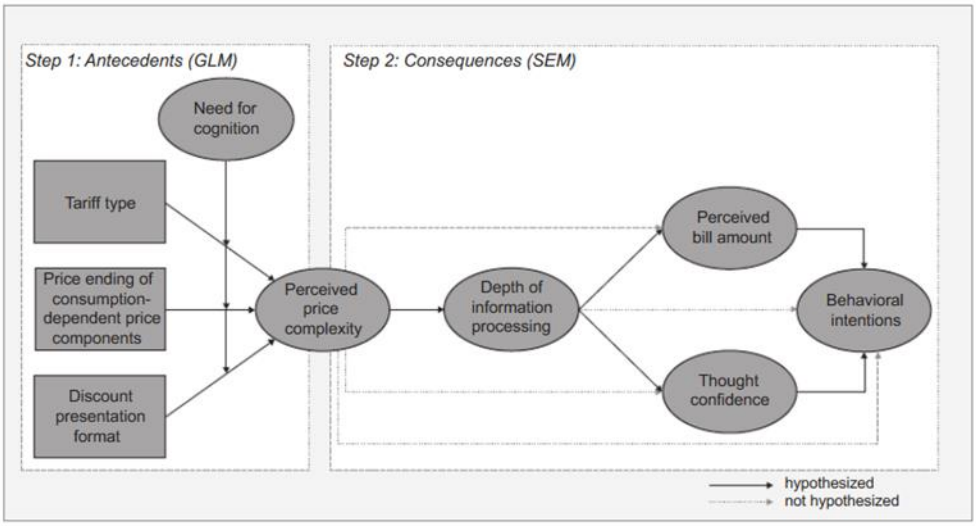

Figure 1 Conceptual model and analytic procedure.

3. Development of conceptual model and hypotheses

Fig. 1 presents our conceptual framework and the analytic steps by which we go forward. To motivate our conceptual model, we draw on the behavioral pricing literature that contributes to our understanding of consumer evaluations and reactions to different pricing tactics such as price partitioning (e.g., Morwitz et al., 1998; Greenleaf et al., 2016) multi-part tariffs (e.g., Lambrecht and Skiera, 2006; Schlereth and Skiera, 2012), and multi-dimensional prices (e.g., Estelami, 1999, 2003), as well as on the social psychology literature on the three primary aspects of thinking (Petty et al., 2002).

3.1. Drivers of perceived price complexity

Based on an online examination of actual electricity tariffs offered in Germany, we expect that the complexity of an electricity tariff will be driven by the following antecedents: (1) the tariff type as it determines the number of price components above and beyond the connection charge, (2) the price ending of the respective consumption-dependent price components, and the (3) presentation format of the discount offered to new customers selecting the tariff. All these aspects contribute to more difficult and cognitively demanding information processing (Estelami, 1999, 2003; Homburg et al., 2014). It can be argued that these antecedents represent an objective form of price complexity that consumers translate in a subjective, perceived price complexity.

Regarding tariff type, we distinguish TOU (i.e., one consumption-dependent price component), CPP with an extra rate for the annual hours with maximal load (i.e., two consumption-dependent price component), and RTP where electricity rates alter on an hourly basis (in our study, designed as a dynamic tariff with three consumption-dependent price components). Hence, to evaluate these dynamic tariffs, consumers need to multiply each consumption-dependent price component with an anticipated consumption per time period, add the resulting numbers and the connection charge together[3]. The more consumption-dependent price components are involved, the higher the cognitive effort. Prior research suggests that the number of price components is an important factor in price evaluations (Carlson and Weathers, 2008; Feurer et al., 2015; Homburg et al., 2014). Regarding the price ending of the respective consumption-dependent price components, prior research shows that odd price endings are more difficult to process than even price endings (Choi et al., 2014; Estelami, 1999). Regarding the presentation format of the discount offered to new customers selecting the tariff, the cognitive effort should be higher for a discount that is presented as a percentage of the connection charge (vs. an absolute number) because multiplying is more difficult than subtracting (Estelami, 1999). Taken together, we hypothesize:

H1: Tariff type has a direct effect on perceived price complexity such that the higher the number of consumption-dependent price components the tariff comprises, the higher the perceived price complexity.

H2: Odd price endings of the consumption-dependent price components of a dynamic tariff lead to higher perceived price complexity than even price endings.

H3: If the discount of a dynamic tariff is presented as a percentage, the perceived price complexity is higher than when it is presented as an absolute number.

As our conceptualization of perceived price complexity is based on the notion of cognitive load, we must acknowledge prior research suggesting that individuals differ not only in their ability but also in their opportunity and motivation to process complex information (MacInnis et al., 1991). Specifically, need for cognition (NFC) refers to a stable dispositional difference in cognitive motivation that is distinguishable from (but related to) intellectual ability (Cacioppo and Petty, 1982). High-NFC consumers have “active, exploring minds and, through their senses and intellect, reach and draw out information from their environment” (Cacioppo et al., 1996, p. 199). Hence, high-NFC consumers enjoy facing complex situations while low-NFC con-sumers are cognitive misers who lack intrinsic cognitive motivation and are thus more likely to avoid cognitively strenuous work (Goodman and Irmak, 2013). Consequently, we expect that high (low) NFC individuals are capable of processing more (less) complex tariff information before experiencing cognitive overload and hence perceived price complexity. We hypothesize:

H4: NFC moderates the effects proposed in such that the effects are weaker (stronger) for individuals high (vs. low) in NFC.

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[3] It can be argued that this exercise is further complicated by the fact that consumers would require detailed knowledge of the household's load curve. We thank an anonymous reviewer for noting this.

3.2. Consequences of perceived price complexity

Prior research suggests that perceived price complexity may have several adverse consequences, including reduced perceived transparency of the firm's pricing and reduced price fairness (Carlson and Weathers, 2008; Homburg et al., 2014; Feurer et al., 2015). For the present study, we propose that three variables play a central (i.e., mediating) role, linking perceived price complexity to behavioral intentions: (1) the extent of heuristic processing, (2) perceived bill amount, and (3) thought confidence. These three variables relate to different aspects of thinking about an issue that leads to attitude formation and, ultimately, behavior.

According to Petty et al. (2002), the social psychology literature emphasizes three primary aspects of thinking. We incorporate each of these aspects on thinking about a tariff in our model. The first aspect is the extent of thinking, which we capture by the depth of information processing. We conceptualize this variable to represent a continuum reaching from heuristic (“shallow”) processing to systematic (“deep”) processing (Chaiken, 1980). If the information processing is systematic, individuals exert considerable cognitive effort to perform the evaluation task. If the information processing is heuristic, individuals exert little cognitive effort in evaluating a tariff but apply heuristics which “are quite useful, but sometimes they lead to severe and systematic errors” (Tversky and Kahneman, 1974, p. 1124).

The second aspect of thinking is content, relating to how favorable or unfavorable the thoughts are in response to the thought object. We capture this aspect by the perceived bill amount, which we define as the subjective monetary burden of a tariff. The inclusion of this variable is important because consumers do not always know, encode or estimate an objective price correctly (Carlson and Weathers, 2008; Zeithaml, 1988).

The third aspect of thinking we capture is thought confidence. Thought confidence reflects a more meta-cognitive aspect of thinking that relates to an individual's thoughts about his or her own thought processes (Jost et al., 1998; Petty et al., 2002). In line with prior research by Goode et al. (2013) and Petty et al. (2002), we define thought confidence as the extent to which a person has confidence in their thoughts related to the evaluation of the tariff.

We expect that perceived price complexity has an effect on all three aspects of consumers’ thinking about a dynamic tariff. First, perceived price complexity may determine whether consumers engage in systematic or heuristic processing. If the perceived price complexity exceeds the consumer's processing limit, information overload may occur, representing an uncomfortable situation (Grisé and Gallupe, 1999). As a result, consumers may reduce this cognitive load by applying heuristic processing (Malhotra, 1982; Miller, 1956). When this happens, the consumer will not be able or motivated to calculate the final billing amount. Instead, she or he will be more likely to rely on a rough estimate of the costs involved in selecting the respective tariff. Indeed, Morwitz et al. (1998) provide evidence that consumers apply simple anchoring heuristics when evaluating partitioned prices. In contrast, if the perceived price complexity and consequently information load is low, consumers are more likely to take all of this information into account within an evaluation task and attempt to calculate the final bill amount (e.g., Chaiken, 1980; Shiffrin and Schneider, 1977).

H5: Perceived price complexity of a dynamic tariff is negatively related to the depth of information processing.

Prior research indicates that the application of heuristics plays a central role in consumers’ price judgments (Alba et al., 1999; Morwitz et al., 1998). Hence, we propose that the depth of information processing has an impact on the perceived bill amount. For instance, Morwitz et al. (1998) argue that for partitioned prices consumers focus on the base price but insufficiently adjust for the surcharges. Another heuristic used when evaluating prices is the left-digit effect, predicting that consumers focus on the left-most digit of the price and ignore the ones that follow, also leading to an underestimation (Thomas et al., 2010). In contrast, Carlson and Weathers (2008) observe that for price partitioning with a large number of price components, consumers overestimated the total price. As their study design is closest to the complexity inherent in dynamic energy tariffs, we expect that heuristic (systematic) processing leads to an overestimation (underestimation) of the perceived bill amount. Thus:

H6a: Depth of information processing is negatively related to the perceived bill amount.

The depth of information processing itself may also influence consumers’ thought confidence. We expect that a high depth of information processing (i.e., systematic processing) increases thought confidence because consumers are aware that all relevant and potentially important price information have been incorporated in the tariff evaluation. Reversely, if the depth of information processing is low (i.e., heuristic processing), a consumer may lose faith in his or her own ability to evaluate the tariff in an adequate manner (cf. Jacowitz and Kahneman, 1995). In fact, a consumer may not even be able to name or recognize the heuristic she or he applies to evaluate the electricity tariff but still be aware of the fact that heuristic information processing is activated (Chen and Chaiken, 1999). Hence:

H6b: Depth of information processing is positively related to thought confidence.

The last two hypotheses are rather straightforward. In what is a common consensus in the literature, the subjective price is negatively related to perceived value and ultimately behavior (e.g., Bornemann and Homburg, 2011; Zeithaml, 1988).

Furthermore, we expect that thought confidence has a positive effect on behavioral intentions (cf. Bennett and Harrell (1975)). This notion is in line with Festinger's (1957) theory of cognitive dissonance. If a consumer has low thought confidence in his or her own tariff evaluation, he or she is expected to seek to reduce dissonance by leaving the exchange relationship, defer choice or produce a less favorable evaluation, all of which relate to lower behavioral intentions. Similarly, low levels of thought confidence imply a certain degree of uncertainty, reducing behavioral intentions (cf. Goode et al., 2013; Mitchell, 1999). Hence:

H7: The perceived costs of a tariff have a negative effect on behavioral intentions.

H8: The confidence towards the tariff evaluation has a positive effect on behavioral intentions.

4. Method

4.1. Sample

We used a commercial consumer panel to recruit a representative sample of German consumers to participate in an online experiment. A total of 1048 completed questionnaires were obtained. In a first step, to ensure that all participants read and understood the scenario and the following questions well, we excluded 246 participants for obvious speeding and for pausing more than six minutes after reading the scenario. In a second step, we excluded 138 participants for suspicious answering patterns. The resulting effective sample size is 664. The sample is representative of the German population in terms of gender, age, education and income. Table 1 provides a summary of the sample composition.

Table 1

Sample Composition.

Characteristic	Representative distribution	Effective sample distribution	
Gender			
Male	49%	51%	(341)
Female	51%	49%	(323)
Age			
18–24 years	10%	8%	(50)
25–34 years	14%	12%	(82)
35–44 years	19%	19%	(123)
45–54 years	18%	20%	(136)
55–64 years	14%	17%	(115)
65+ years	24%	24%	(158)
Education			
Low	42%	32%	(213)
Medium	29%	33%	(220)
High	28%	35%	(231)
Monthly net income			
Below 1300 Euro	20%	20%	(129)
1300 – 2599 Euro	33%	35%	(232)
2600 – 3599 Euro	18%	18%	(122)
3600 – 4999 Euro	15%	17%	(113)
5000 Euro or more	13%	10%	(68)

Education was queried throughout seven categories and has been clustered to the three characteristics of low, medium and high. Low education includes subjects with secondary modern school qualification or without school qualification. Medium education includes subjects with secondary school leaving certificate or vocational school qualification. High education includes any kind of university degree as well as high-school diploma.

4.2. Experimental design and procedure

Participants were randomly allocated to the 16 treatment conditions of a 4 (Tariff type: standard vs. TOU vs. CPP vs. RTP) x 2 (Price endings of consumption-dependent price components: odd vs. even) x 2 (discount presentation format: percent vs. absolute) full-factorial between-subjects design. Note that the tariff type corresponds to the number of consumption-dependent price components over and above the monthly connection charge (standard = 1 consumption-dependent price components, TOU = 2 pay-per use components, CPP = 3 consumption-dependent price components, and RTP = 4 consumption-dependent price components). In our experimental setup, the TOU tariff comprises two price components for different times of day. The CPP tariff includes a price component that is activated in the 100 hours with highest load occurring, and the RTP tariff additionally includes a price component that is activated in the 100 hours with highest solar radiation occurring. Table 2 presents the stimuli used in our study.

The participants were asked to imagine that they moved to a different city and were now to select an energy tariff as a new customer. Subsequently, consumers were presented one of the manipulated tariffs from a fictional supplier together with an artificial consumption pattern. The supplier name was fictional to avoid reputation influences of the provider (Homburg et al., 2014). The artificial consumption pattern was necessary to enable consumers to calculate the final billing amount and at the same time control for inter-participant variance in consumption. The artificial consumption pattern (see Table 3) was designed such that in all experimental conditions, based on the average German household consumption of 3500 kWh, the bill amount added up to about €962 per year. Note that this total amount varies slightly across conditions due to our efforts to construct indisputable manipulations of our experimental variables. Still, we argue that all results that will be presented in later sections of this article can be attributed to consumer perceptions of price complexity rather than to differences in the monetary sacrifice of electricity consumption.

4.3. Measurement

Following the presentation of the scenario and the tariff, participants went on to respond to a questionnaire that included the focal variables. All latent constructs were measured on seven-point Likert scales or semantic differentials, using items derived from prior publications in top-tier marketing journals. The items were translated into German and adapted to the focal context. Additionally, perceived bill amount was measured on a single-item scale, asking participants to indicate the overall bill amount per year. Table 4 provides a summary of the measurement and psychometric properties. All multi-item scales were found to be unidimensional and to show high convergent validity (see Table 4) and discriminant validity on the Fornell and Larcker (1981) criterion (see Table 5).

The full survey is available as Supplementary online material.

5. Results

5.1. Analysis of antecedents of perceived price complexity

5.1.1. Findings

We analyzed the data using SPSS 23. We started with manipulation checks for the respective predictors. In the questionnaire, respondents answered the question ("How many different price components per kWh did the tariff comprise depending on the time of consumption?") on a scale anchored 1 and 5. Contrast tests between the four respective tariffs (Standard, TOU, CPP, RTP) indicated that the number of price components was perceived as significantly distinct ($M_{Standard}$ = 2.14 vs. M_{TOU} = 2.45; t = –2.83, p < .01; M_{TOU} = 2.45 vs. M_{CPP} = 2.96; t = –4.65, p < .01; M_{CPP} = 2.96 vs. M_{RTP} = 3.23; t = –2.57, p = .01). Thus, the tariff type manipulation was successful. Furthermore, participants indicated on a seven-point semantic differential scale with the anchors 1 = "definitely even" and 7 = "definitely odd" that the consumption-dependent price components were perceived as having different price endings (M_{even} 3.27 vs. M_{odd} = 5.20; F(1, 662) = 186.20, p < .01). Hence, the price ending manipulation was effective in the intended direction. Last, participants indicated on a seven-point semantic differential scale anchored 1 = "definitely absolute" and 7 = "definitely a percentage" that the discount was presented in a distinct manner (Mabsolute = 2.30 vs. Mpercent = 5.27; F(1, 662) = 412.05, p < .01). Hence, the discount presentation format manipulation was successful.

Prior to further analysis, we split NFC at the median (4.75). Subsequently, we ran a general linear model with perceived price complexity as the dependent variable and tariff type, price ending of consumption-dependent price components, discount presentation format, and NFC as predictors (F(31, 632) = 4.298, p < .001; Adjusted R2 = .134). We found a significant main effect of tariff type (F(3, 632) = 7.626, p < .001) that generally supports H1, indicating that the perceived price complexity increases with more consumption-dependent price components. However, Fig. 2 reveals a somewhat more complex pattern. We explored this pattern using the Ryan-Einot-Gabriel-Welch F post hoc test to identify homogeneous subsets. The test reveals two distinct subsets (p < .05), the first including standard and TOU, and the second including CPP and RTP of which the latter induces a significantly higher level of perceived price complexity.

Second, odd (M_{odd} = 4.38) vs. even (M_{even} = 4.06) price endings of the consumption-dependent price components contribute to a higher perceived price complexity (F (1, 632) = 7.036, p < .01), supporting H2. Third, and in support of H3, we observe that the discount presentation formatted as a percentage (Mpercent = 4.35) leads to a higher perceived price complexity than formatted as an absolute number (Mabsolute = 4.09; F(1, 632) = 4.870, p < .05). Last, albeit not hypothesized, the main effect of NFC (F(1, 632) = 4.253, p < .001) was negative and significant, suggesting that individuals high in NFC generally have a lower perception of price complexity than their low-NFC counterparts.

Table 2

Stimuli.

	Treatment condition	Consumption-dependent price components	Period of occurrence	New subscriber discount[a]	Connection Charge
Standard tariff	1	29.00 cents/kWh	All-day	€133	€80 p.a.
	2	29.43 cents/kWh	All-day	€148	€80 p.a.
	3	29.00 cents/kWh	All-day	165%[b]	€80 p.a.
	4	29.43 cents/kWh	All-day	185%[b]	€80 p.a.
TOU tariff	5	26.00 cents/kWh 34.00 cents/kWh	All-day, except 05 pm–10 pm	€148	€80 p.a.
	6	25.67 cents/kWh 34.44 cents/kWh	All-day, except 05 pm–10 pm	€148	€80 p.a.
	7	26.00 cents/kWh 34.00 cents/kWh	All-day, except 05 pm–10 pm	185%[b]	€80 p.a.
	8	25.67 cents/kWh 34.44 cents/kWh	All-day, except 05 pm–10 pm	185%[b]	€80 p.a.
CPP tariff	9	26.00 cents/kWh 30.00 cents/kWh 90.00 cents/kWh	All-day, except 05 pm–10 pm 100 h/a[c]	€148	€80 p.a.
	10	25.67 cents/kWh 30.17 cents/kWh 94.22 cents/kWh	All-day, except 05 pm–10 pm 100 h/a[c]	€148	€80 p.a.
	11	26.00 cents/kWh 30.00 cents/kWh 90.00 cents/kWh	All-day, except 05 pm–10 pm 100 h/a[c]	185%[b]	€80 p.a.
	12	25.67 cents/kWh 30.17 cents/kWh 94.22 cents/kWh	All-day, except 05 pm–10 pm 100 h/a[c]	185%[b]	€80 p.a.
RTP tariff	13	26.00 cents/kWh 38.00 cents/kWh 18.00 cents/kWh 6.00 cents/kWh	06 am – 05 pm 05 pm–10 pm 10 pm – 06 am 100 h/a[d]	€148	€80 p.a.
	14	25.67 cents/kWh 37.95 cents/kWh 18.93 cents/kWh 6.72 cents/kWh	06 am – 05 pm 05 pm–10 pm 10 pm – 06 am 100 h/a[d]	€148	€80 p.a.
	15	26.00 cents/kWh 38.00 cents/kWh 18.00 cents/kWh 6.00 cents/kWh	06 am – 05 pm 05 pm–10 pm 10 pm – 06 am 100 h/a[d]	185%[b]	€80 p.a.
	16	25.67 cents/kWh 37.95 cents/kWh 18.93 cents/kWh 6.72 cents/kWh	06 am – 05 pm 05 pm–10 pm 10 pm – 06 am 100 h/a[d]	185%[b]	€80 p.a.

Turning to the moderating effects, we find a significant tariff type × NFC interaction effect ($F(3, 632) = 5.799$, $p = .001$). As Fig. 3 depicts, the effect of tariff type depends on whether participants are high or low in NFC. However, the moderation is somewhat different from what we expected. Whereas low-NFC individuals seem to generally perceive all tariffs as relatively high in price complexity, consumers high in NFC perceive the price complexity of the standard and TOU tariff to be lower than the CPP and RTP tariffs. Hence, the effect of tariff type is stronger for high-NFC than for low-NFC individuals. The same post hoc test as before was performed separately for the high-NFC and low-NFC subsamples. In the case of low NFC, all tariff types form one subset in which price complexity does not differ significantly. In case of high NFC, we see two subsets (standard and TOU; CPP and RTP) for which price complexity differs across but not within. All other interaction terms involving NFC are not significant. Still, H4 is not supported.

Table 3

CONSUMPTION PATTERN

ELECTRICITY CONSUMPTION P.A.	Kwh
6 AM – 9 AM	900
9 AM – 5 PM	600
5 PM – 10 PM	1500
10 PM – 6 AM	500
TOTAL	3500

Table 4

Measurement.

Construct	Alpha	IR	CR	AVE	M	SD
Behavioral intentions (7-point semantic differential; adopted from Chandran and Morwitz, 2005)	.92		.93	.76	3.81	1.28
Me choosing the VoltStrom tariff is…						
unlikely / likely		.71				
improbable / probable		.87				
unsure / sure		.60				
impossible / possible		.85				
Perceived price complexity (7-point Likert scale; adapted from Homburg et al., 2014; Ittersum et al., 2010)	.97		.97	.73	4.22	1.60
With that many prices, I had a hard time understanding the VoltStrom tariff.		.74				
I would need to know a lot to understand the VoltStrom tariff.		.64				
The VoltStrom tariff looks very complicated to me.		.76				
It was difficult for me to obtain an overview of the price of the VoltStrom tariff.		.83				
It was tough to calculate the total price.		.77				
It was difficult for me to cope with the single numbers.		.74				
I concentrated a lot to carry out the many different calculations.		.57				
To determine the total costs, you need a calculator.		–[a]				
It was difficult to deal with the VoltStrom tariff.		.87				
I had to concentrate a lot to evaluate the VoltStrom tariff.		.66				
It took a lot of time to evaluate the VoltStrom tariff and to make a decision.		.68				
I had difficulties to keep an overview of the tariff.		.81				
Depth of information processing (7-point Likert scale; adapted from Novak and Hoffman, 2009; reverse coded)	.89		.89	.67	4.40	1.40
I relied on my sense of intuition while evaluating the VoltStrom tariff.		.72				
I trusted my hunches while evaluating the VoltStrom tariff.		.84				
I used my gut feelings while evaluating the VoltStrom tariff.		.81				
I went by what felt good to me.		—[a]				
I relied on my impressions while evaluating the VoltStrom tariff.		.65				
Perceived bill amount (slider reaching from €0 to €2400)	n/a		n/a	n/a	1115	110
Given the consumption pattern, what would be the overall bill amount per year?		n/a				
Thought confidence (7-point semantic differential; adopted from Keller et al., 2002)	.94		.94	.84	4.23	1.38
How confident/ certain/sure are you that your first estimate is correct?						
not at all confident – completely confident		.81				
not at all certain – completely certain		.87				
not at all sure – completely sure		.84				
Need for cognition (7-point Likert scale adopted from Cotte and Wood, 2004; reverse coded)	.81		.81	.52	4.76	1.43
I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.		.42				
I try to anticipate and avoid situations where there is a likely chance I'll have to think in depth about something.		—[a]				
I only think as hard as I have to.		.40				
The idea of relying on thought to get my way to the top does not appeal to me.		.66				
The notion of thinking abstractly is not appealing to me.		.62				
Domain Specific Involvement (7-point Likert scale taken from Coulter et al., 2003)	n/a		n/a	n/a	2.87	1.77
Electricity tariffs fascinate me.						

Table 5

Construct Correlation and Discriminant Validity

	1	2	3	4	5	6
1 Need for cognition	.695					
2 Perceived price complexity	−.450	.854				
3 Depth of information processing	.214	−.395	.820			
4 Behavioral intentions	.024	−.162	−.024	.870		
5 Thought confidence	.223	−.487	.311	.325	.915	
6 Perceived costs	−.075	.104	−.126	−.099	−.003	n/a

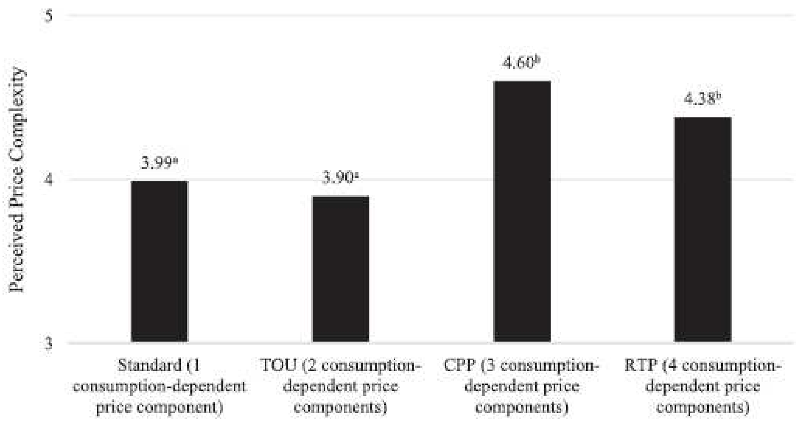

Figure 2: Perceived Price Complexity across Tariff Type. Note: Means marked by the same superscripts form homogenous subsets based on an R-E-G-W-F post hoc test, indicating that the mean differences are insignificant within, but significant across subsets ($p < .05$).

Furthermore, albeit not hypothesized, we find a significant price ending × discount presentation format interaction ($F(1, 632) = 4.253$, $p < .05$), suggesting that the positive effect of percent (vs. absolute) discount presentation format on price complexity appears in cases of even, but not odd price endings. The interaction is depicted in Fig. 4. All other two-way, three-way, and four-way interactions were not significant.

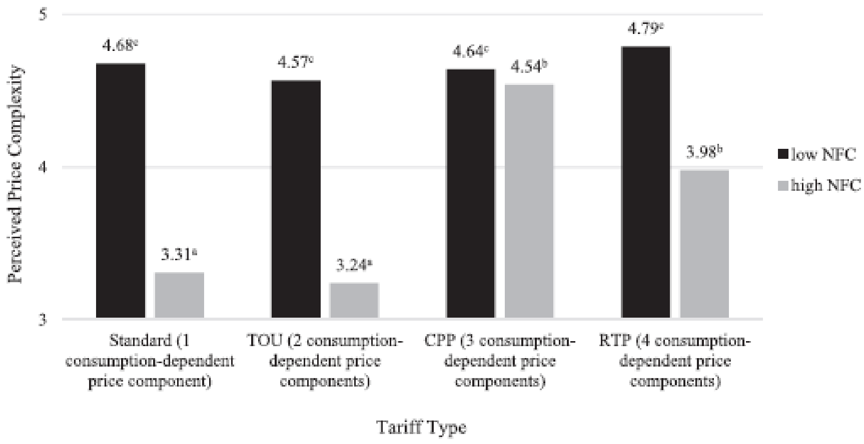

Figure 3: Tariff Type × NFC Interaction Effect. Note: Means marked by the same superscripts form homogenous subsets based on an R-E-G-W-F post hoc test, indicating that the mean differences are insignificant within, but significant across subsets ($p < .05$). The tests are conducted separately for the respective low/high-NFC subsamples.

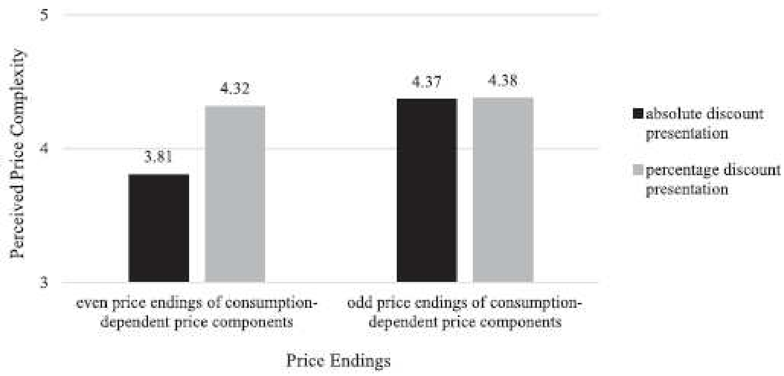

Figure 4: Price Endings of Consumption-dependent Price Components × Discount Presentation Format Interaction.

6. Discussion

With the exception of H4, the data lend support to our rationale that the focal characteristics of dynamic tariffs lead to an increase in perceived price complexity. As Figs. 2 and 3 depict, the tariff type plays a central role in the perception of price complexity. Specifically, we see that CPP and RTP are perceived more complex than the standard and TOU tariffs. We believe that this step-like effect can be explained by the somewhat different nature of the former tariff subset, featuring price components that become effective in peak-load times for which occurrence is hard to anticipate by consumers. This additional cognitive effort then translates into a higher price complexity.

Even though the nature of the tariff type × NFC interaction is different to what we hypothesized, it adds to our understanding of how different consumer segments perceive dynamic tariffs. We expected that cognitive effort-inducing variations in tariff design would to a smaller extent translate into perceived price complexity for high-NFC consumers. Intriguingly, we observe that low-NFC consumers perceive high levels of price complexity for all tariff types. This pattern allows for the interpretation that for low-NFC consumers, the introduction of the presumably more complex dynamic tariffs cannot make matters much more difficult. This finding is consistent with consumers' concerns expressed in focus group interviews that “tariffs may become even more complex than they currently are” (Darby and Pisica, 2013; p. 2329, italics added).

The interaction of price endings of consumption-dependent price components and discount presentation format (Fig. 4) is unexpected.

Specifically, we observe only a difference in perceived price complexity due to a variation of price endings when the discount is framed as an absolute number, but not when it is framed as a percentage. A possible interpretation is that the presence of a percentage number is so salient and effort-inducing that consumers do not more focus on price end-ings. In this way, this interaction speaks for the possibility of a ceiling effect such that at some point, it requires a very substantial increase in cognitive effort to further increase price complexity. This conclusion can also be drawn from Figs. 2 and 3.

6.1. Analysis of consequences of perceived price complexity

6.1.1. Findings

To investigate the consequences of perceived price complexity we carried out a structural equation model (SEM) using AMOS 23. All fit indices were in line with the recommended cutoff-values indicating good fit of the model with the data ($\chi 2/df = 2.658$; GFI = .927; AGFI =.908; CFI = .975; RMSEA = .050). We report standardized path coefficients.

The results show that perceived price complexity has a negative impact on the depth of information processing ($\beta = -.395$, $p < .001$), supporting H5. As hypothesized in H6a and H6b, depth of information processing has a negative effect on perceived bill amount ($\beta = -.102$, $p < .05$) and a positive effect on thought confidence ($\beta = .140$, $p < .001$), respectively. The effect of the perceived bill amount on behavioural intentions was negative and significant ($\beta = -.089$, $p < .05$), supporting H7. Furthermore, thought confidence has a positive effect on behavioral intentions ($\beta = .345$, $p < .001$), supporting H8.

We also assessed whether depth of information processing, perceived bill amount and thought confidence serve as partial or full mediators in the causal chain we propose. The direct effect of perceived price complexity on perceived bill amount is insignificant ($\beta = .062$, $p > .10$), lending support for the key role of depth of information processing. However, perceived price complexity has a significant and negative direct effect on thought confidence ($\beta = -.432$, $p < .001$), suggesting that depth of information processing partially mediates the perceived price complexity-thought confidence link. However, the direct path between perceived price complexity and behavioral intentions is not significant ($\beta = -.049$, $p > .10$). Last, we observe a negative and significant direct effect of depth of information processing on behavioral intentions ($\beta = -.162$, $p < .001$), suggesting that the effect of depth of information processing on behavioral intentions is partially mediated by perceived bill amount and thought confidence. Taken together, we conclude that depth of information processing, perceived bill amount, and thought confidence are the critical constructs linking perceived price complexity with behavioral intentions. The results of the SEM appear in Fig. 5.

6.1.2. Discussion

Before discussing the results from our SEM, it is worth taking a step back and recapitulating the early point we made regarding the unique context of decision-making for consumers when choosing between energy tariffs.

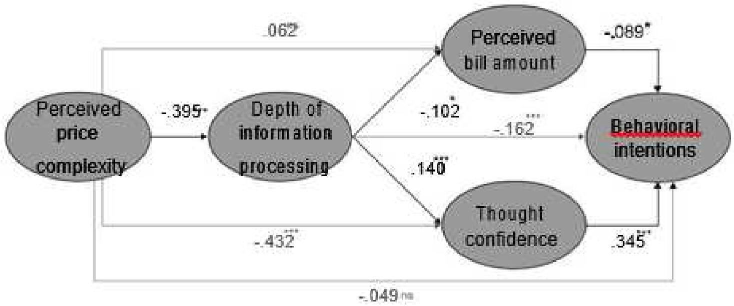

*Figure 5 Structural Results of Consequences of Perceived Price Complexity. p < .05; **p < .01; ***p < .001; ns = not significant*

To motivate the examination of depth of information processing, we argued that, albeit highly relevant for everyone, the focal category evokes only very little consumer involvement. Consequently, we expected that despite the substantial monetary sacrifice (€962), many consumers would lack the motivation to engage in systematic processing once the level of perceived price complexity increases. To support this reasoning, we included a single-item scale for domain-specific consumer involvement in our questionnaire (“Electricity tariffs fascinate me”). On a scale anchored 1 (not at all) to 7 (very much so) the mean in our representative sample was 2.87 (SD = 1.77) and the median was even lower (2.0). This finding reinforces the challenge energy providers and policymakers face when promoting dynamic tariffs in Europe. In this context, depth of information processing, perceived bill amount and thought confidence play important roles in the consumers' tariff evaluation process. As the SEM reveals, our hypotheses are supported. The perception of price complexity first and foremost leads to a decrease in depth of information processing, that is, the likelihood with which consumers apply heuristic processing increases. A so reduced depth of information processing has a twofold effect: the perceived bill amount increases and the thought confidence decreases, both resulting in lower behavioral intentions. It is also worth noting that across all tariffs, consumers overestimate the annual bill amount (M = €1.115, SD = €110) by about €150 or 15.9% on average. This is interesting because seminal research on price partitioning suggests the application of an anchoring heuristic in which the connection charge is used as an anchor that is only insufficiently upward adjusted for the other price components (Morwitz et al., 1998). It could be that in the realm of dynamic tariffs, the connection charge is not perceived as a base price because it contributes relatively little to the final bill amount and hence other price components may be more salient.

The SEM also reveals that the direct path between perceived price complexity and behavioral intentions is not significant, suggesting that the effect is fully mediated by the proposed three mediators. At closer examination of the proposed causal chain, however, we find that the unhypothesized relations between perceived price complexity and thought confidence and between depth of information processing and behavioral intentions are both negative and significant. Concerning the former, perceived price complexity apparently decreases thought confidence by a mechanism other than depth of information processing that is not included in our model. It is possible that consumers who experience price complexity fear being “nickel-and-dimed” by the tariff provider and thus lose faith in their evaluation (Carlson and Weathers, 2008, p. 725). It is also possible that the prospect of behavior change to reduce the bill amount has such an effect, an aspect that is not the focus of our research. Concerning the latter, one could speculate that a higher depth of information processing increases consumers’ awareness for the overall cost of electricity per year. Furthermore, higher depth of information processing may increase consumers’ cost of thinking (Shugan, 1980) which may decrease behavioral intention by a reduced price fairness (Feurer et al., 2015). Clearly, more research is necessary to understand this relationship. Apart from the data suggesting partial mediations in two cases, the effect of price complexity on perceived bill amount is fully mediated by depth of information processing.

7. Conclusion and policy implications

7.1. Contributions

In many countries across the globe, decarbonization efforts are getting off the ground and the share of fluctuating, renewable-based electricity generation is increasing significantly. However, shifts from nuclear and fossil energy sources to renewables bear the challenge of a better alignment of energy production and consumption. Some re-searchers highlight the fact that dynamic tariffs are an important piece in the puzzle, but residential consumers show adverse reactions to their inherent price complexity (e.g., Breukers and Mourik, 2013; Dütschke and Paetz, 2013). In Europe, these tariffs are offered as opt-in options only, and their success ultimately depends on consumers selecting them.

In response, the overarching goal of this study was to better understand how consumers’ perceptions of price complexity are formed and by which processes price complexity in turn shapes behavioral intentions to select a dynamic tariff. Using a large and representative sample of German consumers, our research identifies tariff type, price endings of the consumption-dependent price components and the discount presentation format as well as NFC as important drivers of perceived price complexity. Depth of information processing and perceived bill amount and thought confidence are important variables that mediate the effect of perceived price complexity on behavioral intentions.

In revealing these relationships, our research provides several contributions. First, our research bridges literature streams from several disciplines and demonstrates how an interdisciplinary approach can provide valuable insights into dynamic tariff-choice behavior. In so doing, we contribute to the growing literature on consumer reactions to dynamic tariffs in the realm of DSM (e.g., Dupont et al., 2014; Grünewald et al., 2015; Salies, 2013). Specifically, by illuminating the decision-making process, we add to the young literature stream that specifically adopts a consumer perspective (e.g., Darby and Pisica, 2013; Dupont et al., 2014; Dütschke and Paetz, 2013; Stenner et al., 2015). While this research acknowledges that a tariff should be simple, “most of the evidence comes from focus groups, attitudinal survey and pilots” (Quillinan, 2011, p. 547). With our study, we illuminate how price complexity and cognitive burden affect the decision-making process.

Second, we advance the literature on price complexity (e.g., Homburg et al., 2014; Feurer et al., 2015) that is still in its infancy, and on price partitioning (Carlin, 2009; Greenleaf et al., 2016; Morwitz et al., 1998). For example, while Greenleaf et al. (2016) acknowledge that pricing schemes “have become more complex and sophisticated, often making [the price] more difficult for consumers to accurately process” (p. 107), traditional price partitioning research focuses on simple base-price-and-surcharge situations. Specifically, our research adds to the price complexity and price partitioning literature by examining the special context of dynamic energy tariffs in which prices are highly complex, and the salience of the base price (i.e., connection charge) and of consumer involvement is low. In doing so, we also add to the literature that examines behavioral effects of complex tariff structures (e.g., Lambrecht and Skiera, 2006).

7.2. Limitations

We acknowledge that our research has several limitations that provide avenues for further research. First, our unit of analysis is the individual consumer. While it is possible that in many households the decision for an energy tariff is made by one single individual, prior research assumes a joint decision-making process in many cases (Gottwalt et al., 2011; Wilson and Dowladabadi, 2007). Future research should consider a joint decision-making process and illuminate how this process is affected by differences in family role structure and different decision strategies (Ashraf, 2009; Davis, 1976).

Second, this study is limited by several issues that arise from the nature of our experimental design and procedure. As it is extremely difficult in Europe to observe actual electricity tariff choice behavior in the realm of a field experiment, we relied on a scenario experiment with behavioral intentions rather than actualized behavior as a dependent variable. As such, participants stated preferences in an artificial tariff choice situation. In real life, consumers might be willing to invest more cognitive effort in the evaluation of a dynamic tariff.

7.3. Implications

The results of our empirical study yield several implications. First and foremost, policymakers and managers of power suppliers need to understand that the requirement to offer dynamic pricing as opt-in options has upgraded residential consumers and their perceptions of price complexity to be critical factors. If consumers cannot be convinced to select these tariffs, their potential to contribute to successful decarbonization is likely to be untapped.

To overcome the challenges of perceived price complexity, policy-makers could rethink the opt-in rule and incentivize the introduction of dynamic tariffs as a standard tariff. Alternatively, managers must design very attractive dynamic tariffs that compensate consumers for the inherent complexity. In our view, it must be feared that the needed flexibilization of residential electricity demand may be unrealistic in the current opt-in policy framework. Even a relatively simple two-stage TOU tariff may not overcome the challenges in the future electricity system with high shares of volatile electricity generation. In this light, locally operating aggregators as emerging market players, may have an advantage in that they can better utilize individual flexibilities by achieving a high degree of automatization that is often unnoticed by consumers (e.g., by postponing the charging of electric vehicles during the night). If this potential can be tapped, relatively simple tariffs may be used.

Taken together, all market players need to be aware that tariff design is no longer only a means to the end of price discrimination to maximize profits in the light of heterogeneous demand. Rather, tariff design may contribute substantially to system stability. From a policy standpoint, dynamic tariffs are attractive in that they contribute to grid stability in a relatively timely and cost effective manner (compared to the expansion of the grid itself) and should thus be held in high regard. Hence, system stability, not profitability, should be prioritized.

Our research also helps in understanding the psychological pro-cesses by which consumers perceive and react to the complexity dynamic tariffs imply. When designing dynamic tariffs, managers should first and foremost try to limit perceived price complexity for consumers in ways possible, for instance, by offering absolute dis-counts and even price endings where possible. Given the increased level of perceived price complexity for tariffs that feature price components that become effective in peak-load times, special caution is required. At the same time, if such a tariff is to be offered, the non-linear increase in complexity provides some room for even more complex tariffs because the objective increase in complexity does not lead consumers to perceive price complexity over and above the extent they already do.

Second, tariff design should take into account the special role of NFC. Different tariffs should be offered and communicated such that they meet the tastes of high- and low-NFC consumers, respectively. Simple TOU tariffs with two consumption-dependent price components could be targeted at high-NFC consumers specifically as they are not perceived as more complex than the standard tariff. For those consumers lacking the motivation to process at higher levels of price complexity, two alternatives seem feasible. First, measures could be taken to reduce the cognitive burden (e.g., offering a function on the website that calculates the total bill amount) or to increase consumer involvement and ultimately cognitive motivation (e.g., gamification). Finally, it may be possible to target CPP and RTP tariffs at low-NFC consumers, utilizing the fact that they perceive all electricity tariffs as rather complex in any case.

7.4. Further research

Even though our experimental approach is quasi-standard in marketing research (Bemmaor, 1995), it would be desirable for future research to validate our results by observing real tariff choice behavior. Furthermore, to design a valid manipulation, it was necessary to provide participants with an artificial consumption pattern. However, due to low involvement, consumers may in reality not know about their consumption or may find it difficult to predict their (future) consumption given a particular tariff (Goodman and Irmak, 2013; Nunes, 2000). Future research should investigate the role this difficulty plays for the evaluation of dynamic tariffs. Furthermore, analyzing other forms to incentivize consumers, such as normative drivers or alternative approaches attaching game-like attributes to demand response measures, might be further fields of investigation.

More work also needs to be done to understand which factors lead consumers to overestimate or underestimate the total cost of electricity tariffs. Our research suggests that consumers frequently apply heuristics when evaluating dynamic tariffs but does not illuminate which heuristics were applied.

Last, as always, future research needs to ensure generalizability by replicating and extending our findings with different samples and differently designed dynamic tariffs.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.enpol.2017.02.051

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