PREFERENCES FOR DYNAMIC ELECTRICITY TARIFFS: A COMPARISON BETWEEN GERMANY AND JAPAN

Miwa Nakai, Fukui Prefectural University, miwanakai@fpu.ac.jp
Victor von Loessl, University of Kassel, vonloessl@uni-kassel.de
Heike Wetzel, University of Kassel, heike.wetzel@uni-kassel.de

Overview

Global climate change constitutes one of the greatest challenges in the history of humanity. In order to reach the goals of the Paris Climate Agreement, countries around the world take action to reduce their greenhouse gas (GHG) emissions. To this end, a particular focus is placed on the energy sector, which alone is responsible for three-quarters of global GHG emissions (IEA, 2021). Naturally, rapidly growing shares of renewable energy sources contribute to reducing GHG emissions. However, they also result in more volatile electricity production, which stresses the stability of electricity grids and increases the need for demand side management. In this respect, dynamic electricity tariffs are a frequently discussed policy instrument to balance electricity supply and demand (Dutta & Mitra, 2017). In these tariffs, price signals are used to incentivize shifts in electricity consumption into more favourable time zones. Thereby, dynamic pricing schemes not only support grid stability, but also reduce the demand for peak capacity, and foster the integration of renewable energy sources. Although many benefits are associated with dynamic electricity tariffs, residential consumers typically prefer constant electricity prices (e.g. Ruokamo, 2019; Yoshida et al., 2017; Buryk et al., 2015; Dütschke & Paetz, 2013).

To identify acceptance barriers as well as possible ways of overcoming them, we empirically examine a stated choice experiment on dynamic electricity tariffs. In particular, our experimental design allows disentangling two central tariff characteristics, namely the intra- and interday frequency of price adjustments. Our analysis relies on two representative household surveys, conducted in Germany and Japan, respectively. Each survey constitutes a baseline and a treatment group, with the latter receiving additional information regarding the environmental benefits of dynamic tariffs. Next to analyzing country differences and treatment effects, we explore determinants, such as socio-demographic characteristics as well as economic preferences, of the general acceptance level for dynamic tariffs.

Methods

In both surveys, our sampling strategy follows a two-stage approach. First, professional research companies recruited respondents according to quotas for age, gender, education and inhabited area. Second, only those participants, who indicated to be involved in their households' decision making, were allowed to proceed the survey. Our samples are thus representative for household decision makers. We restrict them in such a way, in order to increase the reliability of our results. After excluding those who failed at any of the quality and attention checks, we have 1,059 and 2,682 observations based on the German and Japanese survey, respectively.

Our questionnaire mainly consists of four parts. Firstly, we elicited respondents' individual attitudes, traits, and values. The second part addressed respondents' current electricity tariff as well as their electricity consumption behaviour. In the third part, respondents answered six subsequent choice tasks on dynamic electricity tariffs. Finally, we elicited socio-demographic characteristics. The electricity tariffs shown in our choice experiment are characterized by six attributes. Table 1 summarises each attribute and the corresponding attribute levels.

Table 1: Overview of attributes and levels

Attribute	***Levels***			
Number of time zones	2 (base)	4	12	24
Price update	Yearly (base)	Monthly	Weekly	Daily
Potential savings (shown in Euro or JPY)	5% of your current electricity bill per month	10% of your current electricity bill per month	15% of your current electricity bill per month	
Necessary shift of consumption	0%	5%	10%	15%
Cap for additional costs (shown in Euro or JPY)	At maximum 5% higher than in your current contract (base)	At maximum 10% higher than in your current contract	At maximum 15% higher than in your current contract	No cap for additional costs
Data utilization	Charging only (base)	Charging and data analysis	Charging, data analysis, and shared with third parties	

To the best of our knowledge, we are the first to disentangle the *number of time zones,* which indicate the number of price changes within a day, and the frequency of *price updates,* which indicate how often the electricity price is updated in general. Both are essential determinates of the potential pro-environmental impact of dynamic tariffs, as they determine how well a tariff can reflect actual market situations. In general, high shares of renewable electricity production are associated with low spot market prices, due to almost zero marginal production costs. Therefore, we provided the treatment group with the following additional information: "*Dynamic electricity tariffs promote the consumption of low-priced renewable electricity. On the one hand, this reduces CO_2 emissions, and on the other, it lowers the costs of system stability. The more price zones and the more frequently the prices are updated, the better a tariff can reflect the current market situation and the greater the benefit for the environment and the energy system.*"

To get first insights into respondents' choice behaviour, we use a tobit regression model to investigate how often they choose any of the three dynamic tariffs over the status quo alternative. Furthermore, we use probit regression models to analyse determinants of the likelihood to either 'always' or 'never' choose a dynamic tariff. In order to address the central aim of this paper, we then analyze the stated choice experiment in more detail. To this end, we conduct a 2x2-split sample (country x treatment) analysis using mixed logit regression models. Based on the complete combinatorial test, suggested by Poe et al. (2005), we can compare estimated willingness to accept (WTA) values for all attributes or attribute levels across countries and treatment groups.

Results

As the first step, we investigate the determinants of respondents' general acceptance of dynamic electricity tariffs and potential differences between Germany and Japan. Our estimation results suggest that respondents, who have greater environmental attitudes, who indicate a higher level of trust, and who are generally more risk-seeking, more patient and married are more likely to choose a dynamic tariff, compared to the corresponding counterparts. Furthermore, we detect almost no significant differences between the German and the Japanese sample. However, the positive correlation of being married and the frequency to choose a dynamic is significantly less pronounced among Japanese respondents, as is the effect of the indicated level of trust.

To answer our main research question, we conduct a 2x2-split sample analysis based on the stated choice experiment and compare estimated WTA values across countries and treatments. First, we summarize the estimation results based on the mixed logit regression models for the baseline groups of both countries:

Intuitively, the estimated coefficients for *potential savings (necessary shifts of consumption)*, are positive (negative) in both countries, indicating that respondents prefer (avoid) tariffs, which yield greater financial savings (require greater shifts in electricity consumption). Furthermore, our results indicate that people appreciate price caps to eliminate the risk of additional costs and tend to avoid tariffs, which utilize the electricity consumption data not only for the purpose of charging, but also for data analysis and sharing such information with the third parties. These findings are rather similar across the two countries. On the other hand, the results with respect to the *number of time zones* and *price update* are significantly different. While we find no significant preferences in the Japanese sample with respect to the different numbers of time zones, German respondents have a strong aversion against hourly price changes. Similarly, the more frequent the price is updated, the greater is the aversion of German respondents towards the corresponding tariff. In contrast, Japanese respondents actually prefer monthly price changes to annual ones, and only tend to avoid daily price updates.

By comparing the estimated WTA values using the full combinatorial test suggested by Poe et al. (2005), we confirm that the described differences across the two countries are statistically significant. Furthermore, this procedure allows us to analyse potential treatment effects. In particular, German respondents who received the environmental information need significantly less additional savings in order to accept weekly or monthly price updates, compared to the respondents from the baseline group. For the Japanese sample, we see the same trend; however, the corresponding treatment differences are not statistically significant.

Conclusions

We conducted two representative household surveys in Germany and Japan to examine preferences and acceptance barriers towards dynamic electricity tariffs. Our unique experimental design allows to disentangle inter- and intraday price changes, which are two central determinants of the benefits associated to dynamic tariffs. Our results indicate that households in Germany and Japan need significant compensation in order to accept frequently changing price patters. However, this tendency is significantly stronger for the German sample, indicating that Japanese households are more willing to accept dynamic tariff. Interestingly, we find that our respondents do not mind several price adjustments during a day, with the only exception of German respondents, who disapprove hourly changing prices. This suggests that as long as price patterns are known and fixed for a long period, respondents do not mind tariffs with several price zones. Such Time-of-Use tariffs therefore seem capable to overcome households' adoption barriers and thus might partially unlock the benefits associated to dynamic electricity tariffs.

Furthermore, environmental information can help to decrease households' aversion against frequent price adjustments, which could further promote dynamic electricity tariffs. Since providing additional information is typically inexpensive, this can be a highly cost-effective policy instrument to increase households' preference towards dynamic electricity tariffs.