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On the relevance of economic preferences, values, norms, and socio-demographics for electricity consumption

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Abstract

As long as electricity is generated from fossil fuels, the reduction of its consumption is an important direction for climate protection and related policy measures. Based on data of more than 3700 respondents in Germany, we thus empirically examine the relevance of a large set of well-known determinants of electricity consumption such as household and dwelling characteristics, but also of individual values and norms. Since behavioral economics highlights the importance of economic preferences in such public good contexts, we additionally consider risk and time preferences, trust, altruism, and reciprocity in our econometric analysis. With respect to the latter group of factors, however, only time preferences have a strong significant effect on electricity consumption. Furthermore, norms also play only a minor role. In contrast, our estimation results suggest a high relevance of dwelling characteristics and socio-demographics. Interestingly, it seems that a low electricity consumption is no important climate protection activity of German inhabitants with strong environmental values, which is in contrast to the demand of such citizens for green electricity.

JEL classification: C21, Q41, Q54

Keywords: electricity consumption, economic preferences, individual values, social norms, econometric analysis

1. Introduction

The use of electricity is a substantial component of household consumption and expenditures. The average German household, for example, consumed about 2,800 kilowatt hours in 2018 (e.g. BDEW, 2019), while paying a price of about 30 Eurocent per kilowatt hour, which is the highest price in the European Union after Denmark (e.g. Bundesnetzagentur, 2019). While almost every person is using electricity, only a few people know the costs of a unit of electricity. For example, Blasch et al. (2017) find that only 27% of the respondents in their Swiss sample knew the average price of electricity and Brounen et al. (2013) report that just 47% in their Dutch sample knew their monthly charges for electricity consumption. Another fact showing the low interest in electricity as consumer good is that about 70% of the consumption of German households is provided by basic suppliers and only about 10% of German households changed their electricity supplier in 2018 (e.g. Bundesnetzagentur, 2019). However, as long as electricity is generated from fossil fuels, the consumption of electricity leads to substantial CO₂ emissions and thus contributes to climate change. Besides switching to renewable energy sources (e.g. wind energy, solar thermal energy), a possibility for private households to limit the contribution to climate change is the reduction of electricity demand.

However, the low interest in the topic leading to close to zero price elasticities for electricity raise doubts about the effectivity of price-based policy interventions like electricity taxes (e.g. Werthschulte and Löschel, 2019; Frondel and Kussel, 2019). Besides command and control regulations (e.g. the prohibition of traditional light bulbs), voluntary programs encouraging the reduction of electricity consumption are thus a possible policy direction. Against this background, several field experiments examine the effects of smart meters in order to motivate reductions in electricity consumptions (e.g. Houde et al., 2013; Jessoe and Rapson, 2014; Carroll et al., 2014). In addition to real time feedback, also other measures that increase the salience and information on electricity consumption are tested such as social comparisons, commitment devices, goal setting, and labeling (see e.g. Andor and Fels, 2018, for a review of empirical studies on causal effects of energy conservation interventions). Real world examples are specific public information campaigns for electricity conservation or also private initiatives such as the German “electricity savings check” (“Stromspar-Check”, www.stromspar-check.de) or the “electricity saving initiative” (“Stromsparinitiative”, www.die-stromspar-initiative.de). However, Aydin et al. (2018) found for a Dutch sample that electricity reductions due to such interventions especially arise in households already interested in economic use of electricity beforehand. A necessary condition for the effectiveness of such programs is therefore a deeper knowledge of factors that determine electricity use.

While there is a great extent of empirical analyses on the influence of dwelling, household, and socio-economic characteristics on electricity consumption, studies on determinants beyond technical and structural characteristics are rather restricted. Previous studies show that the electricity consumption (per capita) increases with dwelling size and is, on top of that, higher for households living in houses compared to apartments and also higher for homeowners compared to tenants (e.g. Thøgersen and Grønhøj, 2010; Chong, 2012; Brounen et al., 2012; Costa and Khan, 2013; Blasch et al., 2017; Frondel and Kussel, 2019). Considering household characteristics, it is shown that electricity consumption increases with household size and varies with household composition, for example, households with elderly people consume more electricity per capita, while households with small children consume less (e.g. Brounen et al., 2012; Blasch et al., 2017; Frondel and Kussel, 2019). Results on socio-economic characteristics show that electricity consumption (per capita) is increasing with household income as well as age and that females as well as highly educated persons consume less electricity (e.g. Brounen et al., 2012; Blasch et al., 2017; Frondel and Kussel, 2019).

Beyond those factors, only a few studies consider further determinants such as individual values, social norms, or economic preferences that generally play an important role for a large range of individual behavior like educational attainment, smoking behavior, donations, and being in a relationship (e.g. Falk et al., 2018). Werthschulte and Löschel (2019) report, for example, that present biased individuals consume more electricity compared to time-consistent individuals. Costa and Khan (2013) reveal a strong effect of political identification on electricity use in the United States, namely that households in liberal communities consume less electricity compared to households in conservative communities. Broadening the scope from electricity consumption to general energy related behavior, empirical studies stress the relevance of economic preferences. Volland (2017) shows that energy consumption is negatively related to trust and risk aversion. Fischbacher et al. (2015) additionally reveal that future oriented and pro-environmental homeowners consume less energy. Studies examining energy efficiency measures, for example, investments in highly efficient appliances or energetic restoration of dwellings, show that less risk averse and future-oriented individuals are more likely to invest in energy efficiency (e.g. Schleich et al, 2019; Newell and Sikamäki, 2015; Fischbacher et al., 2015; Qui et al., 2014). Studies examining electricity contract switching also found evidence for influences of economic preferences. Schleich et al. (2018) find on the basis of data from a European large-scale survey that risk seeking and future-oriented individuals are more likely to have changed their electricity contracts in the past 10 years and Ziegler (2018) shows that future-oriented individuals with higher levels of trust

and altruism are more likely to switch to a green electricity contract in Germany. In addition, these studies also reveal that environmental awareness positively affects the different energy behaviors and that political preferences influence energy related behavior as well (e.g. Fischbacher et al., 2015; He and Reiner, 2017; Schleich et al., 2018; Ziegler, 2018).

While these findings show that economic preferences and individual values are important determinants of behavior in the context of residential energy, it is not clear if the same patterns apply to residential electricity consumption, for example, due to its unconsciousness or differences in the degree of visibility to the social environment. Furthermore, the interesting insights on economic preferences, environmental awareness, and political orientation had been included mostly isolated so far. What is missing is research on the interactions between all of these insights and the standard arguments for electricity consumption (e.g. dwelling and household characteristics). This is extremely important as the fragmentation of explanatory variables may lead to the problem of omitted variable bias since the explanatory variables are probably highly correlated with each other as shown for environmental awareness and altruism, reciprocity, and trust (e.g. Ziegler, 2019), income and time preferences (e.g. Golsteyn et al., 2014), age, gender, and cognitive skills with risk, time, and social preferences (e.g. Falk et al., 2018). This is also true for economic preferences themselves. For example, Albanese et al. (2017) show with survey data from Italy and Germany that risk and time preferences are highly correlated with trust. Furthermore, Dohmen et al. (2008) provide evidence based on German survey data for a positive relationship of trust and reciprocity (see Burks et al. (2009) and Dean and Ortoleva (2019) for a detailed investigation of the correlations of different economic behaviors.

We therefore contribute to the literature by an empirical analysis of the determinants of electricity consumption based on data from a representative web-based survey among 3705 German households. Our econometric analysis includes a large set of relevant variable groups, i.e. dwelling characteristics, socio-demographics, and individual values (e.g. political identification, environmental preferences, and religious affiliation) in order to avoid distorted estimation results due to omitted variable biases. In addition, it also includes six key economic preferences, i.e. social and time preferences, trust, risk preferences, positive and negative reciprocity. The latter four factors are measured by experimentally validated questions. The inclusion of artefactual field experiments allow the measurement of social preferences (based on a dictator game) and time preferences. In contrast to previous studies, we additionally analyze psychological motives like feelings of warm glow and social norms. Furthermore, due to our

survey strategy that asked respondents to have their electricity bill at hand for participating in the survey, we derived more trustworthy values for household electricity consumption.

Our estimation results show that beyond household and dwelling characteristics only time preferences highly significantly influence electricity consumption, i.e. respondents who are more patient consume less electricity. In addition to that, electricity use is lower for respondents with a conservative or social political orientation. Interestingly, environmental values do not reveal to be important for electricity consumption, but respondents who feel responsible for environmental protection consume, contradicting to our expectations, more electricity. However, this effect depends on the strength of responsibility. Overall, our findings can help in the design of public information campaigns, but also to increase the efficiency of private initiatives targeted on reductions in residential electricity use.

The paper proceeds as follows: Section 2 gives a description of the data and introduces the variables and methods used for the econometric analyses that is presented in Section 3. Section 4 provides a discussion of the preliminary results as well as first policy implications.

2. Data and variables

2.1. Data

To investigate the relationship between economic preferences, individual values, dwelling, and individual characteristics and residential electricity consumption, data for our empirical analysis was gathered by means of a large-scale computer-based survey in cooperation with the professional market research company Psyma in June and July 2016. The questionnaire included questions on the electricity consumption of the household, on economic preferences, on personal values and attitudes (including two incentivized experiments¹), on socio-economic characteristics of the respondents and their households and a stated choice experiment that is, however, not considered in this paper. The median time needed for the completion of the survey was about 28 minutes. In total, 3705 German citizens from a Psyma Panel participated in the survey. To obtain qualified responses, only respondents who were involved in the decisions on the households' electricity plan were selected for the survey. In order to include all relevant population groups, the sample was stratified in terms of age, gender, place of residence, and religious affiliation so that it is representative for the German population for

¹ For both experiments we informed the respondents that about 1% of them were randomly selected to be paid, respectively. Furthermore, we informed them that the winners are notified after the survey and that the Euro amount is credited in bonus points on their account as member of the Psyma panel.

these criteria.² 85 respondents were not able to provide the name of their electricity tariff or provider. Therefore, information on their electricity mix is not available such that we exclude them from our main analysis such that the estimation sample consists of 3620 respondents. We do, however, consider different model specifications as robustness tests, also including model specifications that are based on the total sample.

One rather problematic issue when dealing with residential consumption is that total consumption depends not only on one but on all individuals belonging to the household. Some studies rely on findings on intra-generational transmission of attitudes and related fields of research (e.g. Dohmen et al., 2012) and therefore aggregate values across household members for individual preferences (e.g. Volland, 2017; Lange et al., 2014). Other studies built on psychological literature, assuming that it is sufficient to instrument the distribution of attitudes and preferences within the household by information on one representative household member (e.g. Sapci and Considine, 2014; Abrahamse and Steg, 2009). We follow the latter approach using one member of the household who is involved in the decision making process related to choices in the electricity sector as representative for all household members. Table 1 reports the means and standard deviations of the variables used in the econometric analysis.

2.2 Measure of electricity consumption

The dependent variable of this study is the natural logarithm of the energy consumption reported in the last electricity bill of the respondents, i.e. in the year preceding the survey. The questionnaire contained a section³ on residential electricity consumption³ in which respondents were asked to take their last year's electricity bill at hand and to fill in the exact number of the electricity consumption of the household in kilowatt hours in the last year as well as the exact value of the total net invoice account of the electricity cost. This procedure was extremely important with respect to data reliability as e.g. Blasch et al. (2017) and Brounen et al. (2013) report that knowledge about electricity prices or monthly electricity cost is rather low. The questionnaire included a description where the information could be most probably found in the electricity bill. After filling in the electricity consumption and cost, respondents were asked to align their entries with their electricity bill again. We used two validity checks to secure reliability. First, we screened out respondents who stated to consume less than 500 kilowatt hours or more than 12.000 kilowatt hours a year. In addition, we screened out re-

² However, this sampling strategy can lead to deviations for other criteria, for example, to an overrepresentation of high education.

³ Respondents were asked to refer to their main dwelling if they had several residences.

spondents, whose ratio of electricity cost in Euro and electricity consumption in kilowatt hours was lower than 0.20 Euro or larger than 0.50 Euro. The range is chosen based on the distribution of households' electricity prices in 2016 (Bundesnetzagentur, 2016)⁴. In a follow up question, respondents could upload their anonymized electricity bill to prove that they typed in the correct values. 321 respondents uploaded their bill. The market research company double checked their imputations and corrected the values if necessary. The mean household electricity consumption across all 3705 respondents was 2826.51 kilowatt hours, leading to average total electricity costs per household of 795.95 Euros and an average electricity price of 29.43 Eurocents as shown in Table 2. In 2016, the average price for households with an annual consumption of 2.500 to 5.000 kilowatt hours was 29.80 cents per kilowatt hour (Bundesnetzagentur, 2016). Therefore, our sample fits the total population with respect to electricity prices.

For the econometric analysis, we consider the natural logarithm of three different specifications of electricity consumption. The first specification is the residential electricity consumption in kilowatt hours. The second specification weights residential electricity consumption by household size such that we divide the total electricity consumption of the household by the number of persons living in the household (electricity consumption per person). In the third specification, residential electricity is weighted by household composition using OECD weighting (equivalent household electricity consumption).⁵

2.2 Measures of economic preferences and psychological motives

Particular attention was given to measures variables reflecting economic preferences, i.e. risk aversion, patience, reciprocity, altruism, and trust. The measures are described in detail in the following.⁶ Time preferences are measured with the help of an incentivized intertemporal choice experiment. Respondents had to decide 12 times in a row whether they wanted to receive 80 Euro in one month or a higher amount ranging from 80 to 108 Euros in seven months if they belong to the winners in the lottery (e.g. Fischbacher et al., 2015). Table 3 shows the choice table of the time preference experiment. For the econometric analysis the minimum

⁴ Bundesnetzagentur (2016) reports averages and distributions of household electricity prices for different consumption levels. The highest price of 50.38 Eurocents stems from basic supply contracts with an annual consumption of less than 1.000 kWh. The lowest price of 23.61 Eurocents stems from a contract with a non-regional electricity supplier and an annual consumption of 5,000 to 10,000 kWh.

⁵ The first adult in the household is weighted with the factor one, further household members older than 14 years are weighted with the factor 0.5 and children younger than 14 years are weighted with the factor 0.3.

⁶ The described survey questions on risk preferences, trust, and reciprocity are frequently applied in large scale surveys such as German Socio-Economic Panel and the General Social Survey and analyzed in various empirical studies (e.g. Dohmen et al., 2008, Fischbacher et al., 2015, Jäger et al., 2010).

discount factor was calculated in line with Fischbacher et al. (2015) by dividing the amount in one month by the amount in seven months at which the respondent has chosen the payment in seven months for the first time. Therefore, a higher minimum discount factor indicates that a person is more patient. The minimum discount factor in our sample ranges between 0.74 and 1 with a mean of 0.86. The detailed frequencies of the minimum discount factors are reported in Table 4.

Risk aversion is measured using a validated survey question (e.g. Dohmen et al., 2011; Vieider et al., 2015; Falk et al., 2016, 2018). Respondents were therefore asked how willing they are generally to take risks on a five-point scale with the response categories “not at all willing to take risks”, “rather not willing to take risks”, “undecided”, “rather willing to take risks”, and “very willing to take risks”. For the econometric analysis, we construct the dummy variable “risk preference” that takes the value one if the respondent indicated to be rather or very willing to take a risk. 28% of respondents are willing to take a risk in our sample.

Altruism is measured by means of an incentivized dictator game in which the respondent had to allocate the amount of 100 Euro in steps of 10 Euros between herself and another randomly selected respondent in the case they belong to the winners in the lottery (e.g. Fischbacher et al., 2015). Table 5 shows the choice table in the social preferences experiment. The higher the amount allocated to the other respondent, the stronger the altruism of the allocating respondent. Table 6 reports the detailed frequencies of the allocations. 45% of respondents transferred 50 Euros to the unknown respondent. For the econometric analysis, we consider the continuous variable “altruism” which is the amount that is allocated to another person divided by 100. Therefore, the variable ranges between 0 and 1 with a mean of 0.34.

Trust is measured by the following experimentally validated survey questions (e.g. Fehr et al., 2003): “In general, one can trust people”, “these days you cannot rely on anybody else”, and “when dealing with strangers, it is better to be careful before you trust them”. The respondents indicated their agreement to these statements on a symmetric scale with the five ordered response categories “totally disagree”, “rather disagree”, “undecided”, “rather agree”, and “totally agree”. We assigned integers from one to five for the first item and decreasing integers from five to one for the two latter items. Thus, higher values indicate higher levels of trust. For the econometric analysis, we construct the variable “trust” as an index that adds the values across the three items. Therefore, the trust index ranges between 3 and 15 with a mean value of 8.16.

Reciprocity is measured by the help of two aspects of the Personal Norm of Reciprocity questionnaire (e.g. Perugini et al., 2003), namely positive and negative reciprocity. The indicator for positive reciprocity is based on the stated agreement to the following statements: “If someone does me a favor, I am ready to return it”, “I go out of my way to help somebody who has been kind to me before”, and “I am ready to undergo personal costs to help somebody who helped me before”. The indicator for negative reciprocity is based on the stated agreement to the following statements: “If I suffer a serious wrong, I will take revenge as soon as possible, no matter what the costs”, “if somebody puts me in a difficult position, I will do the same to him/her”, and “ if somebody offends me, I will offend him/her back”. The respondents stated how strongly they agree with the statements the five-point scale also used for the measure of trust. The two indices sum up the corresponding three ordinal statements. Therefore, they range between 3 and 15. Higher values indicate higher levels of reciprocity. Table 2 shows that the mean for positive reciprocity is 12.72 and for negative reciprocity it is 10.51.

In contrast to previous studies, we additionally consider psychological motives, namely social descriptive as well as injunctive norms, leading by example, a feeling of responsibility, warm glow, and the freerider rational. The measure for the psychological motives is borrowed from Schwirplies and Ziegler (2016) and are based on the agreement on our five-point scale to the following statements: “Society expects me to contribute to environmental protection” (injunctive norm), “I feel responsible to contribute to environmental protection” (feeling of responsibility), “I contribute to environmental protection to be a role model” (leading by example), “I have a feeling of warm glow if I contribute to environmental protection” (warm glow), “my social environment (friends, family, colleagues) contribute to environmental protection” (descriptive norm), and “others, who do not contribute to environmental protection, benefit from my contribution to environmental protection” (freerider rational). In the empirical analysis, the psychological motives are considered as dummy variables taking the value one if respondents rather or totally agree to the corresponding statement. Table 2 shows that about one half of respondents agree to the statements on the injunctive and descriptive norm, as well as leading by example and the freerider rational, 73% of respondents have a feeling of responsibility for environmental protection and feel warm glow through environmentally friendly actions. The detailed frequencies of answers are reported in Table 7.

2.3 Measures of individual values

Environmental awareness is measured with the New Ecological Paradigm (NEP) scale (e.g. Dunlap et al., 2000) that is increasingly used in economics (e.g. Fischbacher et al., 2015, Ziegler, 2019). In line with Whitmarsh (2011), the indicator is based on the following six statements: “Humans have the right to modify the natural environment to suit their needs”, “humans are severely abusing the planet”, “plants and animals have the same right to exist as humans”, “nature is strong enough to cope with the impacts of modern industrial nations”, “humans were meant to rule over the rest of nature”, and “the balance of nature is very delicate and easily upset”. The respondents indicated how strongly they agree with these statements based on our five-point scale. We assigned increasing integers from one to five for the three environmentally positively worded statements and decreasing integers from five to one for the three environmentally negatively worded statements and added up the values in order to build the variable “environmental awareness” for the econometric analysis. Therefore, our indicator varies between 6 and 30 with a mean of 24.18.

Political orientation is measured with the four following statements in line with Ziegler (2017): “I identify myself with conservatively oriented politics”, “I identify myself with liberally oriented politics”, “I identify myself with socially oriented politics”, and “I identify myself with ecologically oriented politics”. Respondents indicated their agreement on the five ordered response categories “totally disagree”, “rather disagree”, “undecided”, “rather agree”, and “totally agree”. For the econometric analysis, we construct the four dummy variables “conservative identification”, “liberal identification”, “social identification”, and “ecological identification” that take the value one if the respondent indicated rather or totally agree. While 64% of respondents identify themselves with social oriented politics and 49% with ecological politics, only 34% identify themselves with liberal politics and 22% with conservative politics. For religious affiliation, respondents indicated their official membership to a religious group, e.g. to the Roman Catholic Church, to Protestant Churches, to Islam, to other religious communities, or whether they have no religious affiliation. In order to avoid confounding effects by several religious affiliations, we construct the dummy variable “no religious affiliation” that takes the value one if a respondent does not belong to any religious group, which is the case for 35% of the respondents.

2.4 Dwelling characteristics, household and socioeconomic characteristics

Regarding the household composition and socioeconomic characteristics, our data set includes information on the number of adults and the number of children younger than 14 years. Furthermore, we capture sex, age in years, level of education and health status of the respondent as well as the monthly net household income in Euro. The dummy variable “female” takes the value one if the respondent is a women, the dummy variable “healthy” takes the value one if the respondents is rather or very healthy while the dummy variable “high education” takes the value one if the highest level of education is at least a bachelor’s degree. In line with the three specifications of electricity consumption, we are using the logarithm of the three corresponding specifications for net household income, i.e. either the reported value, the value divided by household size, or the value weighted by the household composition using the OECD scale in the econometric analysis.

Furthermore, dwelling characteristics are described by a dummy indicating whether the dwelling is rented or owned, a dummy indicating whether the dwelling is a house or an apartment, and the living space in square meters (which is also considered in the three specifications considered for the dependent variable and described above). Two other binary variables capture whether the household uses electricity for heating and water heating. Since it can be expected that relocations are related to a major replacement of old appliances, we also consider a dummy variable indicating that the respondent has changed her primary residence within the last ten years. Unfortunately, further information on the appliance stock is not available⁷. On top of that, we also consider a dummy indicating if the consumed electricity has been produced by renewable energies. The dummy variable Eastern Germany indicates if the dwelling is located in the new federal states including Berlin. It is extremely important to consider those control variables when including economic preferences as previous studies revealed strong correlations with them, e.g. Falk et al. (2018) showed that women are less patient and more risk averse than men, that higher cognitive skills are related to higher time, risk, and social preferences, and that all economic preferences underlie age patters.

⁷ For an analysis of differences in electricity consumption due to appliance stocks see e.g. Frondel et al. (2019).

3. Preliminary econometric analysis

Table 8 reports OLS estimations in three log-linear regression models based on different specifications of our dependent variable.⁸ The results across the three specifications are qualitatively robust such that we will concentrate our interpretation on our preferred specification using equivalent measures for electricity consumption, household net income and flatsize. The table reveals that the estimated parameters for the included economic preferences and psychological motives are not significantly different from zero with two exemptions. People, who are more patient consume highly significantly less electricity while respondents who feel responsible for environmental protection consume significantly more electricity. The latter relationship is, however, only significant on the 10% level. An increase of 0.1 of the minimum discount factor results in a decrease of equivalent electricity consumption by 2.03%. If a respondent feels responsible for environmental protection her electricity consumption is 3.7% higher compared to a person who does not or is undecided. The effect of time preferences is in line with previous findings, e.g. of Fischbacher et al. (2015) or Werthschulte and Löschel (2019), who try to explain the effect by the fact that the payment and consumption of electricity is temporally detached. Another possible explanation for this result is that patient citizens are more likely to invest in energy efficiency measures (e.g. Newell and Siikamäki, 2015; Schleich et al., 2019). The counterintuitive result for the feeling of responsibility points out that electricity consumption might not be considered as a sustainable or environmentally friendly behavior in Germany. However, if we have a closer look on the variable, e.g. by including dummy variables for the single answer categories, we find that the effect depends on the selected base category.⁹ If a dummy for respondents who feel very responsible is included instead of the dummy for respondents who feel rather and very responsible, the effect is highly significantly negative. Therefore, only respondents with a high level of responsibility consider electricity consumption as sustainable behavior. This pattern could be also related to the distribution of the feeling of responsibility in our sample. Table 7 shows that, 48% of respondents feel rather responsible while about 25% of respondents feel very responsible. 19% of our respondents are undecided and only about 8% do rather or totally disagree with the statement. This indicates that perceived responsibility to contribute to environmental protection is high in Germany such that the inconspicuous difference between feeling rather or very responsibility makes a large difference for sustainable behavior.

⁸ All estimations (and all descriptive statistics discussed above) were conducted with the statistical software package Stata.

⁹ Results are not reported due to brevity but are available upon request.

Regarding individual values, neither environmental awareness nor ecological identification show any significant influence on electricity consumption while those variables have regularly been shown to influence pro-environmental attitudes and behavior (e.g. Fischbacher et al., 2015; He and Reiner, 2017; Schleich et al., 2018; Ziegler, 2018). This result supports the explanation, introduced in the previous paragraph, that electricity consumption might not be considered as sustainable behavior. Surprisingly, a conservative and social policy identification of the household head leads to a significantly lower equivalent electricity use. However, the latter effect is only significantly different from zero on the 10% significance level. If a respondent has a conservative or social political orientation, the electricity consumption is about 3% lower. The estimated parameter for religious affiliation is not significantly different from zero. These results are robust to several robustness check in which e.g. either environmental awareness or political orientations had been included as explanatory variables in order to check for potential problems due to multicollinearity.

Our result support previous findings on the high relevance of household composition, socio-economic and dwelling characteristics. The more people are living in a household, the higher is its electricity consumption. An additional adult increases household electricity consumption by 19.1% while an additional child increases consumption by 10.2%. Considering the per capita consumption, we learn that shared habitation is recommended in order to reduce electricity consumption as basic service can be used jointly. These effects are considered by the consideration of equivalent electricity consumption which is therefore our preferred specification of our dependent variable. Older respondents consume statistically more electricity. An increase of age by 10 years leads to an increase of electricity consumption by 4%. Females consume about 4% less electricity and respondents with a high level of education consume 6.6% less electricity. An increase of the equivalent household income by 1% increases electricity consumption by 0.04%. The main determinants of electricity consumption are, however, dwelling characteristics. Households living in a house instead of an apartment, in larger dwellings, in dwellings with electric heating or water heating consume significantly more electricity. Respondents who relocated in the last 10 years and therefore might have updated their appliance stock consume about 8% less electricity. Respondents from the eastern part of Germany have a 8% lower electricity consumption compared to respondents from the western part of Germany. There is no hint on an effect of owning or renting a dwelling on electricity consumption. Interestingly, there is also no hint on a difference in electricity consumption between households that have chosen an electricity contract guaranteeing that electricity had been produced by renewable energies only, i.e. their electricity consumption is free of green-

house gas emissions which would have been a potential explanation for the non significant effect of environmental attitudes for electricity consumption.

4. Discussion and preliminary policy implications

This paper empirically examines the factors related to household electricity consumption. The econometric analysis with more than 3700 observations includes a large set of explanatory variables such as dwelling characteristics and socio-demographic characteristics and specifically focuses on economic preferences, psychological motives and individual values. We find that beyond household and dwelling characteristics only time preferences, a feeling of responsibility as well as a conservative and social political orientation are relevant. While more patient, conservatively and socially politically oriented respondents consume less electricity, respondents feeling responsible for environmental protection seem to consume more electricity at a first glance. However, this counterintuitive effect is from low statistical significance and changes its direction when differentiating between respondents who rather and strongly feel responsible. Together with the missing hint on correlations of electricity consumption and environmental values, these results point on the possibility that the economical use of electricity is not considered as climate protection activity in Germany. This is in line with Lange et al. (2014) who find that pro-environmental attitudes are not associated with lower heating expenditures but in contrast to Sapci and Considine (2014) who find that pro-environmental attitudes are related to lower energy consumption in the US.

Our preliminary findings could help in the design of public information campaigns but also to increase the efficiency of private initiatives that target reductions in residential electricity use. In line with Werthschulte and Löschel (2019), our results suggest to shrink the distance between consumption and billing of electricity in order to reduce the present bias in electricity consumption. In addition, information campaigns could establish the missing link of environmental values and electricity consumption by stressing the relevance of an economical use of electricity for climate protection side by side to the necessary change from conventional to renewable energy sources.

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Tables

Table 1: Descriptive statistics of dependent and explanatory variables in the econometric analysis (3620 observations)

Variables	Mean	Standard deviation	Minimum	Maximum
Electricity consumption				
Electricity consumption	2822.85	1553.12	500	11706
Log electricity consumption	7.80	0.55	6.21	9.37
Electricity consumption per capita	1430.88	828.05	125	11120
Log electricity consumption per capita	7.13	0.51	4.83	9.32
Equivalent electricity consumption	1838.74	923.79	238.10	11120
Log equivalent electricity consumption	7.41	0.46	5.47	9.32
Economic preferences and psychological motives				
Time preferences	0.86	0.10	0.74	1
Risk preferences	0.28	0.45	0	1
Social preferences	0.34	0.20	0	1
Trust	8.16	2.22	3	15
Positive reciprocity	12.72	1.65	3	15
Negative reciprocity	10.51	2.67	3	15
Injunctive norm	0.53	0.50	0	1
Feeling of responsibility	0.73	0.44	0	1
Leading by example	0.54	0.50	0	1
Warm glow	0.77	0.42	0	1
Perceived descriptive norm	0.54	0.50	0	1
Free-rider rational	0.51	0.50	0	1
Environmental attitudes and political orientation				
Environmental awareness	24.18	3.77	6	30
Conservative identification	0.22	0.42	0	1
Liberal identification	0.34	0.47	0	1
Social identification	0.64	0.48	0	1
Ecological identification	0.49	0.50	0	1
No religious affiliation	0.35	0.48	0	1
Household composition and socioeconomic characteristics				
Adults	1.94	0.85	1	8
Kids	0.25	0.62	0	5
Age	48.72	15.10	18	87
Female	0.50	0.50	0	1
Health status	0.59	0.49	0	1
Higher education	0.28	0.45	0	1
Household net income	2574.72	1436.80	250	8250
Log household net income	7.68	0.63	5.52	9.02
Household net income per capita	1299.24	760.34	50	8250
Log household net income per capita	7.02	0.58	3.91	9.02
Equivalent household income	1677.78	868.24	83.33	8250
Log equivalent household income	7.29	0.55	4.42	9.02
Dwelling characteristics				
Tenant	0.58	0.49	0	1
House	0.38	0.49	0	1
Living space	96.88	85.15	12	4200
Log living space	4.45	0.47	2.48	8.34
Living space per capita	49.43	31.04	4	1050
Log living space per capita	3.79	0.46	1.39	6.96
Equivalent living space	63.36	40.02	6.67	1680
Log equivalent living space	4.06	0.40	1.90	7.43
Electric heating	0.12	0.32	0	1
Electric water heating	0.34	0.47	0	1
100% renewable energy mix	0.29	0.46	0	1
Relocated in the last 10 Years	0.54	0.50	0	1
Eastern Germany	0.21	0.40	0	1

Table 2: Measures of electricity consumption (3705 observations)

Variables	Mean	Standard deviation	Minimum	Maximum
Electricity consumption	2826.51	1551.48	500	11706
Electricity consumption per capita	1430.61	828.68	125	11120
Equalized electricity consumption	1829.49	923.48	238.10	11120
Household electricity costs	795.95	407.68	110.27	3.564.32
Electricity price	29.43	5.62	20	50

Table 3: Choice table of the time preferences experiment

Choice situation	Option A (payment amount in one month)	Option B (payment amount in seven months)
1	80 Euro <input type="checkbox"/>	80 Euro <input type="checkbox"/>
2	80 Euro <input type="checkbox"/>	80,50 Euro <input type="checkbox"/>
3	80 Euro <input type="checkbox"/>	81 Euro <input type="checkbox"/>
4	80 Euro <input type="checkbox"/>	82 Euro <input type="checkbox"/>
5	80 Euro <input type="checkbox"/>	83,50 Euro <input type="checkbox"/>
6	80 Euro <input type="checkbox"/>	85,50 Euro <input type="checkbox"/>
7	80 Euro <input type="checkbox"/>	88 Euro <input type="checkbox"/>
8	80 Euro <input type="checkbox"/>	91 Euro <input type="checkbox"/>
9	80 Euro <input type="checkbox"/>	94,50 Euro <input type="checkbox"/>
10	80 Euro <input type="checkbox"/>	98,50 Euro <input type="checkbox"/>
11	80 Euro <input type="checkbox"/>	103 Euro <input type="checkbox"/>
12	80 Euro <input type="checkbox"/>	108 Euro <input type="checkbox"/>

Table 4: Frequencies of minimum discount factors (3705 observations)

Discount factors	Frequencies
0.741	1046 (28.23%)
0.777	209 (5.64%)
0.812	177 (4.78%)
0.847	203 (5.48%)
0.879	412 (11.12%)
0.909	436 (11.77%)
0.936	296 (7.99%)
0.958	164 (4.43%)
0.976	102 (2.75%)
0.988	80 (2.16%)
0.994	275 (7.42%)
1	305 (8.23%)

Table 5: Choice table in the social preferences experiment (i.e. dictator game)

Amount for you	0 Euro	10 Euro	20 Euro	30 Euro	40 Euro	50 Euro	60 Euro	70 Euro	80 Euro	90 Euro	100 Euro
Amount for another randomly selected person	100 Euro	90 Euro	80 Euro	70 Euro	60 Euro	50 Euro	40 Euro	30 Euro	20 Euro	10 Euro	0 Euro
Decision	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Table 6: Frequencies of payment amounts (in Euro) for other participants in the social preferences experiment (i.e. dictator game)

Payments	Frequencies
0	626 (16.90%)
10	208 (5.61%)
20	336 (9.07%)
30	396 (10.69%)
40	378 (10.20%)
50	1670 (45.07%)
60	24 (0.65%)
70	16 (0.43%)
80	21 (0.57%)
90	15 (0.40%)
100	15 (0.40%)

Table 7: Frequencies of support of the psychological motives (3705 observations)

Statements	Totally disagree	Rather disagree	Undecided	Rather agree	Totally agree
Injunctive norm	188 (4.78)	465 (12.55)	1116 (30.12)	1521 (41.05)	426 (11.50)
Feeling of responsibility	108 (2.91%)	205 (5.53%)	690 (18.62%)	1781 (48.97%)	921 (24.86%)
Leading by example	189 (5.10%)	554 (14.95%)	981 (26.48%)	1449 (39.11%)	532 (14.36%)
Warm glow	91 (2.46%)	164 (4.43%)	596 (16.09%)	1840 (49.66%)	1014 (27.37%)
Descriptive norm	96 (2.59%)	378 (10.20%)	1250 (33.74%)	1583 (42.73%)	398 (10.74%)
Freerider rational	142 (3.83%)	423 (11.42%)	1242 (33.52%)	1396 (37.68%)	502 (13.55%)

Table 8: OLS estimation in linear regression models (3620 observations)

Dependent variables Explanatory variables	Electricity consump- tion	Electricity consump- tion per capita	Equivalent electricity consumption
Economic preferences and psychological motives			
Time preferences	-0.196*** (-2.76)	-0.216*** (-3.06)	-0.203*** (-2.88)
Risk preferences	0.010 (0.61)	0.015 (0.96)	0.013 (0.80)
Altruism	0.024 (0.68)	0.009 (0.25)	0.016 (0.48)
Trust	-0.004 (-1.35)	-0.003 (-0.83)	-0.004 (-1.07)
Positive reciprocity	0.001 (0.33)	0.002 (0.37)	0.002 (0.36)
Negative reciprocity	0.003 (1.29)	0.003 (1.08)	0.003 (1.20)
Injunctive norm	-0.004 (-0.28)	-0.004 (-0.24)	-0.004 (-0.27)
Feeling of responsibility	0.039* (1.74)	0.037* (1.68)	0.037* (1.71)
Leading by example	0.002 (0.12)	-0.005 (-0.27)	-0.001 (-0.04)
Warm glow	-0.012 (-0.52)	-0.014 (-0.64)	-0.012 (-0.55)
Descriptive norm	-0.012 (-0.72)	-0.014 (-0.88)	-0.013 (-0.82)
Free-rider rational	-0.005 (-0.38)	-0.006 (-0.40)	-0.005 (-0.34)
Individual values			
Environmental awareness	0.000 (0.03)	-0.000 (-0.03)	0.000 (0.05)
Conservative identification	-0.032* (-1.90)	-0.033* (-1.95)	-0.031* (-1.88)
Liberal identification	0.005 (0.33)	0.006 (0.36)	0.006 (0.38)
Social identification	-0.032* (-1.95)	-0.032** (-1.97)	-0.032** (-2.00)
Ecological identification	0.005 (0.32)	0.012 (0.75)	0.007 (0.44)
No religious affiliation	-0.005 (-0.32)	-0.001 (-0.08)	-0.003 (-0.21)
Household composition and socioeconomic characteristics			
Adults	0.191*** (17.75)	-0.107*** (-9.24)	-0.007 (-0.78)
Kids	0.102*** (8.55)	-0.146*** (-11.07)	-0.015 (-1.37)
Age	0.004*** (6.74)	0.004*** (6.55)	0.004*** (6.92)
Female	-0.040*** (-2.72)	-0.040*** (-2.76)	-0.040*** (-2.73)
Health status	-0.070*** (-4.92)	-0.073*** (-5.18)	-0.070*** (-4.92)
Higher education	-0.070*** (-4.36)	-0.063*** (-3.93)	-0.063*** (-3.98)
Log household net income	0.055*** (3.81)	-	-
Log household net income per capita	-	0.027* (1.83)	-
Log equivalent household income	-	-	0.036** (2.48)

(Continues on the next page)

Dependent variables	Electricity consump-	Electricity consump-	Equivalent electricity
Explanatory variables	tion	tion per capita	consumption
Dwelling characteristics			
Tenant	0.012 (0.63)	0.016 (0.83)	0.007 (0.38)
House	0.114*** (5.24)	0.110*** (5.23)	0.122*** (5.72)
Log living space	0.307*** (11.12)	- -	- -
Log living space per capita	- -	0.303*** (11.78)	- -
Log equivalent living space	- -	- -	0.277*** (10.56)
Electric heating	0.157*** (5.89)	0.156*** (5.78)	0.155*** (5.84)
Electric water heating	0.179*** (11.53)	0.185*** (12.00)	0.181*** (11.75)
100% renewable energy mix	-0.002 (-0.15)	0.001 (0.04)	-0.002 (-0.11)
Relocated in the last 10 Years	-0.081*** (-5.31)	-0.084*** (-5.55)	-0.081*** (-5.38)
Eastern Germany	-0.073*** (-4.05)	-0.082*** (-4.58)	-0.080*** (-4.50)
Constant	5.594*** (35.64)	6.048*** (36.76)	6.018*** (36.88)

Notes: * (**, ***) means that the appropriate parameter or effect is different from zero at the 10% (5%, 1%) significance level, respectively.