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Elke D. Groh and Andreas Ziegler

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Coordination: Bernd Hayo • Philipps-University Marburg
School of Business and Economics • Universitätsstraße 24, D-35032 Marburg
Tel: +49-6421-2823091, Fax: +49-6421-2823088, e-mail: hayo@wiwi.uni-marburg.de

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Elke D. Groh and Andreas Ziegler

Elke D. Groh

University of Kassel, Institute of Economics

Nora-Platiel-Str. 5, 34109 Kassel, Germany

E-Mail: elke.groh@uni-kassel.de

Phone: +49/561/804-3044

Andreas Ziegler

University of Kassel, Institute of Economics

Nora-Platiel-Str. 5, 34109 Kassel, Germany

E-Mail: andreas.ziegler@uni-kassel.de

Phone: +49/561/804-3038

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Abstract

Based on data of more than 3700 citizens in Germany, this paper empirically examines the relevance of several groups of explanatory factors for electricity consumption. Besides controlling for individual housing and dwelling characteristics as well as socio-demographics, we analyze the effect of environmentally-related values and norms. Since behavioral economics reveals the importance of economic preferences for many individual activities, we additionally consider time and risk preferences, altruism, trust, and reciprocity in our econometric analysis. With respect to the latter factors, only patience has a significantly negative effect on electricity consumption. Our estimation results instead suggest a high relevance of individual housing and dwelling characteristics and socio-demographics. The most interesting result is probably that neither environmentally-related values such as ecological policy identification and environmental awareness nor environmentally-related social norms have a significant effect. In contrast to the USA and to the demand for green electricity in Germany, these estimation results suggest that citizens in Germany with strong environmental identity do not consider low electricity consumption as an important direction for environmental and climate protection.

Keywords: Electricity consumption, values, norms, economic preferences, econometric analysis

1. Introduction

The generation of energy strongly contributes to air pollution as well as to total CO_2 emissions and thus climate change if fossil fuels are used. Furthermore, it also leads to nuclear waste (next to the danger of horrible accidents) in the case of nuclear energy. These environmental problems are major reasons for worldwide energy transitions towards renewable energies such as wind or solar energy. In Germany, for example, the energy transition is mainly characterized by two measures, i.e. the nuclear phase-out and the expansion of renewable energies (e.g. Frondel et al., 2015; Ziegler, 2019). However, switching to alternative energy sources requires large and costly investments for the development of the energy infrastructure such as power grids. Therefore, an important additional direction for economic and especially environmental and climate policy is the reduction of energy production and demand. With respect to electricity, for example, the German government aims at reducing consumption in Germany by 25% until 2050 compared to 2008 (e.g. BMWi, 2019). In order to achieve such goals, several policy instruments such as traditional command and control regulations (e.g. the prohibition of traditional light bulbs in the EU) and common price based policies (e.g. energy and carbon taxes) are possible. In addition, voluntary programs encouraging the reduction of electricity use in the household sector (which is an important portion of total energy demand, e.g. BMWi, 2019) are also increasingly popular.

One example of such approaches to motivate reductions in electricity consumption is the voluntary use of technical devices. In fact, several field experiments examine the potential effects of smart meters as a possible tool (e.g. Houde et al., 2013; Jessoe and Rapson, 2014; Carroll et al., 2014; Lee et al., 2020). In addition to real time feedback, other measures that increase the salience and information on electricity use, such as social comparisons, commitments, goal setting, economic incentives, community-based initiatives, or labeling, are also tested (see e.g. the reviews of empirical studies on causal effects of interventions in Andor and Fels, 2018, and Iweka et al., 2019). Broad examples for real-world measures 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). However, Aydin et al. (2018) show that electricity reductions due to such interventions especially arise in households that are already interested in the economic use of electricity beforehand. A necessary condition for the effectiveness and efficiency of such programs is therefore a deeper knowledge about factors that determine the use of electricity. Against this background, this paper empirically examines the relevance of several groups of explanatory factors for electricity consumption in Germany.

Not surprisingly, previous studies show that individual housing and dwelling characteristics are of high importance. For example, electricity use (per capita) increases with dwelling size and is higher for households living in houses compared to apartments (e.g. Thøgersen and Grønhøj, 2010; Chong, 2012; Brounen et al., 2012; Costa and Khan, 2013a; Blasch et al., 2017). With respect to socio-demographic (including socio-economic) characteristics, it is, for example, shown (e.g. Brounen et al., 2012; Frondel and Kussel, 2019; Bardazzi and Pazienza, 2020) that electricity consumption increases with age (an exception is Costa and Khan, 2013a), income, and low education. Furthermore, these studies reveal that females use less electricity than males. However, studies considering explanatory factors beyond individual housing and dwelling characteristics and a few socio-demographics are rather limited. One reason for these restrictions in previous studies is the lack of appropriate information, for example, on values and norms when official data on electricity consumption are used. Reversely, if such data, for example, from surveys are available, the collection of reliable information on electricity consumption is very difficult since it mostly relies on individual estimates of personal electricity use, which can lead to severe measurement errors.

With respect to values, Costa and Khan (2013a, 2013b) show a strong relevance of political identification in the USA, i.e. electricity consumption is lower in liberal (i.e. left-wing) households. In line with Kotchen and Moore (2008) and Delmas and Lessem (2014), they additionally reveal that households with a higher environmental awareness consume less electricity. Umit et al. (2019), Schleich (2019), and Fischbacher et al. (2021) also report that environmentally concerned or aware individuals are more likely to buy energy efficient appliances, adopt energy saving measures, and to invest in energy retrofits. These results suggest that the individual reduction of electricity use is commonly considered as an appropriate direction for environmental and climate protection. The results are therefore in line with other empirical analyses revealing strong positive effects of left-wing and especially ecological policy identification as well as environmental awareness on environmental and climate protection activities such as using public transit (e.g. Kahn 2007), participating in green electricity programs (e.g. Kotchen and Moore, 2007), living in solar homes (e.g. Dastrup et al., 2012), carbon offsetting (e.g. Schwirplies and Ziegler, 2016), buying electric vehicles (e.g. Potoglou et al., 2020), or purchasing green electricity (e.g. Ziegler, 2020a). Schwirplies and Ziegler (2016) additionally show that feelings of warm glow from climate protection as well as specific norms from the social environment and the society in this context can be relevant.

Finally, economic preferences are also considered recently. In behavioral economics, especially risk, time, and social preferences (e.g. Falk et al., 2016, 2018) play an important role for individual activities and life outcomes (e.g. Guiso et al., 2008; Dohmen et al., 2009, 2012; Golsteyn et al., 2014). With respect to energy-related behavior, for example, Qiu et al. (2014), Newell and Siikamäki (2015), and Schleich et al. (2019b) analyze investments in energy efficiency. Furthermore, Schleich et al. (2019a) find that risk-taking and future-oriented individuals are more likely to switch their electricity contracts. Ziegler (2020a) confirms this result for time preferences and additionally shows that higher levels of patience, altruism, and trust are positively correlated with the specific change to green electricity contracts. Similarly, Kotchen and Moore (2007) reveal that altruistic individuals are more likely to participate in green electricity programs. Closer related to energy demand, Caferra et al. (2021) find that trust has a positive effect on an index capturing the reduction of energy consumption. Furthermore, Fischbacher et al. (2021) reveal that future oriented homeowners have lower heating and energy costs and Volland (2017) shows that risk aversion and trust decrease energy expenditures. Werthschulte and Löschel (2019) also examine risk and time preferences and find that electricity consumption is higher for individuals with present bias. Recently, Fuhrmann-Riebel et al. (2021) consider a large number of economic preferences showing that altruism, trust, and reciprocity are important for energy-saving behavior and more specifically that lower negative reciprocity and higher levels of patience decreases electricity expenditures.

This paper examines and compares a wide range of explanatory factors, i.e. environmentally-related values and norms, economic preferences, socio-demographics, and individual housing and dwelling characteristics, which are shown to be relevant for electricity consumption in previous studies, but which have (to the best of our knowledge) never been analyzed simultaneously so far. This empirical approach thus provides a broader view on the determinants of electricity use and also increases the reliability of the estimation results by reducing possible omitted variable biases if some groups of explanatory variables are correlated. For example, the estimated effects of some socio-demographics might be spurious due to their correlations to values and norms, and vice versa. Due to strong correlations between several economic preferences (e.g. Dohmen et al., 2008; Albanese et al., 2017; Falk et al., 2018), this potential problem might be especially pronounced in previous studies only including single economic preferences (e.g. Werthschulte and Löschel, 2019). Similar to Fuhrmann-Riebel et al., (2021), we therefore jointly consider risk and time preferences, altruism, trust, as well as positive and negative reciprocity. Furthermore, in contrast to most previous studies (but similar to Werthschulte and Löschel, 2019), our empirical analysis is based on more reliable data about electricity consumption since we did not ask the more than 3700 survey participants in Germany to estimate their usage, but rather asked them to enter their electricity consumption according to their last electricity bill.

The paper proceeds as follows: Section 2 presents the data and the variables in the econometric analysis. Section 3 discusses the estimation results and Section 4 concludes with some policy implications.

2. Data and variables

2.1. Sample

The data for our econometric analysis were collected by means of a large-scale computer-based survey in Germany, which was carried out in cooperation with the professional market research company Psyma in June and July 2016. After some screening questions and first socio-demographic variables, the first part of the questionnaire included individual values, norms, attitudes, and economic preferences, comprising two artefactual field experiments to identify time preferences and altruism. The next two parts referred to details about the electricity consumption and costs including specific housing and dwelling characteristics. The fourth part of the questionnaire comprised a stated choice experiment, which is, however, not considered in this paper. The last part referred to further socio-economic and socio-demographic variables. In total, 3705 citizens from the Psyma Panel participated in the survey. To obtain reliable responses, only respondents who are solely or partially responsible for the electricity decisions in their household were selected for the survey. In order to include all relevant population groups, the sample was stratified in terms of age groups, gender, place of residence, and religious affiliation so that it is representative for the German population for these criteria.[1] The median time needed for the completion of the survey was about 28 minutes among all respondents.

2.2 Electricity consumption

The dependent variables in our econometric analysis refer to household electricity consumption. For this reason, we asked the respondents to pick up the last electricity bill of the household and to enter the annual electricity costs in Euros and especially the annual electricity use, measured in kilowatt hours (kWh). As already mentioned, this procedure is extremely important for data reliability since previous studies show that the knowledge about personal electricity prices, costs, and use is rather low. For example, Blasch et al. (2017) find that only

[1] However, this sampling strategy can lead to deviations in other criteria, for example, due to an overrepresentation of high education among individuals who are responsible for electricity decisions in the household.

about 27% of the respondents in their Swiss sample know the average price of electricity and Brounen et al. (2013) report that only about 47% in their Dutch sample know their monthly electricity costs. Therefore, the respondents were thoroughly informed where the cost and consumption information can most probably be found on their electricity bill. After entering the corresponding values, the respondents were asked to align their entries with their electricity bill again. In a follow-up question, respondents could upload their anonymized electricity bill to prove that they typed in the correct values, of which 321 respondents did so. The market research company double checked the entries of these respondents and corrected the values if necessary.

In order to ensure high reliability of the data, Psyma additionally eliminated two groups of respondents during the survey (maintaining the aforementioned representativeness of the sample). First, respondents who indicated to consume less than 500 kWh or more than 12.000 kWh were screened out. Second, respondents, whose ratio between electricity costs and electricity consumption was lower than 20 eurocents or higher than 50 eurocents per kWh, were screened out. This range was chosen on the basis of the distribution of electricity prices in 2016. According to Bundesnetzagentur (2016), the prices varied between 23.61 eurocents (stemming from a contract with a non-regional electricity supplier and an annual consumption between 5000 kWh and 10000 kWh) and 50.38 eurocents (stemming from a basic supply contract with an annual consumption of less than 1000 kWh). Table 1 shows that the average household electricity costs are 795.95 Euros and the average household electricity consumption is 2826.51 kWh across all 3705 respondents in our sample. The average electricity price in our sample is 29.43 eurocents per kWh, while the actual average electricity price for households with an annual consumption between 2500 kWh and 5000 kWh was 29.80 eurocents per kWh in 2016 (e.g. Bundesnetzagentur, 2016). Therefore, the electricity prices in our sample are in line with the corresponding prices in the total population.[2]

In our econometric analysis, we focus on two dependent variables, namely total household electricity consumption (e.g. Thøgersen and Grønhøj, 2010; Costa and Kahn, 2013a; Frondel and Kussel, 2019) and electricity consumption that is corrected for household size to identify the individual contribution to electricity use. However, instead of adjusting on a per capita basis (e.g. Brounen et al., 2012) that weights young children and adults equally, we note that

[2] It should be noted that we are not able to include electricity prices since we only have information about total costs including basic charges. While prices in general are relevant for decision making, previous studies report very low price elasticities for electricity (e.g. Werthschulte and Löschel, 2019; Frondel and Kussel, 2019). Therefore, we do not expect that this shortcoming will lead to serious omitted variable biases in our econometric analysis.

not all household members contribute equally to electricity contribution and that there are economies of scale in energy use (e.g. Schulte and Heindl, 2017), for example, through the joint use of appliances. In line with, for example, Groh and Ziegler (2018), we therefore transfer the concept of equivalized income to the case of electricity consumption to account for scale effects. Our approach refers to a modified OECD equivalence scale (e.g. Horsfield, 2015)[3], which weights the first adult in the household with the factor one, children up to the age of 13 years with the factor 0.3, and other older household members with the factor 0.5. Table 1 reports that the average value of equivalized electricity consumption is 1839.49 kWh in our sample. In order to interpret the estimated parameters as estimated semi-elasticities or elasticities, we specifically consider the natural logarithm of these two specifications of electricity consumption as is common in previous studies (e.g. Chong, 2012; Cho, 2019).

2.3 Values and norms

In line with Schwartz (1973), we assume that behavior, including electricity consumption, is based on an underlying system of values and norms. Activities which are not in line with these values and norms can lead to psychological costs and thus to a loss in individual utility. With respect to the analysis of variables for values and norms in our case, however, one challenge is that total electricity consumption depends not only on the characteristics of one individual, but on the characteristics of all members of the household. Therefore, some studies consider aggregate individual characteristics across all household members (e.g. Lange et al., 2014; Volland, 2017). This approach is based on results revealing within-household heterogeneity for individual characteristics such as economic preferences as discussed below (e.g. Dohmen et al., 2012). Other mostly psychological studies assume that it is sufficient to characterize the distribution of individual characteristics within a household by one representative household member (e.g. Brandon and Lewis, 1999; Abrahamse and Steg, 2009; Sapci and Consideine, 2014). We widely follow the latter approach for all individual explanatory variables and examine single respondents who are solely or partially responsible for the electricity decisions in their household and who can thus be considered as representative in this respect.

As discussed in the introduction, previous studies show a strong relevance of political orientation for electricity consumption. In line with Ziegler (2020a, 2020b), we consider four separate indicators instead of a simple one-dimensional indicator for a right-wing or a left-wing political identification, which is not appropriate in Germany due to the relationships between different political orientations. We therefore asked the respondents how strongly they agree

[3] See also https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Equivalised_disposable_income.

with the following four statements: “I identify with conservatively oriented policy”, “I identify with liberally oriented policy”, “I identify with socially oriented policy”, and “I identify with ecologically oriented policy”. The respondents indicated their agreement on a symmetric scale with 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 policy identification”, “liberal policy identification”, “social policy identification”, and “ecological policy identification” that take the value one if the respondent stated to rather or totally agree, respectively. Table 2 shows that about 64% of the respondents in our sample identify with social policy. Furthermore, about 49% of them identify with ecological policy, 34% of them with liberal policy, and only about 22% of them with conservative policy. In line with previous studies (e.g. Costa and Kahn, 2013a, 2013b), we hypothesize that respondents with a left-wing and especially ecological policy identification consume less electricity.

Environmental orientation is not only addressed by ecological policy identification, but also by environmental awareness, measured with a New Ecological Paradigm (NEP) scale according to Dunlap et al. (2000). The NEP scale is a standard instrument in the social and behavioral sciences and also increasingly common in economics (e.g. Ziegler, 2019; Fischbacher et al., 2021). In line with Whitmarsh (2011), our NEP scale 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 were asked how strongly they agree with these statements on a scale with five ordered response categories, ranging from “totally disagree” to “totally agree” as described before. We assign 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. By adding up the values we construct the variable “environmental awareness” which varies between six and 30 with a mean value of 24.18 in our sample according to Table 2. In line with previous studies (e.g. Kotchen and Moore, 2008; Delmas and Lessem, 2014), we hypothesize electricity consumption to decrease with increasing environmental awareness.

In addition to environmental awareness, we also consider an attitudinal variable that aims at capturing feelings of warm glow from environmental protection (e.g. Andreoni, 1989, 1990). If individuals are aware of the consequences of their behavior, they feel responsible for it.

Therefore, warm glow motives can lead to psychological benefits when reducing electricity use. However, the hypothesized mechanism of these warm glow motives, but also of environmental identity as discussed before and environmentally-related social norms as discussed below is only effective if the reduction of electricity consumption is generally accepted as an appropriate direction for environmental and climate protection. Our indicator for warm glow motives is based on the two statements (e.g. Schwirplies and Ziegler, 2016) “I feel responsible to contribute to environmental protection” and “I have a feeling of warm glow if I contribute to environmental protection”. The respondents had again to indicate their agreement to these statements on a scale with the same five ordered response categories as before. The dummy variable “warm glow motives” takes the value one if the respondent rather or totally agreed to at least one of the two statements. Table 2 shows that about 82% of the respondents in our sample have such feelings of warm glow.

Finally, as aforementioned, we examine two indicators for social norms, which are general rules that indicate which behavior or attitudes are considered as appropriate or inappropriate by specific groups such as the family, friends, work colleagues, but also by society as a whole (e.g. Rege, 2004). One channel for social norms is individual identity. According to Akerlof and Kranton (2000), the identity of an individual is the internalization of behavioral rules belonging to a certain social category. The violation of these rules can lead to psychological costs and thus to a loss in utility. For the analysis of two environmentally-related social norms we asked the respondents how strongly they agree with the two statements “society expects me to contribute to environmental protection” and “my social environment (friends, family, colleagues) contributes to environmental protection”. The dummy variables “expectation society” (indicating an injunctive norm) and “contribution social environment” (indicating a descriptive norm) take the value one if the respondent indicated to rather or totally agree, based on five ordered response categories, ranging from “totally disagree” to “totally agree” as described before. Table 2 shows that about 53% of the respondents in our sample orient to these two environmentally-related social norms, respectively.

2.4 Economic preferences

The second group of main explanatory variables in our econometric analysis refers to economic preferences, i.e. time and risk preferences, altruism, trust, as well as positive and negative reciprocity. Our variable for time preferences is based on an incentivized artefactual field experiment. In a multiple choice task with 12 choices the respondents had to decide to receive 80 Euros one month after the survey or a higher amount varying between 80 Euros and 108

Euros seven months after the survey, conditional on belonging to the group of winners in a lottery (for details of the experiment, see Ziegler, 2020b). For the econometric analysis, we construct the variable “patience” in line with, for example, Dohmen et al. (2010) or Fischbacher et al. (2021). This variable is the ratio between the fixed amount one month after the survey and the amount at which the respondent chose the higher payment seven months after the survey for the first time. According to Table 2, the variable therefore varies between 0.74 and 1 with a mean of 0.86 in our sample, whereby a higher value indicates a higher level of patience. With respect to our expectation of the effect of time preferences, it might be argued that more patient individuals invest in energy-saving measures such as energy-efficient appliances or energy-efficient renovations (resulting in lower electricity use) more often, since these investments lead to immediate costs in the present and only offer economic benefits (i.e. less energy costs) in the future. In line with the corresponding results of Werthschulte and Löschel (2019), Fischbacher et al. (2021), and Fuhrmann-Riebel et al. (2021), we therefore hypothesize that electricity consumption decreases with increasing levels of patience.

Our variable for risk preferences is based on a validated survey question (e.g. Dohmen et al., 2011; Vieider et al., 2015; Falk et al., 2016, 2018) according to the German Socio-Economic Panel (SOEP). The respondents were thus asked how willing they generally are to take risks on a symmetric scale with the five ordered 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-taking preferences” that takes the value one if the respondent indicated one of the latter two categories. According to Table 2, about 29% of the respondents in our sample self-assess as rather or very willing to take risks. Since energy saving measures such as investments in energy-efficient appliances or energy-efficient renovation decisions can be perceived as risky (e.g. Qiu et al., 2014; Fischbacher et al., 2021), it might be argued that higher risk-taking preferences lead to more such measures, which in turn decreases electricity use. However, Volland (2017) reports that risk-taking preferences increase energy (including electricity) expenditures. One possible reason for this result is that risk-taking preferences also increase the number of different appliances which increases total electricity consumption. Therefore, no clear hypothesis about the relationship between risk preferences and electricity can be derived.

In addition to risk and time preferences, we consider four components of social preferences, i.e. altruism, trust, as well as positive and negative reciprocity. Our variable for altruism is also based on an incentivized artefactual field experiment. The experiment was based on a dictator game, where the respondents had to divide 100 Euros with another randomly selected respondent in case that the respondent turns out to be the winner in a lottery (for details see Ziegler, 2020b). For the econometric analysis, we construct the variable "altruism" which is the amount that is allocated to another respondent divided by 100. According to Table 2, the variable therefore varies between 0 and 1 with a mean of 0.34 in our sample, indicating that the respondents allocated about 34 Euros on average to another respondent. It can be argued that social preferences such as altruism, but also trust (which are generally strongly positively correlated, e.g. Falk et al., 2018), are relevant in public good dilemmas. This means that individuals with higher social preferences contribute more to public goods since they more often assume that people in general voluntarily contribute to public goods in spite of having the option to free-ride (e.g. Volland, 2017; Fuhrmann-Riebel et al., 2021). By considering the reduction of energy demand as a component of the public good environmental and climate protection, we hypothesize that electricity consumption decreases with increasing social preferences like altruism. In fact, Volland (2017) shows that an indicator for altruism leads to lower energy expenditures, although his very specific indicator related to volunteering cannot directly be compared with general approaches of altruism.

In line with, for example, Dohmen et al. (2012), our variable for trust is based on the following three experimentally validated survey items from the SOEP: "In general, one can trust people", "these days one cannot rely on anybody else", and "when dealing with strangers, it is better to be careful before one trusts them". The respondents had again to indicate their agreement to these statements on a scale with five ordered response categories, ranging from "totally disagree" to "totally agree" as described before. We assign increasing integers from one to five for the first item and decreasing integers from five to one for the two latter items. Therefore, higher values indicate higher levels of trust, respectively. For the econometric analysis, we construct the variable "trust" which is the sum of the single values for the three items. According to Table 2, the variable therefore varies between 3 and 15 with a mean value of 8.16 in our sample. In line with Volland (2017) and Fuhrmann-Riebel et al. (2021), as discussed above, we hypothesize that electricity consumption decreases with increasing levels of trust. In fact, Volland (2017) reveals that trust decreases energy expenditures and Caferra et al. (2021) shows that trust has a positive effect on an index capturing the reduction of energy consumption, although their indicators for political and social trust cannot directly be compared with general approaches of trust.

Our variables for positive and negative reciprocity are in line with several previous studies (e.g. Dohmen et al., 2008, 2009; Caliendo et al., 2012) and thus with survey questions from the SOEP. The indicator for positive reciprocity is based on the following three statements: “If someone does me a favor, I am ready to return it”, “I particularly try to help someone who has helped me before”, and “I am willing to incur costs to help someone who has helped me before”. The indicator for negative reciprocity is based on the following three statements: “If I suffer a serious wrong, I will take revenge as soon as possible, no matter what the cost”, “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 were again asked to indicate how strongly they agree with these statements on a scale with five ordered response categories, ranging from “totally disagree” to “totally agree” as described before. For the econometric analysis, we construct the variables “positive reciprocity” and “negative reciprocity” which are the sums of the single values for the three items in both cases. According to Table 2, the two variables therefore vary between 3 and 15 with mean values of 12.72 for positive reciprocity and 10.51 for negative reciprocity in our sample. By also considering reciprocity as an indicator for social preferences, as discussed above, we hypothesize that electricity consumption decreases with increasing positive reciprocity and increases with increasing negative reciprocity. In fact, Fuhrmann-Riebel et al. (2021) provides some evidence for a positive effect of negative reciprocity on electricity expenditures.

2.5 Socio-demographics and individual housing and dwelling characteristics

Our first group of control variables refers to socio-demographics. With respect to individual socio-demographic characteristics, the variable “age” is the age of the respondent in years, the dummy variable “female” takes the value one if the respondent is a woman, the dummy variable “high education” takes the value one if the highest level of education is at least a university degree, and the dummy variable “good health” takes the value one if the respondent indicates to be rather or very healthy on a symmetric scale with five ordered response categories. Table 2 shows that the respondents in our sample are on average almost 49 years old. Furthermore, about 50% of the respondents are female (which is in line with the stratified sampling strategy), about 20% of them have at least a university degree, and about 58% of them are in good health. In line with previous studies (e.g. Brounen et al., 2012; Blasch et al., 2017; Frondel and Kussel, 2019; Bardazzi and Pazienza. 2020), we hypothesize that electricity use increases with age and that females and highly educated individuals have a lower electricity consumption compared to males and lower educated individuals. Furthermore, we hypothesize a higher electricity consumption of more unhealthy individuals since it can be expected that they stay at home more frequently and thus, for example, have a higher demand for lighting and the use of appliances.

With respect to household socio-demographics, the relevance of household composition and household size is already discussed above in the specification of our dependent variable. On this basis, we consider the two variables “number of adults in household” and “number of children in household” in the econometric analysis. It is reasonable to assume that an increase in household size increases electricity use, for example, due to the increase of the demand for lighting and use of appliances. According to Table 2, the households of the respondents in our sample consist of almost two adults and about 0.25 children on average. Furthermore, we consider the monthly net household income in Euros. For this reason, the respondents were asked to indicate an income class among 18 classes overall. The variable “household income” indicates the mean value of the income class. On the basis of the discussion above, we also consider the variable “equivalized income” (using the same weights as for equivalized electricity use) to adjust household income for household size and composition.[4] In line with previous studies (e.g. Brounen et al., 2012; Blasch et al., 2017; Frondel and Kussel, 2019), we hypothesize that income increases electricity use since higher income can, for example, lead to a larger demand for appliances, possibly overcompensating their higher energy efficiency (e.g. Cayla et al., 2011), and to a lower frequency of engaging in energy curtailments (e.g. Umit et al., 2019).

The second group of control variables refers to individual housing and dwelling characteristics. With respect to individual housing, the dummy variable “relocation in last ten years” takes the value one if the respondent changed the primary residence within the last ten years. In addition, the dummy variable “living in Western Germany” takes the value one if the dwelling of the respondent is located in the old federal states of Germany excluding Berlin. According to Table 2, about 54% of the respondents in our sample relocated within the last ten years and about 79% of them live in Western Germany (which is also in line with the stratified sampling strategy). In line with Frondel and Kussel (2019), we hypothesize higher electricity consumption for dwellings located in the Western part of Germany. Furthermore, it can be expected that relocations are often connected with a major replacement of old appliances with new energy efficient appliances[5] and with a higher salience of electricity consumption due to new electricity contracts. In fact, Cho (2019) shows that electricity use of recently

[4] In the econometric analysis we consider the natural logarithm of these income variables.
[5] Unfortunately, further information on the appliance stock in the households is not available. For an analysis of differences in electricity consumption due to the appliance stock, see e.g. Frondel et al. (2019).

relocated households is lower, but increases with a growing duration of residence. Therefore, we hypothesize that individuals who relocated in the last ten years consume less electricity compared to individuals who did not relocate in this period.

Furthermore, the dummy variable "living in house" takes the value one if the dwelling of the respondent is a house and the dummy variable "housing ownership" takes the value one if the household of the respondent owns the dwelling and thus does not live in a rented dwelling. Table 2 shows that about 38% of the respondents in our sample live in a house and that about 42% of them belong to a household that owns the dwelling. It can be expected that households living in houses consume more electricity than households in multi-party houses, for example, due to a higher electricity use for exterior or staircase lighting, which is generally shared between dwellings in multi-party houses. With respect to the effect of ownership of the dwelling, some studies (e.g. Tilov et al., 2019; Frondel and Kussel, 2019) reveal higher electricity consumption. In contrast, Cho (2019) shows a reverse effect of ownership. He argues that most house or apartment owners pay their utility fees and thus might be more incentivized to reduce their electricity consumption since they are more aware of electricity decisions. However, we do not expect such a negative effect since all respondents in our sample are solely or partially responsible for the electricity decisions in their household. Therefore, we hypothesize that living in a house and owning the dwelling lead to higher electricity use.

With respect to dwelling characteristics, the variable "household dwelling size" indicates the household living space of the respondent in square meters. Similar to equivalized electricity use and income as discussed above, we additionally consider the variable "equivalized dwelling size" to adjust household dwelling size for household size and composition.[6] Furthermore, the dummy variables "heating with electricity" and "water heating with electricity" take the value one if the household of the respondent uses electricity for heating or for water heating. Table 2 shows that the average household living space of the respondents in our sample is 96.74 square meters, that about 12% of the respondents use electricity for heating, and that about 34% of them use electricity for water heating. It is reasonable to assume that that these dwelling characteristics increase electricity use (since e.g. larger dwelling sizes usually lead to a higher demand for lighting). In line with previous studies (e.g. Thøgersen and Grønhøj, 2010; Brounen et al., 2012; Costa and Khan, 2013a; Blasch et al., 2017; Cho, 2019; Frondel and Kussel, 2019), we therefore hypothesize that electricity consumption is higher for larger household dwelling sizes and in the case of electric heating and water heating.

[6] In the econometric analysis we consider the natural logarithm of these dwelling size variables.

3. Econometric analysis

Table 3 reports the ordinary least squares (OLS) estimation results for two linear regression models based on the two specifications of our dependent variable, i.e. logarithmized household electricity consumption (see the results in the first column) and logarithmized equivalized electricity consumption (see the results in the second column).[7] In order to avoid possible problems of omitted variable biases due to strong correlations of explanatory variables, for example, between environmental awareness and economic preferences (e.g. Ziegler, 2020b), between age, gender, and economic preferences (e.g. Falk et al., 2018), or among economic preferences (e.g. Dohmen et al., 2008; Albanese et al., 2017), we jointly include all discussed explanatory variables in these regression models. While the log-linear approach for unlogarithmized explanatory variables allows the interpretation of estimated parameters to be approximately estimated semi-elasticities, the log-log approach for logarithmized explanatory variables (i.e. income and dwelling size) allows the estimated parameters to be interpreted as approximately estimated elasticities.[8] Table 3 shows that the estimation results are not only qualitatively, but also quantitatively very similar in both model specifications. The only exception refers to household size, measured by the number of adults and the number of children in the household, which has an expected significantly positive effect on household electricity consumption, but no significant effect on equivalized electricity consumption. However, the latter estimation result is not very surprising since the dependent variable is adjusted for household size in this case (see also Schulte and Heindl, 2017).

Table 3 reveals that almost all socio-demographics and individual housing and dwelling characteristics have significant effects on both household and equivalized electricity consumption which is in line with our expectations and most previous studies as discussed above (the only exceptions are household size with respect to equivalized electricity consumption as aforementioned and housing ownership in both model specifications). Therefore, relocations in the last ten years lead to significantly lower (household and equivalized) electricity consumption, whereas living in Western Germany, living in a house, increasing (household and equivalized) dwelling size, and electric heating and electric water heating lead to significantly higher electricity consumption. In particular, the estimated effect of electric heating and electric water heating is non-negligible (and especially stronger than the estimated effects for relocations, for living in a house, or for living in Western Germany), i.e. these two electric heat genera-

[7] All estimations were conducted with the statistical software package Stata 15.

[8] For these two explanatory variables, the household specific values are only included in the first model specification with (logarithmized) household electricity consumption, whereas the equivalized values are only included in the second model specification with (logarithmized) equivalized electricity consumption.

tions increase the estimated electricity consumption by about 16% or 18%, respectively. Furthermore, an increase of household or equivalized dwelling size by 1% leads to an approximately estimated increase of electricity consumption by about 0.3%.

With respect to socio-demographics, age and (household and equivalized) income have significantly positive effects on electricity consumption, whereas the corresponding estimated effects of good health and high education are significantly negative. Furthermore, females consume significantly less electricity than males, whereby the estimated difference is about 4%. Interestingly, the estimated health effect is stronger than the estimated gender effect and about as strong as the estimated education effect. The estimated health and education effects for reduced electricity consumption correspond to a decrease of age by almost 20 years. The estimated effects of (household and equivalized) income suggest moderate income elasticities of about 0.05% for household electricity consumption and more than 0.03% for equivalized electricity consumption. The estimated parameters for both household size variables suggest strong effects and clearly indicate that an increase of adults in the household leads to a larger increase of household electricity consumption compared to an increase of children in the household. The increase due to an additional adult is about double the size compared to the increase due to an additional child. Nevertheless, one child more in the household already leads to an estimated increase of household electricity consumption by about 10%.

In contrast to the previous results for our control variables, Table 3 reveals that economic preferences are overall less relevant since risk preferences, altruism, trust, as well as positive and negative reciprocity have no significant effect on electricity consumption. This result is in contrast to several studies which find that some of these economic preferences play an important role for energy-related behavior (e.g. Kotchen and Moore, 2007; Qiu et al., 2014; Newell and Siikamäki, 2015; Schleich et al., 2019a, 2019b; Ziegler, 2020a) including energy demand (e.g. Volland, 2017; Fischbacher et al., 2021). However, none of these studies specifically analyze electricity consumption so that the results cannot be directly compared. While Fuhrmann-Riebel et al. (2021) report some significant effects of negative reciprocity, it should be noted that their study is based on Peruvian data including self-reported electricity expenditures, which are less reliable. Furthermore, Caferra et al. (2021) show that trust has a significantly positive effect on an index capturing the reduction of energy consumption. However, their indicators for political and social trust cannot directly be compared with general approaches of trust. Furthermore, their dependent variable is not directly comparable with our measurement of electricity use, either.

In contrast to the previous five economic preferences, Table 3 shows that time preferences have a significant effect on electricity consumption. In line with our expectation, the estimated electricity consumption is lower with higher levels of patience. This result is in line with the results of Fischbacher et al. (2021) and especially similar to the results of Fuhrmann-Riebel et al. (2021) on the basis of their Peruvian data and the results of Werthschulte and Löschel (2019) on the basis of reliable electricity consumption data from Germany. In line with the argumentation above, it can be assumed that more patient individuals invest in energy-saving measures more often resulting in less electricity consumption since these investments lead to immediate costs in the present, whereas the economic benefits through less energy costs only occur in the future. However, it should also be noted that the estimated effect is economically rather moderate since an increase of our patience indicator by 0.1 units (which is about one standard deviation) only leads to an estimated decrease of electricity consumption by about 2%.

With respect to values and norms, Table 3 reveals a significantly negative effect of social policy identification, which would be in line with our expectations, but surprisingly also a significantly negative effect of conservative policy identification on electricity consumption. The latter result is unexpected and all attempts of explanation are highly speculative. For example, it is possible that more conservative individuals are rather reluctant in using a large number of modern electric devices, which leads to lower electricity consumption. Nevertheless, the significantly negative effect of social policy identification is also ambiguous. The main argument for a negative effect of left-wing policy identification refers to higher environmental orientation compared to right-wing policy identification. In this case, the effect of ecological policy identification should be dominant. However, ecological policy identification has no significant effect on electricity consumption with an unexpected positive parameter estimate. In addition, the effects of all further environmentally-related values and norms, i.e. environmental awareness, warm glow motives for environmental protection, expectations from society to environmental protection, and contributions from the social environment to environmental protection are insignificant. These probably most interesting estimation results suggest that citizens in Germany with strong environmental identity do not consider low electricity consumption as an important direction for environmental and climate protection.

While such estimated non-results might generally be statistically criticized as basis for further conclusions, we would like to mention that our econometric analysis is based on more than 3700 observations so that statistical power problems should be negligible. Perhaps more importantly, not only the estimated parameter for ecological policy identification, but also the estimated parameters for environmental awareness and especially warm glow motives are positive. In addition, we have checked the robustness of our estimation results in further model specifications.[9] For example, in order to avoid possible multicollinearity problems, we have considered linear regression models that only include single environmentally-related values and norms. Furthermore, we have additionally included variables for green electricity contracts in the household[10] or for other pro-environmental attitudes. However, the main estimation results remain qualitatively extremely stable. Therefore, it is reasonable to conclude that environmental identity has little relevance for lowering electricity consumption in Germany.

4. Conclusions and policy implications

This paper empirically examines the relevance of a wide range of explanatory factors for electricity consumption. Besides controlling for individual housing and dwelling characteristics as well as socio-demographics, we analyze the effects of environmentally-related values and norms and economic preferences, i.e. time and risk preferences, altruism, trust, and reciprocity. In line with previous studies, our econometric analysis on the basis of data of more than 3700 citizens in Germany reveals a high relevance of individual housing and dwelling characteristics such as relocation activities or dwelling size as well as socio-demographics such as age, gender, or income. In contrast, values and norms as well as economic preferences play a minor role. With respect to economic preferences, only patience has a significantly negative effect on electricity consumption, whereas the other five economic preferences are of lower relevance. With respect to values and norms, the most interesting result is probably that neither environmentally-related values such as ecological policy identification and environmental awareness nor environmentally-related social norms have a significant effect. In contrast to the results in the USA and the demand for green electricity in Germany, these estimation results suggest that citizens in Germany with strong environmental identity do not consider low electricity consumption as an important direction for environmental and climate protection.

Our results support the specification of voluntary programs encouraging the reduction of electricity use in terms of effectiveness and efficiency. One important conclusion is that only triggering environmental identity is evidently not the most effective strategy in Germany. Instead, the economic aspects of reducing electricity consumption in terms of reduced electricity costs seem to be more promising. In line with Werthschulte and Löschel (2019), our estimation results for time preferences also suggest reducing the duration between electricity consump-

[9] These estimation results are not reported for brevity, but are available upon request.
[10] Unfortunately, data for the electricity contract in the household of the respondents are not available for all respondents. Therefore, we do not include the corresponding variable in our main model specifications.

tion and electricity billing in order to decrease the present bias in electricity use. Furthermore, in line with several studies on the energy efficiency gap (e.g. Blasch et al., 2017; Schleich et al., 2019b), our estimated effects of relocations in the past suggest that investments into energy efficient appliances are highly relevant. In addition, voluntary programs might focus on specific socio-demographic groups as well as specific individual housing and dwelling characteristics.

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Tables

Table 1: Descriptive statistics of electricity costs and consumption (3705 observations)

Variables	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Household electricity costs in Euros	795.95	407.68	110.27	3564.32
Household electricity consumption in kWh	2826.51	1551.48	500.00	11706.00
Equivalized electricity consumption in kWh	1839.49	923.48	238.10	11120.00

Table 2: Descriptive statistics of explanatory variables (3705 observations)

Variables	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Values and norms				
Conservative policy identification	0.22	0.42	0	1
Liberal policy identification	0.34	0.47	0	1
Social policy identification	0.64	0.48	0	1
Ecological policy identification	0.49	0.50	0	1
Environmental awareness	24.18	3.77	6	30
Warm glow motives	0.82	0.39	0	1
Expectation society	0.53	0.50	0	1
Contribution social environment	0.53	0.50	0	1
Economic preferences				
Patience	0.86	0.10	0.74	1
Risk-taking preferences	0.29	0.45	0	1
Altruism	0.34	0.20	0	1
Trust	8.16	2.23	3	15
Positive reciprocity	12.72	1.67	3	15
Negative reciprocity	10.51	2.67	3	15
Socio-demographics				
Age	48.72	15.10	18	87
Female	0.50	0.50	0	1
High education	0.20	0.40	0	1
Good health	0.58	0.49	0	1
Number of adults in household	1.95	0.85	1	8
Number of children in household	0.25	0.62	0	5
Household income	2572.67	1440.64	250	8250
Equivalized income	1674.12	867.54	83.33	8250
Individual housing and dwelling characteristics				
Relocation in last ten years	0.54	0.50	0	1
Living in Western Germany	0.79	0.41	0	1
Living in house	0.38	0.49	0	1
Housing ownership	0.42	0.49	0	1
Household dwelling size	96.74	84.52	12	4200
Equivalized dwelling size	63.18	39.74	6.67	1680
Heating with electricity	0.12	0.32	0	1
Water heating with electricity	0.34	0.47	0	1

Table 3: OLS estimates (robust z-statistics) in linear regression models, dependent variables: logarithmized household and logarithmized equivalized electricity consumption (3705 observations)

Variables	**Log household electricity consumption**	**Log equivalized electricity consumption**
Values and norms		
Conservative policy identification	-0.034** (-2.05)	-0.033** (-2.03)
Liberal policy identification	0.005 (0.34)	0.006 (0.41)
Social policy identification	-0.039** (-2.46)	-0.040** (-2.50)
Ecological policy identification	0.006 (0.36)	0.008 (0.48)
Environmental awareness	0.000 (0.18)	0.000 (0.19)
Warm glow motives	0.031 (1.46)	0.029 (1.38)
Expectation society	-0.004 (-0.24)	-0.004 (-0.26)
Contribution social environment	-0.012 (-0.77)	-0.014 (-0.90)
Economic preferences		
Patience	-0.200*** (-2.88)	-0.207*** (-2.99)
Risk-taking preferences	0.010 (0. 62)	0.012 (0.80)
Altruism	0.035 (1.04)	0.028 (0.82)
Trust	-0.004 (-1.29)	-0.003 (-1.01)
Positive reciprocity	0.001 (0.20)	0.001 (0.20)
Negative reciprocity	0.003 (1.27)	0.003 (1.17)
Socio-demographics		
Age	0.004*** (6.59)	0.004*** (6.76)
Female	-0.041*** (-2.84)	-0.041*** (-2.87)
High education	-0.073*** (-4.13)	-0.067*** (-3.84)
Good health	-0.070*** (-4.98)	-0.070*** (-4.99)
Number of adults in household	0.191*** (18.09)	-0.008 (-0.83)
Number of children in household	0.101*** (8.56)	-0.016 (-1.48)
Log household income	0.052*** (3.73)	-- (--)
Log equivalized income	-- (--)	0.034** (2.42)

Individual housing and dwelling characteristics		
Relocation in last ten years	-0.081*** (-5.39)	-0.081*** (-5.47)
Living in Western Germany	0.073*** (4.53)	0.080*** (4.98)
Living in house	0.114*** (5.32)	0.122*** (5.80)
Housing ownership	-0.007 (-0.35)	-0.002 (-0.10)
Log household dwelling size	0.307*** (11.44)	-- (--)
Log equivalized dwelling size	-- (--)	0.278*** (10.87)
Heating with electricity	0.159*** (6.09)	0.157*** (6.02)
Water heating with electricity	0.180*** (11.82)	0.182*** (12.03)
Constant	5.547*** (38.01)	5.955*** (39.23)

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