Quality Uncertainty and the Market for Renewable Energy: Evidence from German Consumers*

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Abstract

Consumers can choose from a wide range of electricity supply contracts, including green power options. Electricity produced from renewable energy involves information asymmetries. With a sample of more than 2,000 German electricity consumers, we tested the proposition of a lemon market for renewable energy in a discrete choice experiment. Specifically, we found that, compared to investor-owned firms, additional willingness-to-pay for renewable energy is approximately double when offered by cooperatives or municipally-owned electricity utilities. Consumers who are experienced with switching suppliers have an additional willingness-to-pay of one Eurocent per kilowatt hour for cooperatives and two Eurocents for public enterprises. The results demonstrate that organizational transformation in dynamically-changing electricity markets is not only driven by political initiatives but also by consumers choices on the market. Public policy may reduce information asymmetries by promoting government labeling of green energy products.

Keywords: Cooperatives; Discrete Choice Experiment; Energy Transition; Germany; Willingness-to-Pay

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1 Introduction

Over the past two decades, European retail markets for electricity have changed fundamentally, and market deregulation has occurred in most countries. Currently, electric utilities owned by municipalities compete for customers with investor-owned firms, newly formed consumer-owned cooperatives and other citizen-initiated business models in power generation [Yildiz, 2014; Yildiz et al., 2015]. In the fulfillment of international agreements, European countries strive for greening their energy systems, and various policy instruments have been established to ensure a reduction in carbon emissions from electricity generation [Lehmann et al., 2012]. For instance, Germany - Europes largest economy - has decided to phase out the utilization of nuclear power and increase its share of renewable energy sources in electricity generation to at least 40 percent by the year 2025 (Renewable Energy Act, 2014). At the municipal level, political referenda initiated by citizens have called for the reorganization of local energy supply. In Hamburg, Germanys second largest city, a majority has been achieved in a political referendum in favor of a deprivatization of the local electricity grid and generation capacities. In Berlin, a similar initiative has reached a majority of 83 percent, but the necessary quorum of 25 percent was missed by 0.9 percent. In both cases, citizens proposed a remunicipalisation by the city or a cooperative model based on the joint investment of citizens in a democratically controlled and consumer-owned enterprise. In addition to the role that citizens play in the political process, they have also started to choose the type of supplier they want on the market. Since 1998, German electricity consumers can freely choose from a wide range of electricity suppliers and tariffs, including green power options. Besides price, a suppliers general service, or the share of renewable energy, various characteristics of suppliers have been identified as important attributes of electricity contracts in discrete choice experiments [Amador et al., 2013]. Firm size, location, or commitments to price transparency affect consumers willingness-to-pay for electricity [Kaenzig et al., 2013; Sagebiel et al., 2014], and differences exist between groups of customers [Sardianou and Genoudi, 2013]. However, these studies have overlooked the fact that supplier characteristics may interact with other properties of supply contracts. In particular, a consumers willingness-to-pay for renewable energy may not only depend on the share of renewable energy in the mix, but may interact with the suppliers commitment to transparency. For the consumers it will be important to know how exactly the renewable energy they buy is produced and how easily these hidden attributes can be observed. The objective of this paper is therefore to study willingness-to-pay of consumers for renewable energy differentiated by the type of supplier. We use data from a discrete choice experiment with German electricity consumers to test if willingness-to-pay for renewable energy differs by supplier governance, namely between cooperative, municipally-owned, and privately owned electric utilities.

2 Literature and Theoretical Framework

2.1 Previous Studies on Consumer Preferences for Renewable Energy

In Germany the market for renewable energy is well-developed, and consumers often pay premiums for electricity generated from renewable energy [Kaenzig et al., 2013]. A large literature is concerned with estimating consumers willingness-to-pay for renewable energy based on stated preferences methods in the absence of adequate revealed preferences market data [see Bigerna and Polinori, 2015; Ma et al., 2015; Soon and Ahmad, 2015; Sundt and Rehdanz, 2015, for recent meta-analyses]. Ma et al. [2015] used a meta-regression to identify the most important factors influencing willingness-to-pay. Among other variables, the authors regressed study design, average income, and average electricity consumption on the willingness-to-pay for renewable energy in US $ Cent per kilowatt hour (kWh). They found an average additional willingness-to-pay of 1.5 Cent per kWh, ranging from -39.6 Cents per kWh to 16.9 Cents per kWh. Willingness-to-pay was substantially higher if the survey used a discrete choice experiment and substantially lower if it was conducted online. Using a similar approach, Bigerna and Polinori [2015] were concerned with understanding the factors that drive consumers acceptance of renewable energy. The authors found that additional willingness-to-pay for renewable energy is substantially higher in Europe and lower in the United States. Similarly, Sundt and Rehdanz [2015] found that willingness-to-pay for renewable energy is lower in the United States. In contrast to Ma et al. [2015], they did not find an impact of the method chosen. Soon and Ahmad [2015] used a meta-regression to investigate differences in monthly willingness-to-pay for electricity from renewable energy. In their study, households would pay on average approximately seven US$ per month to move from electricity produced from conventional sources to renewable energy. Contrary to Bigerna and Polinori [2015] and Sundt and Rehdanz [2015], households from the United States had a higher and households from Asia a lower willingness-to-pay when compared to Europe. Based on a sample of 33 subjects from Germany and an innovative neuroscience-based method, Herbes et al. [2015] estimated additional consumer willingness-to-pay for renewable energy at approximately 15% above that for conventional energy. Krishnamurthy and Kriström [2014] used survey data from eleven OECD countries to estimate price and income elasticities for renewable energy. They found that demand for renewable energy is relatively price-inelastic in the Netherlands and Japan and relatively price-elastic in Australia, Canada, Chile, and Spain, whereas income elasticities are relatively low across all countries. Štreimikienė and Baležentis [2015] estimated willingness-to-pay for renewable energy in Lithuania which in line with previous studies from other countries was positive and driven by income, education, and environmental awareness. Vecchiato and Tempesta [2015] found a positive willingness-to-pay for renewable energy among Italian consumers. The authors distinguished between different sources of renewable energy, and they found that solar was the preferred option. Although there is growing consensus that consumers are generally willing to pay more for electricity from renewable energy [Bigerna and Polinori, 2015; Ma et al., 2015; Soon and Ahmad, 2015; Sundt and Rehdanz, 2015], several drivers of consumers willingness-to-pay are not yet fully explored in the literature. Kaenzig et al. [2013] have proposed that the organizational and institutional context of an electricity supplier influences consumers willingness-to-pay for renewable energy. In a study of German consumers, they did not find a large impact of size of the utility. However, electricity produced in Eastern Europe showed a substantially lower willingness-to-pay, and the presence of certification schemes increased consumers willingness-to-pay. [Sagebiel and Rommel, 2014] investigated preferences for the organizational form of the electricity supplier using a sample of 800 private households in Hyderabad, India. They found a positive willingness-to-pay for a state-owned company by the majority of respondents. Sagebiel et al. [2014] picked up this idea and used a transaction cost economics framework to estimate willingness-to-pay for electricity among a convenience sample of German students. The study focused on specific organizational attributes of the providing utility, such as geographic distance to the consumer, number of owners, price transparency, and decision-making procedures. Based on the same data, Müller and Sagebiel [2015] investigated the interaction of these properties with the share of renewable energy in the electricity mix. In the same vein, we argue here that organizational properties of the providing utility mediate consumers willingness-to-pay for renewable energy. This paper differs from earlier work in at least three aspects. First, unlike our previous studies [Müller and Sagebiel, 2015; Sagebiel et al., 2014], the analysis rests upon a large sample from a representative consumer panel provided by the marketing research institute forsa.omninet. Second, our theoretical framework introduces the idea of quality uncertainty and credence good characteristics into the more general discussion on labeling and trust. Third, instead of using a large number of specific organizational attributes, in this study, we opted for broader organizational labels that are well-known to respondents. This allows us to distinguish willingness-to-pay estimates by organizations that operate in the actual market under investigation.

2.2 Theoretical Framework

Consumers can observe and experience numerous attributes of contracts with their electric utility. Some attributes are independent of the contract and known to the consumer ex-ante (e.g., the expected frequency of power cuts). Other attributes can be experienced by the consumer ex-post (e.g., response time after a complaint is placed). A third group can neither be observed ex-ante nor experienced ex-post. For instance, consumers cannot easily obtain information on the electricity generation process. This is important because, today, different standards regarding electricity generation from renewable energy exist, and firms have adopted a wide range of generation options. While some companies ensure instantaneous generation from renewable sources at all times, other companies base their green power tariffs on Tradable Renewable Certificates which give rise to relabeling and fraud [Sagebiel et al., 2014]. It is difficult for consumers to observe the electricity generation process and assess its environmental impact, thus creating a potential lemon market [Akerlof, 1970] for renewable energy. In Akerlofs model, there are buyers and sellers of goods. Information is asymmetric, and sellers know the true quality of the good they sell. Buyers have information only on the distribution of quality in the market as a whole. A high quality seller would typically ask for a price higher than a buyer would be willing to pay, thus giving rise to adverse selection (i.e., low quality sellers are dragged into the market, and high quality sellers are pushed out). Market failure and even a complete breakdown of the market can be the result. Akerlof concludes that several economic institutions are created to counteract information asymmetries. For instance, labeling or licensing may exist primarily for reasons of quality monitoring. This idea is the basis for Spences signaling model [Spence, 1973] in which the selling party can reveal the quality of a good by engaging in a costly signal whose price negatively correlates with quality. Investment in the signal will pay off only for sellers of good quality. Consequently, prices can be differentiated by quality on the basis of the signal. Although labels and certification schemes exist for renewable energy in Germany, one study found that less than three percent of consumers know them well [Mattes, 2012]. Even more importantly, less than one quarter of respondents who are actually using a renewable-energy-only tariff are aware of labels and certificates (ibid.) Apart from signaling and labeling, the cost of obtaining information on a company differs by firm type. Because obtaining and processing information is a costly process in itself, consumers may assess quality on the basis of these generic firm types as quasi-labels. Vis--vis locally producing firms (e.g., utilities run by the municipality or consumer-owned businesses like cooperatives), it might be easier to obtain information regarding the electricity generation process [Bonus, 1986; Vetter and Karantininis, 2002]. Specifically, the consumers might believe that because information from municipally-owned utilities and cooperatives is accessible at low cost, these firms may be more trustworthy and less likely to engage in dishonest behavior when reporting quality [Castaldo, 2007; Oehlmann and Meyerhoff, 2016]. Thus, the organizational form of the distribution company might help to reduce information asymmetries.

3 Material and Methods

3.1 Empirical Strategy

We modeled consumer utility from electricity consumption on the basis of alternative supply contracts that differ in their attributes. Utility U_{int} of respondent n in choice situation t of alternative i is derived from characteristics A_{int}, where the effect on utility of each element in A_{int} is described by parameter vector β. One element in A_{int} represents the cost associated with an alternative, and $\beta_c ost$ is the respective parameter. We applied a random utility approach so that utility U_{int} is comprised of a deterministic part V_{int} and a stochastic part

ϵ_{int}. The ϵ_{int} are identical and independent (iid) extreme value type I distributed with the cumulative distribution function $F(\epsilon_{int}) = exp(-exp(\epsilon_{int}))$. The utility function then becomes:

$$U_{int} = V_{int} + \epsilon_i nt = \beta A_{int} + \epsilon_{int} \quad (1)$$

In order to estimate willingness-to-pay values from this model, a transformation of the parameters is needed. In particular, the trade-off between the cost and any other attribute must be calculated. Formally, a willingness-to-pay value describes the amount of money a respondent would spend on a marginal increase of an attribute while keeping the utility level constant. Willingness-to-pay is calculated by taking the total derivate of the utility function, setting dU to zero, and solving for $dCost$. With a utility function that is linear in parameters, as used here, willingness-to-pay becomes

$$-\frac{\beta_{attribute}}{\beta_{cost}} \quad (2)$$

We expect preferences for electricity suppliers and for renewable energy to be heterogeneous. Some people may be more environmentally aware than others, resulting in a larger willingness-to-pay for renewable energy. Consumers may also have had negative experiences with a certain type of supplier or they may be more familiar with the electricity market, thus making different choices when offered the same product. Ultimately, in any study the assumption of heterogeneity in preferences should be reasonably justified and empirically tested by incorporating it in the analysis in both environmental [Farizo et al., 2014a,b; Varela et al., 2014] and energy economics [Sagebiel, 2011; Van Rijnsoever et al., 2015]. Although there is consensus that preference heterogeneity exists, its sources are often difficult to identify. Some preference heterogeneity may be explained through observed socio-economic factors, e.g., attitudes or inferred knowledge and familiarity with the good. Such factors could also include the broader context of a respondent, e.g., current endowments with the good under question and regional characteristics [Varela et al., 2014]. Other sources of preference heterogeneity might remain unobserved. A number of econometric models allows for unobserved preference heterogeneity by imposing different error structures. The latent class model and the random parameters model are most commonly applied in the empirical literature (cf. Sagebiel, 2011 for an overview in the context of electricity). Although, additional models have been proposed, including multi-level mixed models [Farizo et al., 2014a,b], discrete mixture models [Hess et al., 2007; Varela et al., 2014], and random parameters latent class models [Greene and Hensher, 2013], there is no theoretical argument for choosing one particular distribution of preference heterogeneity [Hensher and Greene, 2003]. Consequently, the choice must be based on practical considerations, statistical measures of fit, and the researchers judgment [Glenk et al., 2012; Sagebiel, 2011]. In this study, we estimated different specifications of mixed and latent class logit models. In some cases, the latent class logit model outperformed the mixed logit model in terms of measures of fit. However, the mixed logit model showed stable results and plausible parameter estimates which are in line with earlier studies [Müller and Sagebiel, 2015; Sagebiel et al., 2014]. Our main interest was to obtain willingness-to-pay values for which a continuous distribution of preferences eases interpretation without introducing bias (mean willingness-to-pay values are effectively identical in both models). Finally, we opted for a mixed logit model with random parameters, where utility parameters from β are assumed to be normally distributed with density $f(\beta)$ [Hensher and Greene, 2003]. The normal distribution is the most commonly used distribution, because of its relatively simple estimation and interpretation. Sometimes other distributions are a better fit to a particular context and a set of assumptions. For instance, the log-normal distribution ensures that parameters are always positive. However, in our case it is reasonable to assume that some people might have a negative utility from renewable energy and other attributes [Sagebiel, 2011]. Moreover, with large parameters and small standard deviations, the probability of a change in signs is lows, and the normal distribution ensures a much simpler estimation procedure [Meijer and Rouwendal, 2006; Sillano and de Dios Ortand, 2005]. The panel data random parameters (mixed) logit choice probability is given by

$$Pr_n(y=j) = \int_{-\infty}^{\infty} \prod_{t=1}^{T} \frac{exp(V_{jnt})}{\sum_{i=1}^{I}(exp(V_{int}))} f(\beta) d\beta \tag{3}$$

Parameters β can be estimated by using the maximum simulated likelihood method [Train, 2009]. Our discrete choice experiment contained labeled alternatives for three different types of suppliers. Respondents could choose between a cooperative, an investor-owned firm, and a municipally-owned enterprise. In addition, contracts differed in their price per kWh, ranging from 23 to 30 Eurocents and the share of renewable energy (either 0%, 33%, 67%, or 100% share of renewable energy). In the modeling approach, we used alternative-specific parameters for the share of renewable energy and a generic parameter for the cost attribute. Each supplier is identified with an alternative-specific constant (ASC) where we used the constant for an investor-owned firm as the reference. The utility function for each alternative i is

$$V_i = \beta_i ASC_i + \beta_{Ren_i} Ren_i + \beta_c Cost_i \tag{4}$$

where i represents the supplier type, Ren_i is the share of renewable energy from a supplier of type i, the βs are parameters measuring the impact on utility, and $Cost_i$ is the price per kWh charged by supplier i.

3.2 Experimental Design and Data

An introductory text explained both attributes to respondents prior to the discrete choice experiment. We used a d-efficient experimental design, optimized for a multinomial logit model with priors taken from a previous study [Sagebiel et al., 2014], created with the software package NGene [ChoiceMetrics, 2012] which resulted in 24 choice sets divided into three blocks. Thus, each respondent faced eight choice sets. We randomized the order of presentation of choice sets to avoid bias from fatigue and learning effects [Savage and Waldman, 2008]. Table 1 shows a sample choice set.

Table 1: Example of a Choice Set

	Cooperative	**Municipally-owned**	**Private**
Share of Renewable Energy	67%	33%	100%
Price	0.29 Euro per kilowatt hour	0.27 Euro per kilowatt hour	0.23 Euro per kilowatt hour
I choose			

The survey was conducted online from March 10, 2014 to March 24, 2014 with 2,174 German consumers who were older than 18 years and took or would take part in the decision on the electricity supply company of their household. In collaboration with the marketing research institute forsa.omninet, respondents were randomly selected from a panel of 10,000 German households that are representative of Germany with respect to age, income, gender, education, and region. The response rate was 46%. The questionnaire included socio-demographic and attitudinal questions as well as questions concerning energy use. The mean time for completion was approximately 20 minutes. Table 2 presents summary statistics for some important socio-demographic variables of respondents.

Table 2: Summary Statistics of Selected Respondent Characteristics

Variable	**Description**	**Obs.**	**Mean**	**SD**	**Min**	**Max**	**German average**	**Test of the hypothesis that sample mean = German average; p-Value**
AGE	Age in years	2,174	52.78	14.11	19	86	50.32[a]	t-test; p = 0.00
CHANGED	= 1 if respondent has changed supplier in the past	2,169	0.51	0.5	0	1	0.361[b]	One sample binomial test; p = 0.00
FEMALE	= 1 if respondent is female	2,174	0.45	0.49	0	1	0.50[c]	One sample binomial test; p = 0.00
INCOME	Categories for net household monthly income (1 = less than 500 Euros, 10 = more than 4,500 Euros)	1,887	5.6	2.23	1	10	3,132[d]	-
HHSIZE	Number of persons living in the household	2,156	2.19	1.08	1	7	2.2[e]	t-test; p = 0.85
EDUCATION	Highest degree (1 = no degree, 7 = university degree)	2,117	3.68	1.87	1	7		
UNIVERSITY DEGREE	= 1 if person has a university degree	2,117	0.16	0.37	0	1	15.9% = 7[f]	One sample binomial test; p = 0.74
MARRIED	= 1 if married	2,130	0.56	0.49	0	1	.46 [a,g]	One sample binomial test; p = 0.00

Sources: a) Includes only people older than 18 years, Statistisches Bundesamt [2016b]; b) Statista [2016]; c) [Statistisches Bundesamt, 2014a, p.6]; d) Net household income in Euro per month, [Statistisches Bundesamt, 2015a, p.21]; e) Statistisches Bundesamt [2015b]; f) Statistisches Bundesamt [2016a]; g) Statistisches Bundesamt [2014b]

Respondents were on average 52 years old, and roughly half of the respondents were male. The mean monthly income on a ten-point scale was 5.6 (equivalent to 2,000 to 3,000 Euros), and respondents lived in households with two members on average. More than half of the respondents were married. We used a seven-point ordinal scale that included the most common educational attainments in Germany for asking about education. Less than two percent of respondents did not have any degree, and approximately 16 percent had a college or university degree. Roughly half of the respondents had previous experience with changing the electricity supply company. The last two columns of the table show data of the German population average and if applicable test results for a comparison of our sample mean with population data. Although for most variables the differences in means are statistically significant at the one percent level, absolute deviations are rather small. Our survey started with a filter question to include only people who participate in the households decisions on electricity, which might help to explain why male respondents and respondents with experience in changing their supplier are somewhat over-represented in our sample.

4 Results

Table 3 presents estimation results and willingness-to-pay values for two different specifications of the mixed logit model. Note that columns 2 and 4 present coefficient estimates; columns 3 and 5 present willingness-to-pay values. Model 2 is an extension of Model 1 that controls for socio-demographic preference heterogeneity by introducing interaction terms with the type of supplier (a dummy variable for female respondents; a dummy variable for respondents who have switched to another supplier in the past; age in years). For easier interpretation of coefficients, we used deviations from the mean instead of absolute values for the socio-demographic interaction terms.

Table 3: Model Results and Willingness-to-Pay Values

	(1) Attributes only		(2) Socio-demographic Interactions	
Mean	Coefficients	Willingness-to-pay	Coefficients	Willingness-to-pay
Municipally	1.152*** -0.059	1.819*** -0.0898	1.182*** -0.0602	1.867*** -0.0921
Coop	0.347*** -0.0572	0.548*** -0.0899	0.403*** -0.0582	0.636*** -0.0914
Price	-0.633*** -0.0106		-0.633*** -0.0106	
Coop x Ren	0.954*** -0.0358	1.506*** -0.0532	0.957*** -0.0356	1.512*** -0.0529
Municipally x Ren	1.066*** -0.04	1.682*** -0.0584	1.073*** -0.0398	1.695*** -0.0579
Investor x Ren	0.487*** -0.0373	0.769*** -0.0585	0.510*** -0.0368	0.806*** -0.0579
Coop x Female			0.243** -0.0984	0.384** -0.155
Municipally x Female			0.534*** -0.0982	0.844*** -0.155
Coop x Changed			0.543*** -0.0974	0.858*** -0.154
Municipally x Changed			1.166*** -0.0976	1.841*** -0.154
Coop x Age			0.00781** -0.00339	0.0123** -0.00536
Municipally x Age			0.0244*** -0.00342	0.0385*** -0.0054
Standard Deviations of Random Parameters				
Coop x Ren	1.148*** -0.0394		1.132*** -0.0396	

Municipally x Ren	1.291***		1.265***	
	-0.0441		-0.0437	
Investor x Ren	1.224***		1.179***	
	-0.0412		-0.0404	
N		52176		52056
AIC		22429.5		22129.6
BIC		22509.2		22262.5
		3677.6		3446.8
Log Lik. (NULL)		-13044.6		-12773.2
Log Lik.		-11205.7		-11049.8

Standard errors in parentheses, Ren: renewable energy, Coop: Cooperative
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Both models have a high explanatory power as indicated by the large χ^2 values. Parameter estimates are similar in both models. Small differences result from the slightly different samples due to missing observations for some of the socio-demographic variables (cf. Table 2), rounding errors, and random draws even with the same seed used in the simulation process. Positive signs for the type of supplier (Municipally-owned, Cooperative) show that consumers prefer electricity supplied by cooperatives or municipally-owned utilities compared to the baseline of an investor-owned firm. As expected, the coefficient of Price is negative and statistically significantly different from zero, indicating that respondents, ceteris paribus, prefer lower prices. Large, positive, and statistically significant coefficients for the interaction variables of supplier type with renewables indicate that renewables in the energy mix are preferred. Differences in these coefficients indicate that the slope of the increase differs by supplier type. Significant standard deviations of the random parameters show that preferences are heterogeneous, although socio-demographic variables already capture some heterogeneity in specification (2). Specifically, willingness-to-pay for electricity from cooperatives and municipally-owned utilities increases with age, being female, and having experience with a change in supplier. In a dynamically changing market, customers continuously learn. Notably, in the model that includes observed heterogeneity, customers who are experienced with switching their supplier exhibit a larger willingness-to-pay of 0.86 Eurocent per kWh for cooperatives and 1.84 Eurocents per kWh for public enterprises.

Based on model specification (1), Table 4 displays consumers additional willingness-to-pay by type of supplier and share of renewable energy in the power mix. It can be easily seen that consumers prefer electricity provided by municipally-owned suppliers the most, followed by cooperatives. The increase in willingness-to-pay for renewable energy is steep for municipally-owned suppliers and cooperatives. It is lower roughly half for investor-owned firms.

Table 4: Additional willingness-to-pay in Eurocents per kilowatt hour by share of renewable energy and supplier type

		Share of renewable energy is			
		0%	33%	67%	100%
Firm is	investor-owned	0 (Baseline)	0.769	1.538	2.306
			-0.0585	-0.117	-0.176
	municipally-owned	1.819	3.501	5.184	6.866***
		(-0.0898)	(-0.0907)	(-0.123)	(-0.171)
	a cooperative	0.548	2.054	3.560	5.066
		(-0.0899)	(-0.089)	(-0.116)	(-0.157)

Source: own calculations based on delta method; standard errors in parentheses; all estimates are statistically significant at the 1%-level.

5 Discussion

Between 2011 and 2013, the price of a kWh of retail level electricity was between 25 and 29 Eurocents in Germany, including all taxes [Eurostat, 2014]. In our estimates, between non-renewable energy from an investor-owned firm and renewable energy from a municipally-owned utility, one can observe a difference of approximately seven Eurocents, which is roughly equal to one quarter of total price. The difference between a cooperative and an investor-owned firm is less than one Eurocent for non-renewable energy; these figures increase to a difference of approximately two and a half Eurocents for tariffs that are entirely based on renewable energy. Trust vis--vis public enterprises and vertical integration via consumer cooperatives appear to be important determinants of willingness-to-pay for renewable energy. Our willingness-to-pay values for renewable energy range from 2.3 Eurocents to 6.8 Eurocents per kWh (see last column in Table 4). These estimates are in line with what is commonly found in the stated preferences literature in Germany and other European countries [Ma et al., 2015; Sundt and Rehdanz, 2015]. For instance, Sundt and Rehdanz [2015] provide an estimate of approximately five US Cents per kWh for electricity from renewable energy in Germany, Herbes et al. [2015] estimate additional willingness-to-pay to be approximately 15 percent, and Grösche and Schröder [2011] find an additional willingness-to-pay of approximately 22 percent for moving from zero to 100 percent of renewable energy in the electricity mix. In a study of German electricity consumers, a lack of trust for 16.1 percent of the respondents has been identified as the main reason for not purchasing renewable energy [Rommel and Meyerhoff, 2009]. This lack of trust could be addressed by promoting certification and labeling schemes. However, currently only a few consumers less than three percent are aware of labels and certificates in Germany [Mattes, 2012]. Moreover, the variety of labels makes it difficult for consumers to learn about the differences, and ultimately, there is the meta-problem of quality uncertainty and fraud regarding labeling and certification [Banerjee and Solomon, 2003]. In Akerlofs (1970) model, the idea of quality uncertainty is illustrated by the market for used cars, a good which is different from electricity in many aspects. Unlike in the case of quality uncertainty regarding renewable energy, buyers of used cars will learn about the good they are considering for purchase. Although this does not necessarily have implications on market functioning ex-ante, it can be important when there are repeated transactions because sellers may be able to develop reputations or they may be able to offer guarantees. For credence goods which are consumed on a permanent basis, this is more difficult as uncertainty cannot be reduced with experience. In our analysis we have used labeled alternatives for three types of suppliers that operate in the actual market under investigation: investor-owned firms, municipally-owned utilities, and cooperatives. It is an advantage of our approach that subjects can easily understand this label, and we are able to provide a single willingness-to-pay value that incorporates all aspects of the organizational form. On the other hand, we cannot dig deeper into preferences for particular characteristics of these different supplier types. Because investor-owned firms are often large enterprises, and cooperatives and municipally-owned enterprises are often small, the observed effect could be driven by size. Other studies have shown that such size effects do not play a prominent role in the electricity market [Kaenzig et al., 2013; Sagebiel et al., 2014]. Since electricity markets were liberalized in Germany, public utilities at the regional or state level have become rare. However, there is a recent trend towards the re-involvement of local governments in electricity utilities. For instance, in 2010 the state of Baden-Wrttemberg rebought the majority of shares from the formerly privatized utility EnBW. There is also the phenomenon of some energy cooperatives becoming large enough to operate at the national level [Höfer and Rommel, 2015; Müller et al., 2015]. Ownership of the utility could thus more broadly be distinguished by the type of owner (state, government, or consumers) and size to evaluate the welfare effects of such future scenarios, as has been done in other contexts. For instance, Sagebiel and Rommel [2014] study Indian electricity consumers to investigate this question. The authors find preferences to remain with the status quo of a large state-owned supplier. In future research one may investigate such effects in Germany by conducting a discrete choice experiment to distinguish willingness-to-pay for the type of owner (private vs. government-owned vs. consumer-owned) and size or scope of operation (supplying many customers or operating at the national level). Our results have shown that there is substantial heterogeneity in preferences regarding the type of supplier. In particular, women, older respondents, and respondents who have experience with switching suppliers exhibit higher willingness-to-pay values for utilities that are not investor-owned. In a study on the marketing efforts of German electricity utilities, Herbes and Ramme [2014] show that firms could improve in communicating environmental benefits to consumers on their websites. Our findings suggest that municipally-owned utilities and cooperatives should also take some effort in communicating their firm type, especially to the elderly and female demographic segments of the market. Marketing channels that are more likely to reach these groups might be preferred. The same applies to people who have changed their supplier in the past.

6 Conclusion

Germany and other European countries seek to green their energy systems. Citizens can articulate their preferences regarding the energy system in at least two ways. On the ballot, they can use their voice to push for political change. In the market, they can opt for the type of supplier they prefer. In this paper, we have focused on the latter aspect. We have shown that consumers are often willing to voluntarily adopt renewable energy tariffs, even if the price is higher. Preferences for supplier type are reflected in a higher willingness-to-pay for electricity from public enterprises and cooperatives. Furthermore, there is a large interaction effect between the share of electricity from renewables and supplier type. Currently, the renewable energy market offers opportunities mainly for cooperatives and public enterprises. Experienced customers are especially willing to pay more. Investor-owned firms may counter information asymmetries by ensuring quality and engaging in (credible) labeling schemes to increase transparency for consumers. Alternatively, some firms may completely abandon generation from exhaustible resources, leading to a polarization in the generation portfolio of investor-owned firms. Consumers can then more easily judge the type of energy they buy. Lower revenues for green power options increase investor-owned firms incentives to cheat. If such cases become publicly known and they are attributed to the specific type of firm, consumers willingness-to-pay may be further lowered. A downward spiral, and ultimately a collapse of the lemon market as predicted by Akerlofs (1970) seminal model, may be the result. Our findings also imply that the successful deprivatization of energy suppliers through political initiatives has the potential to increase consumer welfare, particularly when the share of renewables is large. If consumer information websites and consumer protection organizations were to provide more detailed information on the energy mix and the origin of renewables offered by utilities, information asymmetries could be reduced in the future. Public policy may play a role in setting a clear standard of what constitutes electricity from renewable resources and in promoting respective certification and labeling. Labeling by the government may be preferred over private labels because long-term commitment and credibility are crucial for programs to work effectively [Banerjee and Solomon, 2003]. The positive experience with the European label for organic food, which is now mandatory in all members states (Regulation European Commission No. 834/2007), may serve as an example for policy-makers. As Janssen and Hamm [2012] indicate in a study of six European countries, consumers have difficulties understanding and valuing the many different labels available for organic food. However, if compared to private alternatives, national governments labels and the European Union label of organic food products are relatively well-known. Furthermore, trust, credibility, and consumers perceptions of the strictness of standards and their monitoring reaches high levels for these labels. As of now, Germany and other European countries do not have governmental labeling schemes for renewable energy. Thus, there is an opportunity to develop a transparent label at the European level, preventing a variety of national labels to emerge [Truffer et al., 2001].

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