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Abstract. This paper presents evidence that the accumulating costs of Germany's ambitious plan to transform its system of energy provision – the so-called Energiewende – are butting up against consumers' decreased willingness-to-pay (WTP) for it. Following a descriptive presentation that traces the German promotion of renewable energy technologies since 2000, we draw on two stated-preference surveys conducted in 2013 and 2015 that elicit the households' WTP for green electricity. To deal with the bias that typifies hypothetical responses, a switching regression model is estimated that distinguishes respondents according to whether they express definite certainty in their reported WTP. Our results reveal a strong contrast between the households' general acceptance of supporting renewable energy technologies and their own WTP for green electricity.

JEL classification: D12, Q21, Q41.

Key words: Willingness-to-pay, cheap talk, consequential script.

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1 Introduction

In recent years, the political economy of electricity provision in Germany has been strongly influenced by two factors. The first is the country's ongoing commitment to increase the share of renewable energies, with green electricity production amounting to almost 33% of gross consumption by the end of 2015 (BDEW, 2016:11). The second factor is the nuclear catastrophe at Japan's Fukushima in 2011. This event had a profound impact in exacerbating a longstanding skepticism in Germany on the merits of nuclear power and led to the legal stipulation of its phase-out in the same year. Both factors are the most salient pillars of Germany's so-called Energiewende (energy transition), which advances the most ambitious subsidization program in the nation's history, with costs that may approach those of German re-unification.

This paper presents evidence that the accumulating costs of Germany's Energiewende are butting up against consumers' decreased willingness-to-pay (WTP) for it. We begin with a descriptive overview of the growth of renewable energy technologies in Germany since the introduction of the Renewable Energy Act (EEG) in 2000, focusing on increases in both capacity and the associated costs, which are transmitted via a surcharge on the electricity bill. Thereafter, we turn attention to the public's acceptance of these costs, using the results of two stated-preference surveys conducted in 2013 and 2015 to elicit the households' willingness-to-pay (WTP) for green electricity.

One challenge in relying on hypothetical responses is that they may yield estimates of WTP that have a substantial upward bias. This overestimation problem, referred to as hypothetical bias, is a well-known finding in the literature – see the meta-analysis by LIST and GALLET (2001) and the reviews by HARRISON (2006) and HARRISON and RUTSTRÖM (2008). Various techniques have been proposed to remove or, at least, reduce this bias, one of which is the certainty approach conceived by JOHANNESSON et al. (1998). Drawing on survey data collected on two occasions, in 2013 and 2015, and covering more than 6,000 German households, we investigate the effects of the ex-post certainty approach in estimating the socio-economic determinants of the WTP for green electricity. Upon stating their preferences, all households were asked whether they are probably or definitely sure about their WTP responses, following a similar procedure suggested by BLUMENSCHEIN et al. (1998). Recognizing that the respondent's certainty status and WTP might be jointly influenced by unobservable factors, we employ a switching regression model that accounts for the potential endogeneity of respondent certainty and, hence, biases from sample selectivity.

Among our main findings, the descriptive results suggest a marked decrease of about 17% in the average WTP between the 2013 and 2015 waves of the survey, a period during which the surcharge paid by households for green electricity rose by 17%. Moreover, the survey results reveal a strong contrast between the households' general acceptance of supporting renewable energy technologies and their own WTP for green electricity. On the one hand, the share of respondents who agreed with the statement that, in principle, renewable energy technologies should be supported increased from 84.4% in 2013 to 88.0% in 2015. On the other hand, almost 60% of household heads reduced their WTP for 100% green electricity relative to 2013.

The subsequent section provides a summary of Germany's strong expansion of renewable electricity production capacities and the related costs since the introduction of today's feed-in-tariff promotion scheme in 2000. Section 3 describes the data set. Section 4 provides a description of the estimation method, followed by the presentation and interpretation of the results given in Section 5. The last section summarizes and concludes.

2 Costs of Renewable Capacity Expansion

In Germany, renewable energy sources (RES) are promoted via a feed-in-tariff (FIT) system whereby electricity generated from RES has preferential access to the grid and is remunerated at technology-specific, above-market rates that are commonly guaranteed over a 20-year time period. The system has established itself as a global role model and has been adopted by a wide range of countries (CEER, 2013), even some with a high endowment of sun such as Australia (NELSON et al., 2011).

Since the implementation of Germany's FIT system in 2000, installed capacities of renewable energy technologies have increased remarkably, by more than eightfold between 2000 and 2015 (Table 1). Photovoltaic (PV) systems, until recently the most expensive renewable energy technology in Germany, and onshore windmills have experienced the largest increase, with PV capacities sky-rocketing: In 2010 alone, more than 7,000 Megawatt (MW) were installed, an amount that exceeded the cumulated capacities installed by 2008. According to estimations of FRONDEL et al. (2014:9), the real net cost for all those modules installed between 2000 and 2015 amounts to more than 110 billion Euros.

Table 1: Germany's Conventional and Renewable Electricity Generation Capacities in Gigawatt (GW).

Year	Hydro Power	Wind Onshore	Wind Offshore	Photo-voltaics	Biomass	Total RES Capacities	Conventional Capacities
2000	4.83	6.10	–	0.11	0.70	11.75	109.9
2001	4.83	8.74	–	0.18	0.83	14.57	107.9
2002	4.94	11.98	–	0.30	1.03	18.24	106.5
2003	4.95	14.59	–	0.44	1.43	21.41	105.6
2004	5.19	16.61	–	1,11	1.69	24.59	106.0
2005	5.21	18.38	–	2.06	2.35	27.99	107.0
2006	5.19	20.57	–	2.90	3.01	31.67	107.6
2007	5.14	22.18	–	4.17	3.50	34.99	110.2
2008	5.16	23.82	–	6.12	3.92	39.02	110.4
2009	5.34	25.63	0.06	10.57	4.55	46.14	111.4
2010	5.41	27.01	0.17	17.94	5.09	55.61	111.6
2011	5.63	28.86	0.20	25.43	5.77	65.87	103.2
2012	5.61	31.00	0.31	33.03	6.18	76.10	102.1
2013	5.59	33.76	0.51	36.34	6.52	82.71	103.9
2014	5.61	38.16	1.04	38.24	6.87	89.91	104.3
2015	5.58	40.99	2.79	39.70	8.86	97.92	104.1

Sources: BMWi (2016:12), BDEW (2016:13). With an installed capacity of less than 0.05 GW in 2014, geothermic systems are of negligible relevance and not included in the table.

In 2015, total RES capacities reached about 98 Gigawatts (GW), just 6 GW less than those of conventional power plants (last column Table 1), while the share of green electricity in gross electricity consumption was about 33% (BDEW, 2016:11).[1] This re-

[1]On the importance of the distinction between capacity and electricity production, see ANDOR and

latively modest share owes to the fact that wind and solar power are not permanently available 24 hours a day. Consequently, to reach Germany's renewable goals of a 50% share in gross electricity consumption set for 2030 and 80% in 2050, a multiple of today's capacities have to be installed, an endeavor that will inevitably lead to higher costs of electricity generation. These costs were substantial already in the past: Between 2000 and 2015, consumers paid about 125 billion Euros in the form of higher electricity bills for Germany's RES promotion (Table 2), with the cost shares of industrial and household consumers estimated at 31,5% and 34,5% in 2016, respectively (BDEW, 2016:60).

Table 2: Net Costs of Germany's Promotion of Renewable Energy Technologies in Billions of Euros.

Year	Hydro Power (Bn. €)	Wind Onshore (Bn. €)	Wind Offshore (Bn. €)	Photo-voltaics (Bn. €)	Biomass (Bn. €)	Total RES Net Costs (Bn. €)	Average Net Costs per kWh (Cents/kWh)
2000	0.213	0.397	–	0.014	0.042	0.667	6.4
2001	0.295	0.703	–	0.037	0.105	1.139	6.3
2002	0.329	1.080	–	0.078	0.177	1.664	6.7
2003	0.253	1.144	–	0.145	0.224	1.765	6.2
2004	0.195	1.520	–	0.266	0.347	2.430	6.3
2005	0.193	1.518	–	0.636	0.540	2.997	6.8
2006	0.168	1.529	–	1.090	0.896	3.765	7.3
2007	0.121	1.428	–	1.436	1.307	4.338	6.5
2008	0.081	1.186	–	1.960	1.565	4.818	6.8
2009	0.025	1.608	0.003	2.676	1.991	5.301	7.0
2010	0.192	1.647	0.019	4.465	3.000	9.525	11.6
2011	0.263	2.145	0.057	6.638	3.522	12.774	12.4
2012	0.223	2.944	0.092	7.939	4.576	16.008	13.5
2013	0.303	3.165	0.122	8.276	5.172	17.340	13.8
2014	0.301	3.669	0.208	9.166	5.675	19.222	14.1
2015	0.306	4.136	1.717	9.402	5.552	21.066	13.1
Total Costs	3.460	28.818	2.218	54.221	34.689	124.821	–
Cost Shares	2.8%	23.1%	1.8%	43.4%	27.8%	100 %	–

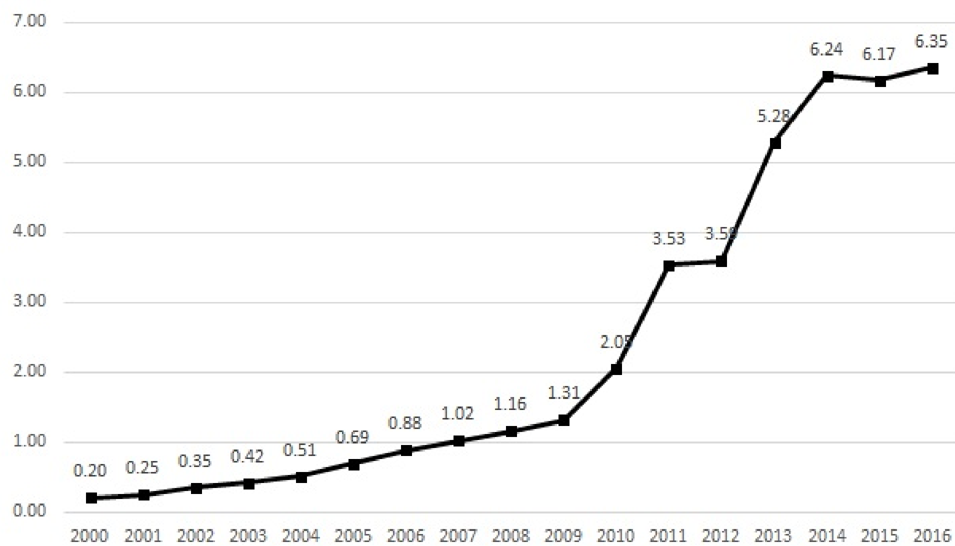
Source: BMWi (2015). Note: Costs of geothermic systems are not included in the table.
Figures for 2015 are unconsolidated forecasts.

The strong increase in alternative electricity generation capacities in Germany

VOSS (2016). These authors conclude that only under very specific circumstances do optimal promotion schemes for renewable energy technologies resemble the demand-independent FIT systems that are popular in many countries.

and the resulting rise in the share of green electricity in consumption led to a surge in the surcharge that appears on German electricity bills (Figure 1). In 2015, the levy of 6.17 cents per kWh comprised roughly 20% of the average per-kWh price of electricity of about 28 cents (Table 3). The increase of this levy is particularly pronounced in the years between 2009 and 2014, a period that largely coincides with the stark extension of PV capacities. In fact, the exploding PV capacity increases in the years 2009-2012 (Table 1) were responsible for the near doubling of average subsidies per kWh between 2009 and 2013 (last column in Table 2). As a consequence, while comprising about 6% of total electricity production (BDEW, 2016:12), PV accounts for 43.4% of total net promotion costs (Table 2), by far the largest cost share among all alternative technologies.

Figure 1: Levy on Electricity Prices (in Cents per kWh) to Support Green Electricity (BDEW 2016:60)



Presuming that the annual subsidy level of more than 20 billion Euros in 2015 (Table 2) is extended for the next two decades, then a crude back-of-the-envelope calculation yields an estimate of 400 billion Euros for the continued promotion of renewable energy. Several considerations render this estimate conservative. First, the annual subsidies are likely to far exceed 20 billion Euros. According to a recent forecast, they will approach 30 billion in 2020 (BDEW, 2016:83), in large part owing to the expansion of offshore-wind capacities, currently the most expensive alternative technology in Germany.

Additional costs arise due to the fact that a large portion of today's conventional power plants has to be sustained to compensate for the intermittency of wind and sun, since storing volatile green electricity is likely to remain unprofitable for the next decades (HESSLER, LOEBERT, 2013:350). Not least, substantial costs of several tens of billions of Euros accrue to consumers from the indispensable expansion of power grids, as the electricity produced by wind power installations in North and East Germany must be transported to the highly industrialized west and south of the country. In short, it is most likely that future electricity prices will rise further if Germany actually reaches its renewable goals.

Table 3: Electricity Prices in Euro Cents per kWh in 2015 for Household and Industrial Consumers in Europe

	Household	Industrial Consumption in Gigawatthours				
	Prices	< 500	< 2,000	< 20,000	< 70,000	< 150,000
Denmark	22.8	26.73	25.90	25.87	24.37	24.18
Germany	28.3	22.76	19.79	17.49	15.05	13.88
Italy	24.4	22.64	18.79	16.65	13.64	11.14
Austria	18.2	14.95	12.47	10.77	9.17	8.32
United Kingdom	16.6	20.05	17.88	16.44	16.03	15.65
Netherlands	17.9	18.06	11.06	9.89	8.51	8.49
France	14.8	14.42	12.08	10.53	9.22	7.71
EU 28	20.8	16.00	13.24	11.74	10.41	13.04

Source: Eurostat (2016). Average Prices including Taxes and Levies in Purchasing Power Standards.

Some sense for the extent of the likely rise can be gleaned from past developments. Between 2000 and 2015, electricity prices more than doubled, from 13.94 to 28.68 ct/kWh (BDEW, 2016:56). For typical households with an electricity consumption of 3,500 kWh per annum, this implies an additional burden of about 520 Euro per year. In terms of purchasing power parities (Table 3), German households now incur the highest power prices in the European Union (EU). In a similar vein, prices for industrial customers are also among the highest in the EU.

Given the now decade-plus history of unabated cost increases, coupled with the prospect that this trend will continue into the foreseeable future, the question arises as to the public's tolerance for continued support of Germany's Energiewende. Although several opinion polls conducted over the years suggest that support has persisted (e. g. AEE, 2014, STATISTA, 2016), such polls are often based on questions that present the costs in collective, rather than individual terms, with one implication being that respondents perceive the cost burden to be distributed across society at large. Empirical studies suggest that the WTP in such collective decision contexts is generally higher than when decisions are reached individually (e. g. WISER 2007, MENGES, TRAUB 2009).

Based on an experiment with monetary incentives, MENGES and TRAUB (2009:338), for example, find that differences in the WTP for green electricity between individual and collective decision contexts can even vary by a factor of three. The authors attribute this difference to free-rider behavior that leads to a lower WTP when decisions on public goods are reached individually. In what follows, our stated preference experiment marks an attempt to measure the support level for RES that emerges when respondents perceive the associated costs to be incurred by themselves individually.

3 Survey Design and Data

To elicit people's WTP for 100% green electricity, we collaborated with the survey institute *forsa*, which maintains a panel of more than 10,000 households that is representative of the German-speaking population.[2] *forsa* collects data using a state-of-the-art tool that allows panelists to fill out the questionnaire using either a television or, if access is available, the internet. Respondents – here the household heads – retrieve and return questionnaires from home and can interrupt and continue the survey at any time.

A large set of socio-economic and demographic background information on all household members is available from *forsa*'s household selection procedure and updated regularly. Within the two survey periods of May 10 to June 17, 2013, and March 3

[2] Information on forsa's panel is available at www.forsa.com.

to April 29, 2015, household heads provided their WTP for green electricity that is exclusively generated from renewable energy technologies. A total of 2,303 respondents provided a WTP bid for 100% green electricity in the 2013 survey, 1,407 of whom did so too in the 2015 survey. There were an additional 4,269 individuals who responded to this question and participated in the survey for the first time in 2015, yielding a total sample size of 7,979 responses (Table 5).

The survey began with a brief introductory text on electricity generation technologies in general. Respondents were then presented with the following text: "We request that you report the maximum amount that you, personally, would be willing to pay. As a basis for comparison, please consider an electricity mix comprised exclusively of the fossil sources coal, natural gas, and oil, which has a price of €100 per month". A more detailed extract of the questionnaire can be found in ANDOR, FRONDEL, VANCE (2014).

While several formats to elicit WTP have been suggested in the literature (see Frew et al., 2003), such as the close-ended, payment scale, and bidding/bargaining formats, the open-ended format used here has the virtue of providing a reference point while at the same time avoiding any binding restrictions on WTP bids. Responses are instead allowed to vary in a very broad range between €0 and €9,999 in discrete increments of €1. A particular advantage of the open-ended format is that, as opposed to the close-ended format, it yields exact WTP information (CARLSSON et al. , 2011:791).

A potential drawback of the open-ended format is the possible occurrence of protest bids, where respondents assign either a zero or an invalidly high value to the good (HALSTEAD et al., 1992). Our empirical analysis indicates, however, that protest bids are hardly present in our data base. For example, with 2.9%, the share of zero bids for 100% green electricity is small, and the incidence of very high bids is even lower: while the mean bid is €99.4 (Table 4), only 0.6% of the sample reported a bid greater than €200. These outcomes provide for an indication that another point of skepticism toward the open-ended format does not apply to our study: If this hypothetical open-ended design had not been incentive-compatible, as is frequently criticized in the literature, the share of zero bids would presumably be higher, as perfectly rational respondents would state a zero bid when their WTP is much lower than the costs of electricity.

Table 4: Mean WTP for 100% Green Electricity and t Statistics on Differences Between those who are either Definitely or Probably Certain about their WTP

		Certainty on WTP		
Survey		Definitely Certain	Probably Certain	
Years		$C = 1$	$C = 0$	Overall
2013				
	Number of observations	1,232	1,040	2,272
	Shares	54.23%	45.77%	100%
	Mean WTP	113,3	112,1	112,8
	H_0: WTP ($C = 1$) - WTP ($C = 0$) = 0		t = 0,683	
2015				
	Number of observations	4,117	1,551	5,668
	Shares	72.64%	27.36%	100%
	Mean WTP	95,7	89,9	94,1
	H_0: WTP ($C = 1$) - WTP ($C = 0$) = 0		t = 2,917	
2013& 2015				
	Number of observations	5,349	2,591	7,940
	Shares	67.37%	32.63%	100%
	Mean WTP	99,7	98,8	99,4
	H_0: WTP ($C = 1$) - WTP ($C = 0$) = 0		t = 0,637	

Upon stating their WTP bids, the respondents were asked about the certainty of their response. For this purpose, we use the certainty approach in the version suggested by BLUMENSCHEIN et al. (1998), which asks whether they are probably or definitely sure about their WTP responses. The share of respondents who are definitely sure about their WTP responses on 100% green electricity, described by certainty variable C, amounts to 67.37%, implying that a minority of 32.63% is just ‘probably sure’ (Tables 4 and 5). As elaborated in the subsequent section, we assume that dummy variable C reflects an endogenous decision of the respondents. This assumption appears to be warranted given the considerably unequal shares of respondents across certainty groups, which indicates that the selection into either of the two certainty groups is non-random.

Table 5: Variable Definitions and Descriptive Statistics

Variable Name	Variable Definition	Mean	# of Obs.
WTP	Willingness-to-pay for 100% green electricity	99.42	7,979
Age31-40	Dummy: 1 if age of respondent is between 31 and 40	0.110	7,979
Age41-50	Dummy: 1 if age of respondent is between 41 and 50	0.187	7,979
Age51-60	Dummy: 1 if age of respondent is between 51 and 60	0.262	7,979
Age>60	Dummy: 1 if respondent is older than 60	0.381	7,979
Female	Dummy: 1 if respondent is female	0.319	7,979
Children	Dummy: 1 if respondent has children	0.166	7,450
C	Dummy: 1 if household ticked the option 'definitely sure' for the certainty question	0.674	7,940
College Prep Degree	Dummy: 1 if household head has a college preparatory degree	0.429	7,400
Low Income	Dummy: 1 if net monthly household income is lower than €1,251	0.180	7,979
Medium Income	Dummy: 1 if net monthly household income is between €1,251 and €2,750	0.211	7,979
High Income	Dummy: 1 if net monthly household income is between €2,751 and €4,250	0.216	7,979
Very High Income	Dummy: 1 if net monthly household income exceeds €4,250	0.233	7,979
East Germany	Dummy: 1 if household resides in in East Germany	0.198	7,979
2. Survey Wave	Dummy: 1 if observation originates from the 2. Survey	0.714	7,979
Price Knowledge	Dummy: 1 respondent has correctly indicated the broad range of average electricity prices	0.218	7,979
Levy Knowledge	Dummy: 1 respondent has correctly indicated the broad range of the levy for renewables	0.262	7,979

Table 4 shows that there is no substantial difference in WTP bids across certainty status in the year 2013 and a modest difference in 2015, with the WTP of certain respondents being roughly six Euros higher. Much larger differences are seen over time: for both groups, the mean WTP shrinks substantially. For instance, for those who are definitely certain, the t-test statistic for the test on the null hypothesis H_0: WTP_{2015} $(C = 1)$ - WTP_{2013} $(C = 1)$ = 0 amounts to -9.61, suggesting the rejection of H_0. Likewise, for the probably certain the t-test statistic of -8,14 suggests rejecting H_0: WTP_{2015} $(C = 0)$ - WTP_{2013} $(C = 0)$ = 0. Altogether, the results indicate a marked decrease of about 17% in the mean WTP between the 2013 and 2015 waves of the survey, from 112,8 to 94,1 Euros (Table 4). It bears noting that even if a hypothetical bias exists in the individual WTP bids, the intertemporal difference in these bids is an unbiased estimator of the change in the true WTP if the hypothetical bias in an individual WTP bid is the same across survey years.

Furthermore, the survey results reveal a strong contrast between the households' general acceptance of supporting renewable energy technologies and their own WTP for green electricity. On the one hand, almost 60% of those household heads who participated in both surveys reduced their WTP relative to 2013. On the other hand, the share of respondents who agreed with the statement that, in principle, renewable energy technologies should be supported increased from 84.4% in 2013 to 88.0% in 2015 when considering the responses of all those 5,004 household heads who answered to this question in both surveys. (The respective shares amount to 85.2% and 88.5% when considering all responses.)

4 Estimation Methodology

To cope with the potential endogeneity of certainty variable C, we apply a switching regression model with endogenous switching (see MADDALA 1983:223-228). The WTP of household heads is described by two regression equations that divide respondents into two regimes, those who are definitely certain about their WTP on green electricity (Regime 1) and those who are just probably certain (Regime 0):

$$WTP_{1i} = \boldsymbol{\beta}_1^T \cdot \mathbf{x}_{1i} + u_{1i}, \quad \text{if } C_i = 1 \quad (\text{Regime } 1), \tag{1}$$

$$WTP_{0i} = \boldsymbol{\beta}_0^T \cdot \mathbf{x}_{0i} + u_{0i}, \quad \text{if } C_i = 0 \quad (\text{Regime } 0). \tag{2}$$

In this equation system, WTP_{1i} and WTP_{0i} denote the household heads' individual WTP bids and $\mathbf{x}_{1i}$ and $\mathbf{x}_{0i}$ include their determinants, such as net household income, while $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_0$ are vectors of the associated parameters to be estimated.

C is a dummy variable indicating the certainty regime:

$$\begin{aligned} C_i &= 1 \qquad \text{if } \boldsymbol{\gamma}^T \cdot \mathbf{z}_i \geq u_i, \\ C_i &= 0 \qquad \text{otherwise,} \end{aligned} \tag{3}$$

where $\mathbf{z}_i$ includes factors that may affect whether a household head i is either definitely certain about her WTP bids ($C_i = 1$) or just probably certain ($C_i = 0$). In the endogenous switching regression model, the error term u_i is assumed to be correlated with the errors u_{1i} and u_{2i} of equations (1) and (2), as there may be unobservable factors that are relevant for both the selection into either regime and WTP bids.

Identification of the switching regression model requires the specification of at least one variable that determines the discrete first-stage outcome on WTP certainty, but not the continuous WTP response relevant for second-stage regression. We specify two such exclusion restrictions, both of which are based on the respondents' familiarity with electricity provision asked during the survey. The first is a dummy indicating whether the respondent is able to correctly state the per-kWh price of electricity within an error margin of 3 cents (*Price Knowledge*), while the second is a dummy indicating whether the respondent provides a good guess of the levy paid for renewable energy (*Levy Knowledge*), within an error margin of 1 cent per kWh. By law, this levy, which at the time of the 2013 survey was 5.3 cents per kWh (Figure 1), is included on every electricity bill. 26.2% of those respondents who provided a WTP bid for green electricity had a broad knowledge about the correct level of the levy paid for renewable energy (Table 5), whereas 21.8% of them had a crude idea about the level of average electricity prices.

The unknown parameter vector $\boldsymbol{\gamma}$ that determines the (first-stage) certainty regime (3) can be estimated – up to a scale factor – using standard probit maximum likelihood methods, where, due to the indeterminacy of the scale factor, $Var(u_i) = 1$ can be assumed. The second-stage equations to be estimated are

$$WTP_{1i} = \boldsymbol{\beta}_1^T \cdot \mathbf{x}_{1i} - \sigma_{1u} \cdot \text{IVM}_{1i} + \varepsilon_{1i}, \text{ for } I_i = 1, \tag{4}$$

$$WTP_{0i} = \boldsymbol{\beta}_0^T \cdot \mathbf{x}_{0i} + \sigma_{0u} \cdot \text{IVM}_{0i} + \varepsilon_{0i}, \text{ for } I_i = 0, \tag{5}$$

where ε_{1i} and ε_{0i} are new residuals with zero conditional mean and

$$\mathrm{IVM}_{1i} := \frac{\phi(\gamma^T \cdot \mathbf{z}_i)}{\Phi(\gamma^T \cdot \mathbf{z}_i)}, \qquad \mathrm{IVM}_{0i} := \frac{\phi(\gamma^T \cdot \mathbf{z}_i)}{1 - \Phi(\gamma^T \cdot \mathbf{z}_i)} \tag{6}$$

represent the two variants of the inverse Mills ratios, with $\phi(.)$ and $\Phi(.)$ denoting the density and cumulative density function of the standard normal distribution, respectively. When appended as extra regressors in the second-stage estimation, the inverse Mills ratios are controls for potential biases arising from sample selectivity: It is likely that intrinsically unobservable characteristics, such as carelessness about electricity bills, also affect WTP bids. If the estimated coefficients – σ_{1u} and σ_{0u} – are statistically significant, this is an indication of sample selectivity. For the second-stage estimation, we insert the predicted values $\widehat{\mathrm{IVM}}_{1i}$ and $\widehat{\mathrm{IVM}}_{0i}$ using the probit estimates $\widehat{\gamma}$ of the first-stage estimation. Given that the variance of the residuals is heteroscedastic in nature (see MADDALA 1983:225), equations (4) and (5) should be estimated by weighted least squares using the Huber-White estimates of variance.

5 Estimation Results

To provide for a reference point in estimating the determinants of an individual's WTP for 100% green electricity, we first present the ordinary least squares (OLS) estimates both for the total sample, as well as the sub-samples of those who are either definitely or probably certain about their WTP (Table 6). We begin our discussion of the results with an estimation that omits the certainty corrective by pooling all observations. With the exception of gender, all of the socioeconomic variables included in the model specification have a statistically significant association with the WTP for green electricity (first column of Table 6). The dummies for the age categories, even if not statistically different from one another, illustrate a pattern wherein individuals in older age cohorts tend to have an increasingly lower WTP, one interpretation for which is a reduced concern for climate change impacts that occur beyond the cohort's lifespan.

Table 6: OLS Estimation Results for the WTP for 100% Green Electricity

	Full Sample		Subsample of the Definitely Certain		Subsample of the Probably Certain		Tests on Differences
	Coeff. s	Std. Errors	Coeff. s	Std. Errors	Coeff. s	Std. Errors	χ^2 Statistics
Female	0.13	(1.36)	1.87	(1.80)	-2.62	(3.14)	2.18
Age31-40	* -5.92	(2.56)	-5.98	(4.19)	-4.53	(7.31)	0.07
Age41-50	** -7.40	(2.43)	-5.67	(3.88)	-10.64	(6.78)	0.95
Age51-60	** -7.16	(2.47)	-6.09	(3.73)	-9.71	(6.51)	0.42
Age>60	** -9.73	(2.44)	* -7.70	(3.69)	* -13.61	(6.24)	1.44
College Prep Degree	** 7.10	(1.51)	** 7.54	(1.69)	5.65	(3.26)	0.27
Children	* 4.24	(1.97)	2.82	(2.35)	** 6.79	(4.07)	0.12
Medium Income	** 5.97	(1.99)	5.58	(2.35)	5.23	(4.18)	0.83
High Income	** 6.54	(2.10)	* 2.79	(2.35)	** 14.93	(4.50)	0.01
Very High Income	** 7.59	(2.33)	** 7.73	(2.52)	6.19	(4.81)	* 4.04
East Germany	** -8.29	(1.66)	**-10.00	(2.10)	-4.42	(3.58)	2.26
2. Survey Wave	**-17.02	(1.18)	**-15.37	(1.93)	**-21.25	(3.10)	* 4.67
Const.	**113.50	(2.71)	**112.76	(4.07)	**115.68	(6.78)	0.27
Number of Observations	6,917		4,730		2,187		

Note: * denotes significance at the 5 %-level and ** at the 1 %-level, respectively.

A similar interpretation may be ascribed to the positive coefficient of the dummy indicating individuals with children, who presumably have a greater stake in averting perceived threats from future climate change and therefore have a higher WTP. Those in higher education and income categories likewise have a higher WTP, the latter of which can be interpreted as a standard income effect that would apply if climate is a normal good. The negative impact of the dummy for East Germany, which suggests a roughly 8-Euro lower WTP than in West Germany, points to large regional differences in Germany in the level of support for green electricity. Moreover, if we were to follow the conclusion drawn by BLUMENSCHEIN et al. (2008) to only take account of the WTP bids of the definitely certain, we would find an average WTP, as given by the estimate of the constant, that is lower for the group of definitely certain than for those who are probably certain – although not statistically significantly lower, as can be seen from the χ^2-statistics presented in the last column of Table 6.

The largest estimate in magnitude, that of the dummy indicating the second survey wave in 2015, indicates that the WTP has decreased by roughly 17 Euros since the first survey in 2013. One interpretation of this strong decrease is that it results from a growing awareness of the ongoing cost accumulation from Germany's Energiewende. As was conveyed through media reports and by way of household electricity bills, the surcharge for green electricity rose from 5.28 Cents per kWh in 2013 to 6.17 in 2015 (Figure 1), corresponding to a 17% increase over the survey period. To the extent that the negative coefficient of -17.02 reflects a response to this cost increase, it would suggest that societal and political support for the Energiewende may begin to wane as households face continually higher electricity bills (see Figure 1).

Turning to the switching regression model that incorporates the certainty corrective, Table 7 presents estimates of the first-stage probit model (3) capturing whether the respondent reported a high level of certainty in their response to the WTP for green electricity. Gender, age, education, income, and geographical location are all seen to have statistically significant effects on this outcome. Women have a lower probability – by about 8 percentage points according to the average marginal effect – of expressing definite certainty than men. Likewise, respondents from East Germany have, on average, a lower probability than those in the West, with a differential of about 6 percentage points. By contrast, those in higher age cohorts, higher income brackets, and with a higher level of education all have higher probabilities of expressing definite certainty. With respect to model identification, one of the two exclusion variables is statistically significant: those with a broad knowledge of the EEG surcharge have a probability of expressing certainty in their WTP that is 5 percentage points higher than those lacking this knowledge.

Table 8 presents the results from the second-stage equations (4) and (5) estimated on the two sub-samples that are distinguished by whether the respondent reported definite certainty in the WTP response. As none of the coefficients on the inverse Mills ratios is statistically significant, there is no indication of sample selectivity and the second-stage results of the switching regression model very much resemble the OLS estimates reported in Table 6.

In the regressions reported in Tables 6 and 8, the difference in WTP between respondents from East and West Germany is statistically significant only for those exhibiting a high level of certainty, but not for the other respondents, an outcome possibly reflecting both differences in unobservable traits across certainty status as well as in observable characteristics, such as geographical location. The same pattern is also seen for the dummy indicating advanced education. As in the pooled OLS model, higher educated household heads exhibit a higher WTP for green electricity, but only in the sample of certain respondents.

Table 7: First-Stage Probit Model Results on the Respondents' Certainty in their WTP for 100% Green Electricity

	Coeff. s	Std. Errors	Marginal Effects	Std. Errors
Female	**-0.23	(0.04)	**-0.078	(0.013)
Age31-40	0.14	(0.08)	0.047	(0.026)
Age41-50	* 0.18	(0.08)	* 0.058	(0.024)
Age51-60	** 0.26	(0.07)	** 0.085	(0.023)
Age>60	0.03	(0.07)	0.009	(0.024)
College Prep Degree	** 0.14	(0.04)	** 0.047	(0.012)
Children	* 0.10	(0.05)	* 0.035	(0.017)
Medium Income	0.07	(0.05)	0.022	(0.015)
High Income	* 0.16	(0.05)	0.053	(0.015)
Very High Income	** 0.30	(0.05)	** 0.097	(0.015)
East Germany	**-0.17	(0.04)	**-0.058	(0.015)
2. Survey Wave	** 0.50	(0.03)	** 0.180	(0.012)
Price Knowledge	-0.04	(0.04)	-0.013	(0.014)
Levy Knowledge	** 0.14	(0.04)	** 0.045	(0.012)
Const.	-0.12	(0.08)	–	–
Number of Observations	6,917			

Note: * denotes significance at the 5 %-level and ** at the 1 %-level, respectively.

Irrespective of certainty status, respondents older than 60 years have a statistically significantly lower WTP than young people below 30. Gender, by contrast, does not have any bearing on WTP. Most notably, in both models, the dummy indicating the second survey wave indicates a statistically negative effect across both certainty groups, providing further evidence that the decrease in WTP for green electricity has been large and broad based.

Table 8: OLS and Switching Regression Results on the WTP for 100% Green Electricity

	OLS		Sub-sample of the Definitely Certain Equation (5)		Sub-sample of the Probably Certain Equation (4)		Tests on Differences
	Coeff. s	Std. Errors	Coeff. s	Std. Errors	Coeff. s	Std. Errors	χ^2 Statistics
Female	0.13	(1.36)	5.32	(3.17)	6.70	(7.62)	0.03
Age31-40	* -5.92	(2.56)	* -7.91	(3.40)	-10.35	(7.37)	0.09
Age41-50	** -7.40	(2.43)	* -8.14	(3.54)	* -17.34	(8.08)	1.10
Age51-60	** -7.16	(2.47)	* -9.66	(4.48)	-19.81	(11.15)	0.72
Age>60	** -9.73	(2.44)	** -8.02	(3.05)	** -14.48	(3.76)	1.82
College Prep Degree	** 7.10	(1.51)	* 5.54	(2.69)	0.09	(7.24)	0.50
Children	* 4.24	(1.97)	1.77	(2.70)	1.85	(4.26)	0.59
Medium Income	** 5.97	(1.99)	3.19	(3.62)	4.13	(4.71)	0.19
High Income	** 6.54	(2.10)	-1.35	(4.62)	-1.05	(6.16)	0.35
Very High Income	** 7.59	(2.33)	6.16	(3.67)	2.87	(7.64)	0.22
East Germany	** -8.29	(1.66)	** -7.55	(2.71)	2.45	(6.01)	2.31
2. Survey Wave	**-17.02	(1.18)	**-22.67	(6.41)	** -40.76	(16.38)	1.06
IVM_1	–	–	-28.15	(24.46)	–	–	–
IVM_0	–	–	–	–	55.89	(49.56)	–
Const.	**113.50	(2.71)	**135.77	(21.13)	** 74.37	(36.18)	2.17
Number of Observations	6,917		4,730		2,187		

Note: * denotes significance at the 5 %-level and ** at the 1 %-level, respectively.

6 Summary and Conclusions

Germany, a country with a sun intensity on par with that of Alaska (SCHWABE, 2016), is home to 17% of the globe's photovoltaics capacity (IRENA, 2016). This impressive circumstance did not arise from market forces, but was rather the result of a highly generous support scheme that extended technology-specific feed-in tariffs (FITs) to renewable energy sources (RES), with particularly high tariffs historically accruing to photovoltaics. The foregoing analysis has documented the substantial costs of this support scheme. We have subsequently presented results from a stated-preference experiment based on two surveys in 2013 and 2015 that were intended to gauge the public's willingness to bear these costs.

Our calculations suggest that, in addition to the 125 billion Euros that consumers paid in the form of higher electricity bills for Germany's RES promotion between 2000 and 2015, over the next 20 the overall costs are likely to exceed 400 billion Euros years, a highly conservative estimate that disregards the required expansion of the power grid and the costs of reserve capacities of conventional power plants, among other factors. Since the introduction of the FIT under the Renewable Energy Act in 2000, household electricity prices have already doubled, following a trajectory that shows no signs of abating. This cost burden notwithstanding, the data analyzed here suggests that the German public, at least in principle, is highly supportive of renewable technologies. Based on the 2015 wave of the survey, some 88% of respondents stated that RES should generally be supported, a finding that is buttressed by other polling.

Whether this principled support has staying power in terms of willingness-to-pay, however, is called into question by the results of our stated preference experiment: the results suggest a marked decrease of about 17% in the mean WTP for 100% green electricity between the 2013 and 2015 waves of the survey. Although hypothetical responses may yield upwardly biased WTP estimates, if this bias is the same across survey years, then the intertemporal difference in bids should be an unbiased estimator of the change in the WTP.

Presuming that decreased WTP is channeled into public resistance to increasing electricity prices, this may force a discussion that leads to a restructuring of Germany's energy transition and climate protection policy. Resistance may be further exacerbated as recognition grows of the marginal environmental benefits of the Energiewende in terms of greenhouse gas emission abatement: Germany's participation in the European Emissions Trading System implies that the country's success in unilaterally reducing greenhouse gas emissions via the FIT releases tradable emissions certificates, thereby reducing their price and resulting in higher emissions elsewhere in Europe.

In short, high costs together with negligible environmental benefits render Germany's FIT highly cost-ineffective, a point that has been recognized by several expert commissions, such as the German Council of Economic Experts (GCEE, 2011: 219) and the International Energy Agency (IEA, 2007:76). To improve cost-effectiveness and dampen future electricity price increases, the German government has recently introduced an auctioning system for the RES promotion, where RES capacities are auctioned separately by technology to foster competition among providers. As these auctions are technology-specific, though, there is still no competition across technologies. Cost-effectiveness could be further improved if future RES capacities were to be increased by technology-neutral auctions.

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