Who Should Pay the Bill for Promoting Green Electricity? An Experimental Study on Consumer Preferences

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Abstract.

This paper presents an experimental investigation of the individual willingness to pay (WTP) for green electricity. The experimental design comprises a public-choice scenario and a individual-choice scenario. It involves three different payment vehicles for the public promotion of renewables: direct tax, indirect tax, and CO2 tax. We test for the extent of free-riding, the impact of different payment vehicles on individual WTP, and crowding-out effects caused by the public promotion of green electricity. Combined with data collected by means of a supplementary opinion survey, our results indicate that individuals prefer binding collective contributions rather than individual market-driven activities in this field.

Key words: crowding out, free-riding, green electricity, taxation, willingness to pay

JEL classifications: C91, H23, Q41, Q42

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1 Introduction

In the current debate about how to mitigate climate change most effectively, renewable energy sources are posted to play a prominent role. The use of renewable energy sources for electricity generation may be increased either directly by paying subsidies for green electricity generation, for example through feed-in tariffs as in Germany[1], or indirectly by taxing fossil sources. The introduction of taxes[2] in order to correct for externalities is in line with the polluter-pays principle because incentives for both producers and consumers are created to avoid emissions, for instance, by switching to renewable energy sources. In contrast, paying subsidies that are financed by taxing other goods is in perfect accord with the public-pays principle. The choice between alternative approaches to support green electricity provokes the normative question of which policy measures should be taken in order to transform collective environmental objectives into individual behaviour and how the costs of improving environmental quality should be shared.

This paper provides for an answer to this question by presenting an experimental investigation of the willingness to pay for green electricity. Since the environmental impact of green electricity is consumed by the society as a whole and it is not possible to exclude certain individuals from consuming it, making the electricity system ‘‘greener’’ can be interpreted as a public good. Textbook economics would predict that private provision leads to an inefficiently low level of the public good as people can free-ride on other people’s contributions (Roberts, 1987). Likewise, the neutrality hypothesis (Bergstrom et al., 1986) holds that people perceive tax financed government grants for the support of green electricity as perfect substitutes for their own contributions. Therefore, government grants are expected to completely crowd out private spending on green electricity.[3] Recent research suggests,

[1] In Europe, various approaches such as feed-in tariffs and quota systems cum certificate trading are pursued to push renewable energy technologies into the market (see Haas et al., 2004, for an overview). Economic theory would predict large efficiency gains from the integration of the different national support systems. For example, Germany pays relatively high subsidies that currently amount to 7.7 bn € and are expected to exceed 10 bn € in 2010 (VDN, 2007).

[2] According to Newberry (2005:7), there are four main economic reasons for taxing energy: “as an optimal import tariff, to reflect and internalise external costs (mainly from pollution), as a second-best instrument for charging for transport infrastructure, and, more generally, as part of a second-best tax structure to improve the redistributive and/or efficiency properties of the remaining feasible taxes”.

[3] Crowding-out effects have been observed in many public goods experiments (see, for example, Bolton and Katok, 1998). Ribar and Wilhelm (2002) conjectured that these may primarily be attributable to small group sizes. Empirical investigations in the context of charity donations led to mixed results. Khanna and Sandler (2000) demonstrated significant crowding-in effects. Brooks (2000) found that low levels of subsidies to nonprofit organisations encourage charitable giving, while high levels of grants crowd-out private donations. Nyborg and Rege (2003) showed that in fairness models (e.g. Fehr and Schmidt, 1999) asymmetric equilibria exist in which taxes do not crowd out private contributions, while subsidies may even crowd in private

however, that spending on a public good like green electricity creates an extra benefit apart from the consumption of improved environmental quality, namely the so-called "warm glow of giving" (Andreoni, 1989), that is, a direct benefit which arises from the act itself of contributing to the public good. The warm-glow effect, thus, may help to understand why people are willing to spend on green electricity at all.[4]

The experimental design involves two scenarios. In the individual-choice scenario, survey participants reveal their preferred individual level of green electricity consumption, given a specified level of public support. In the public-choice scenario, participants are asked to determine a level of green electricity to be valid for the whole society. In this scenario, the participants may be regarded as voters, with the preferred level of green electricity representing the majority vote. We will follow Champ et al. (1997) and distinguish between a participant's willingness to pay (WTP) and his or her *willingness to donate* (WTD). The former is elicited in the public-choice scenario and refers to the case where it is impossible to free-ride. Since the median voter determines the level of green electricity to be valid for all participants under the same treatment and the costs are shared equally, it is individually rational for each participant to state the WTP that reflects his or her true monetary valuation of green electricity, comprising of its environmental impact and the warm glow arising from the contribution itself. In the individual-choice scenario, free-riding cannot be prevented. Ultimately, all participants consume the same environmental quality though they fix their contributions individually. Therefore, strong incentives exist to understate the willingness to spend on green electricity and to free-ride on the contributions of the other participants. Obviously, WTP forms the upper limit for WTD. The two different scenarios allow for separating between WTP and WTD, and thus provide us with a test of the extent of free riding.

Both scenarios involve three different payment vehicles: a lump-sum tax implemented as a direct tax, an electricity tax implemented as an indirect tax, and a CO2 tax where the tax receipts are redistributed to the consumers of green electricity. The basic payoff-structure underlying the six (2 x 3) different treatments is constructed to be identical. The experimental design thus enables us to study the participants' demand behaviour for green electricity with respect to free-riding and different payment vehicles. Crowding-out effects are tested by means of a post-experimental questionnaire. Furthermore, participants are asked a set of

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contributions. Frey (1997) supposed that people's intrinsic or moral motivations are crowded out by external measures such as market regulation (see also Frey and Oberholzer-Gee, 1997, and Brekke et al., 2003).

[4] See Nyborg and Rege (2003) and Garet-Varet et. al. (2000) for an overview of models explaining both the private provision of public goods and crowding-out effects of private contributions caused by public activities

questions concerning their current perception of public measures in the field of renewable energy, and their attitudes towards certain normative aspects of taxation, for instance, the perceived justice of the polluter- and the public-pays principle, respectively.

Our data exhibits strong treatment effects. Under the public-choice treatments, participants are willing to pay far higher contributions to green electricity than under the individual-choice treatments. This observation highlights the large extent of free-riding in the private provision of the public good "environmental quality". We find no significant differences between the payment vehicles. Furthermore, we observe crowding-in effects for low tax rates and crowding-out effects for high tax rates. Altogether, our results suggest that individuals prefer binding collective contributions rather than individual market-driven activities in this field.

The paper is organised as follows. In the next section, we give a description of the experiment. Section 3 states our research hypotheses. Section 4 presents the results of our study. The paper concludes with some final remarks in Section 5.

2 The Experiment

2.1 Experimental Design

The goal of the present paper is to analyze individual demand behaviour for green electricity. In particular, we aim at measuring the extent of *free-riding* caused by the public-good nature of green electricity consumption, the impact of *different payment vehicles* on individual spending, and the sign and strength of *crowding-out effects*. In order to test for free-riding, the experiment involves two different scenarios: the *individual-choice scenario* where the participants reveal their preferred individual level of green electricity consumption, given a specified level of public support; and the *public-choice scenario,* where the participants determine through majority vote the level of green electricity to be valid for the whole society. Each scenario includes three different payment vehicles for green electricity:

- a *direct tax* that is levied from all consumers and the revenue of which is used to subsidize green electricity;
- an *indirect tax* that is "hidden" in the electricity price;
- and a *transfer* to the consumers of green electricity, financed by a *CO2 tax* levied from the producers of conventional electricity, where it is assumed that taxes are to 100% shifted forward to the consumers.

Altogether, there are six treatments (see Table 1). We employ a between-subjects design, that is, each participant is randomly assigned to exactly one of these treatments. *Crowding-out effects* are tested by means of an additional post-experimental questionnaire which will be introduced in Section 2.3.

Table 1: Treatment and Payoff Structure of the Experiment

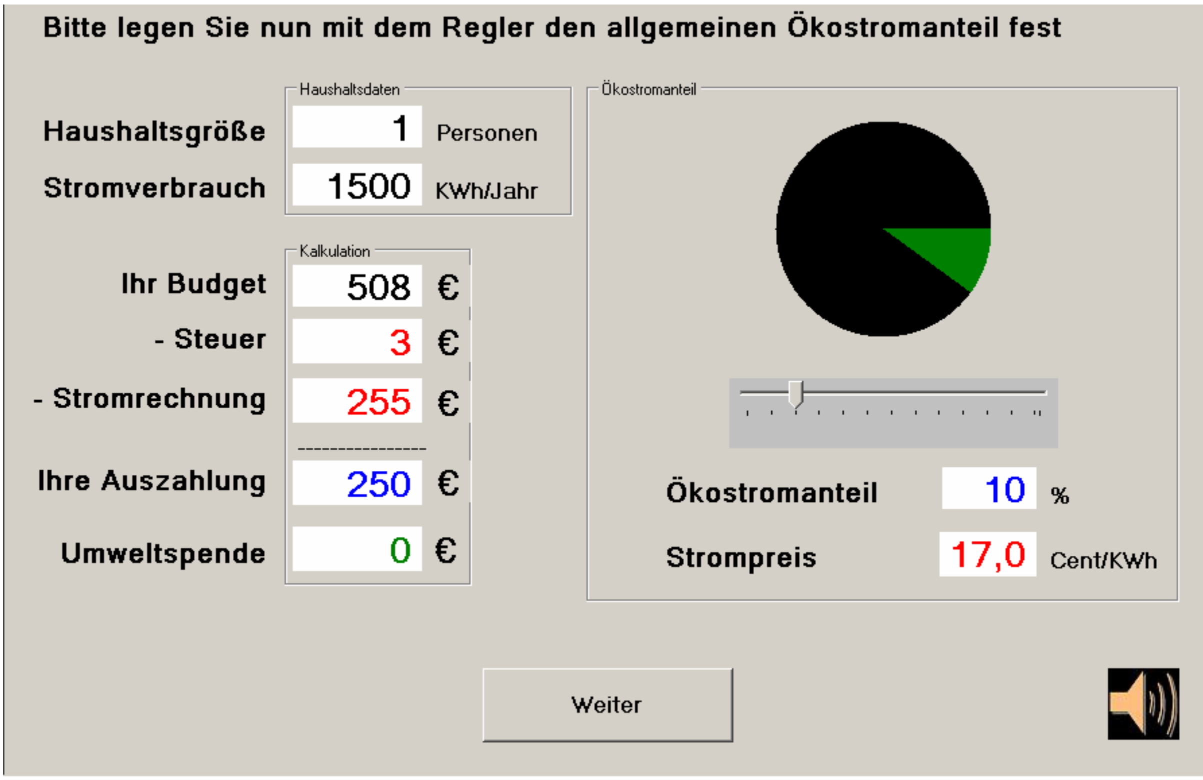
		Scenario	
		Public choice (P)	*Individual choice (I)*
Initial conditions		$p_F = 17, a_0 = 0.1$	$p_F = 17, a = a_0 \equiv 0.1$
		$\pi_h = b_h - C_h = 25{,}000,\ g_h = 25{,}000 - \pi_h = 0$	
Choice parameter		$0.1 \le a_0 \le 1$	$0.1 \le a \le 1$
Supply function		$p_R = \frac{1}{1-a_0} p_F, \frac{\partial p_R}{\partial a_0} = \frac{1}{(1-a_0)^2} p_F$	$p_R = 18.89$
Payment vehicle, cost function	*Direct tax (D)* $C_h = \tau_h + p \cdot x_h$	$\tau_h = a_0 \cdot (p_R - p_F) \cdot x_h$ $p = p_F$ $\frac{\partial \tau_h}{\partial a_0} = \frac{(2a_0 - a_0^2)}{(1-a_0)^2} \cdot p_F \cdot x_h$ $\frac{\partial p}{\partial a_0} = 0$	$\tau_h = 0.189 \cdot x_h$ $p = p_F + 1.89 \cdot (a - 0.1)$ $\frac{\partial \tau_h}{\partial a} = 0$ $\frac{\partial p}{\partial a} = 1.89$
	Indirect tax (I) $C_h = p \cdot x_h$	$t = a_0 \cdot (p_R - p_F)$ $p = p_F + t$ $\frac{\partial p}{\partial a_0} = \frac{\partial t}{\partial a_0} = \frac{(2a_0 - a_0^2)}{(1-a_0)^2} \cdot p_F$	$t = 0.189$ $p = p_F + t + 1.89 \cdot (a - 0.1)$ $\frac{\partial t}{\partial a} = 0$ $\frac{\partial p}{\partial a} = 1.89$
	CO2 tax & transfer (T) $C_h = p \cdot x_h - \phi_h$	$\phi_h = a_0 \cdot (p_R - p_F) \cdot x_h$ $p = p_F + 2\frac{\phi_h}{x_h}$ $\frac{\partial \phi_h}{\partial a_0} = \frac{(2a_0 - a_0^2)}{(1-a_0)^2} \cdot p_F \cdot x_h$ $\frac{\partial p}{\partial a_0} = 2 \cdot \frac{(2a_0 - a_0^2)}{(1-a_0)^2} \cdot p_F$	$\phi_h = 0.189 \cdot x_h$ $p = p_F + 2\frac{\phi_h}{x_h} + 1.51 \cdot (a - 0.1)$ $\frac{\partial \phi_h}{\partial a} = 0$ $\frac{\partial p}{\partial a} = 1.51$

Legend: p consumer electricity price (ct/kW h), p_F producer price of conventional electricity, p_R producer price of green electricity, a_0 national level of green electricity, a individual level of green electricity, b_h household budget (ct), x_h electricity consumption (kW h), h household size, τ direct tax (ct), t indirect tax (ct/kW h), ϕ transfer (ct), C cost (ct), π payoff (ct), g WTP or WTD (ct).

The item of interest is the participants' *willingness to pay* (WTP) or *willingness to donate* (WTD), respectively, for green electricity. Generically, the WTP/WTD for a good or service is defined as the amount of money that renders a person indifferent between receiving the good or service and keeping the money. In all treatments, each participant acts as a price taker and starts with a given budget and a given level of publicly provided green electricity which is financed by one of the three payment vehicles mentioned above. The rationale is to allocate the budget on a composite private good (consumption) and green electricity.

A participant's preference is elicited as follows: The participant is presented the decision task displayed in Figure 1 (the figure refers to the public-choice direct-tax treatment, PD). On the top of the screen, the household size ("Haushaltsgröße") stated by the participant is given. Below, the average annual electricity consumption of the household in kW h, is given ("Stromverbrauch"). This figure is based on standardized values used by utilities.

Figure 1: Sample Screen of the Experiment (Public Choice Scenario, Direct Tax)



In the boxes grouped below the label "Kalkulation" (calculation) five labels and figures are shown: "Ihr Budget" (your budget) states the household's hypothetical annual gross household budget, "Steuer" (tax) the amount of taxes that is withdrawn from the budget in order to subsidize green electricity (in the case of an indirect tax this box stays empty), "Stromrechnung" (electricity bill) the annual cost of electricity to be subtracted from the gross household budget, "Ihre Auszahung" (your payoff) the annual household budget net of taxes and electricity bill, and "Umweltspende" (contribution to the environment) the amount of money that is transferred to the account of an environmental organization (the WTP and WTD, respectively).

On the right hand side of the calculation boxes, a pie chart visualizes the current level of green-electricity generation as a percentage of total electricity generation by black (conventional electricity) and green (green electricity) sectors. Below, a scroll bar and two labelled boxes are displayed. The upper label states the share of green-electricity generation in total electricity generation as a percentage ("Ökostromanteil"). The lower label states the current price of one kW h of electricity.

Table 2: Household Data

Household type h	Annual electricity consumption (kW h) x_h	Annual budget (ct) b_h	Cost (ct) C_h
1 person	1,500	50,800	25,800
2 persons	2,700	71,400	46,400
3 persons	3,600	86,900	61,900
4 or more persons	5,200	114,400	89,400

The figures stated on the screen are computed using the information given in Table 1 and the household-specific data listed in Table 2. In order to illustrate the proceeding, we use a single-person household as an example. Initially, the national level of green electricity promotion is 10% ($a_0 = 0.1$), the producer price of conventional (fossil) electricity is assumed to be $p_F = 17$ ct/kW h and, according to the "stylized" supply function, the producer price of green electricity is $p_R = 18.89$ ct/kW h. Accordingly, an amount of $(p_R - p_F) \cdot a_0 \cdot x_1 = 283$ ct is needed for the promotion of green electricity. In our example, the single-person household has an annual budget of $b_1 = 50{,}800$ ct (508 € as stated in Figure 1) while the costs are given by $C_1 = 25{,}800$ ct (258 €) and can be partitioned into the electricity bill $p \cdot x_1 = 25{,}500$ ct (255 €) and a *direct tax* for the promotion of green electricity $\tau = 283$ ct (3 €). The remainder $\pi_1 = b_1 - C_1 = 25{,}000$ ct (250 €) is the household's maximum payoff. If the payment vehicle is an *indirect tax* instead of a direct tax, the 283 cents are included in the electricity bill. Hence, a mark up of $283/1{,}500 \approx 0.19$ cent per kW h is required. Together with a net price of 17 ct/ kW h this yields a consumer price of $p = 17.19$ ct/kW h.

The previous calculations refer to the *public-pays principle*, that is, the extra costs of green electricity are to be borne by all electricity consumers, irrespective of their mix of green and conventional electricity. According to the *polluter-pays principle*, the producers and users of conventional electricity are responsible for the promotion of green electricity. We assume that the necessary mark up on the marginal costs of conventional electricity is fully shifted to the consumers. It is straightforward to show that the mark up (which may be seen as the price of a *CO2-licence*) is computed as $1.89 \cdot 0.1/0.9 = 0.21$ ct per kW h of conventional electricity. Hence, the initial consumer price of electricity is given by $p = 17.38$ ct/kW h and the electricity bill amounts to 26,070 ct (261 €). In return for the higher electricity bill, the consumers of green electricity are released from the costs of the CO2-licences by a grant or *transfer* of $\phi = 283$ ct. Adding up both results in a gross burden of about 25,800 ct (258 €) like in the other treatments.

In the *public-choice scenario*, a_0 is to be changed. Note that values of a_0 smaller than the initial 10% are not allowed since this level is preset by the Renewable Energy Sources Act. As stated in Table 1, the marginal increase of the price of green electricity, $\partial p_R / \partial a_0$, is identical for all payment vehicles. For example, if the participant votes for a national level of green electricity of 20%, p_R increases from 18.89 to 21.25 ct/kWh and the per-capita costs of promoting green electricity rise by 992 ct. This amount is financed using one of the three payment vehicles described above: under the direct tax treatment only the tax increases, under the indirect tax treatment only the consumer prices increases, and under the CO2 tax treatment both the price and the transfer increase (see the formulas stated in Table 1).

Note, however, that the calculation of the cost increase is not "exact" in the sense that it does not take into account the composition of the sample as to different household sizes (implying different quantities of electricity consumption). In other words, the cost increase is calculated for every participant as if all other participants had the same household size. This proceeding was necessary for technical reasons, because it was not possible to let all 58 participants in each treatment decide simultaneously. Since the marginal cost function is increasing in the quantity of green electricity consumed, this simplification has the effect that small (large) households underestimate (overestimate) the costs of promoting green electricity at societal level. In the regression analysis reported in the results section, we therefore control for household size.

The *individual-choice scenario* is less complicated since the national level of green electricity is fixed at the initial value of 10%. If a participant increases the quantity of green-electricity consumption in his or her personal electricity contract, *a*, the price effect is negligible at the national level. Hence, the only monetary consequence is an increase of the participant's electricity bill due to the replacement of conventional electricity by unsubsidized green electricity. The respective marginal effects are listed in the last column of Table 1. It should be noted that the CO2 tax treatment of the individual-choice scenario is *not* mathematically equivalent to the other treatments as it involves smaller marginal costs of private green electricity consumption.

2.2 The Incentive Mechanism

The incentive mechanism induces our participants to reveal their true WTP or WTD. In all six treatments, the extra costs of increasing the individual or national level of green electricity consumption are stated in the box "Umweltspende" (contribution to the environment). The participants are told at the beginning that one of ten participants is randomly selected for payoff. If a participant is selected for payoff, he or she immediately receives either (if he or she is assigned to the individual-choice scenario) the amount that it listed in the field "Ihre Auszahlung" (your payoff) or (if he or she is assigned to the public-choice scenario) the amount that results from the median voter's decision.[5] The contribution to the environment is transferred to the account of an environmental organization in order to mimic the beneficial impact of consuming green electricity on the environment. Hence, the decision task involves a real trade off between a participant's own payoff to be earned in the experiment and his or her contribution to the public good "environmental quality". In the previous example, where the participant (assumed that he or she is the median voter) sets $a_0 = 0.2$, the contribution to the environment is given by the extra costs of $g_1 = 992\,\text{ct}$ (9.92 €) and his or her payoff is $\pi_h = 24{,}008\,\text{ct}$ (240.08 €).

As soon as a participant has answered all questions, the lottery, where all winner tickets have been previously determined by a random device, is started. While the losers of this lottery receive only an allowance of 5 €, winners additionally receive their payoff. Furthermore, the participants are requested to determine the environmental organization which should receive the contribution to the environment.[6]

Of course, in the experiment, it is neither possible to actually determine the nationwide level of green electricity generation nor do we offer "real" electricity contracts. Hence, the incentive mechanism is accompanied by "cheap talk", that is, participants get informed intensively about the hypothetical nature of the task. Nevertheless, they are asked to behave

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[5] If right the first participant was selected for payoff, the majority vote was conducted by means of computer-simulated additional players.
[6] Similar procedures were also used by Sutter and Weck-Hannemann (2004) and by Menges et al. (2005).

exactly *as if the situation was real*. Cheap talk has been shown to effectively eliminate hypothetical bias (Cummings and Taylor, 1999; List, 2001).

Altogether, 348 participants were involved in the experiment, 58 in treatments 1, 3, 4, and 6, respectively, 57 in treatment 2, and 59 in treatment 5. We paid off 1,740 € as allowances and 7,991 € to the 35 winners of the lottery. The average payoff was 23.57 €. 1,393 € were donated to environmental organizations.

2.3 The Post-experimental Questionnaire

After having finished the decision task, the participants are asked to express their attitudes and opinions concerning three groups of energy policy issues. Before answering these questions, participants are presented some basic facts in order to define the object of interest, thereby securing a common basis of information. First, addressing more general attitudes towards electricity markets, participants have to state their acceptance or denial towards the following topics: the current system to support renewable energy, the liberalization of electricity markets and the announced phasing-out of nuclear energy. Second, participants are asked three questions concerning the perceived justice of financing green electricity; who should bear the cost of green electricity (all customers, solely customers consuming non-renewable energy, or solely green electricity customers)?; who is regarded as being responsible for supporting green electricity (the market, the state, or both)?; should certain industrial consumers receive tax cuts, in order to sustain their internationals competitive position? Third, specific aspects of the promotion of green electricity are surveyed: should more expensive electricity generation technologies receive higher subsidies?; should the financial support be harmonised among European countries?; should Germany should bear more, the same, or less costs in this field than its European neighbours.

Finally, we assess the participants' sociodemographics, including age, sex, income, education, profession and religion. All answers are fed into the computer by selecting items (e.g. based on Likert-scales) from pre-defined lists. At the bottom of each computer screen, participants are informed about the number of remaining questions. Note that, in the results section, we will only comment on those variables which prove to be significant in the statistical analysis.

2.4 Procedure

The experiment including the post-experimental questionnaire is fully computerized. The programme is handled with the computer mouse. The participants are randomly drawn visitors of shopping malls. They are offered 5 € and an additional lottery prize up to 250 € in case of taking part in a survey of about 15 minutes. Participants first draw a lottery ticket and are then briefly taught how to use the headphones and notebooks placed in the field lab consisting of five work places. All further instructions are given by headphones.

The 3-digit number imprinted on the lottery ticket determines the treatment to which the participant is assigned. Then, the participant states his or her household size. This variable enters the calculation of the participant's annual budget and electricity consumption during the experiment. Subsequently, the participant has to estimate the current share of green electricity in the total generation of electricity in Germany. On the next screen, the decision task (Figure 1) is presented. The decision task is followed by the post-experimental questionnaire.

3 Tests and Hypotheses

The participants' stated preferences for green electricity in terms of the chosen scroll-bar positions (representing a_0 in the public-choice scenario and a in the individual-choice scenario) cannot be compared directly. First, participants differ in their household sizes. Second, the price of green electricity is held constant in the individual-choice scenario; in the public-choice scenario it is an increasing function of a_0. Hence, moving the scroll-bar involves different monetary and environmental consequences for different participants. Accordingly, in order to make the participants' choices comparable both between participants and between treatments, we compute their *average* WTP and WTD, respectively, in cents of the Euro per kW h of green electricity associated with the respective scroll-bar positions. For example, if a single-person household is assigned to treatment PD (public-choice scenario, direct tax treatment) and fixes the scroll-bar at $a_0 = 0.20$, the donation to the environment (the extra cost) of 992 cents has to be divided by $0.2 \cdot 1500 = 300$ kW h of green electricity. This yields an average WTP of 3.31 cents per kW h of green electricity.

The experiment is designed to test for free-riding, the impact of different payment vehicles, and crowding-out effects:

- *Free-riding* is tested by comparing the sample means of average WTP and WTD between the scenarios. We hypothesize $WTP > WTD > 0$, that is, due to the warm-glow effect the average WTD in the individual-choice scenario is greater than zero; yet due to free-riding it is smaller than the average WTP in the public-choice scenario.

- The impact of different payment vehicles is tested by comparing the sample means of average WTP and WTD, respectively, within the scenarios. Direct tax and indirect tax are modelled as mathematically equivalent implementations of the public-pays principle. However, there is ample empirical and experimental evidence that the tax burden associated with an indirect tax is systematically underestimated compared to an equivalent direct tax (compare, for example, Sausgruber and Tyran, 2005). This effect has been labelled *fiscal illusion* in the literature.[7] Accordingly, we hypothesize $WTP_{indirect} > WTP_{direct}$ and $WTD_{indirect} > WTD_{direct}$, respectively.

- The CO2 tax is an implementation of the polluter-pays principle. In the public-choice scenario, it is mathematically equivalent to the direct and indirect taxes. Yet, there is an important difference: under the CO2 tax treatment, the participant receives a direct transfer for increasing the level of green electricity consumption (in order to compensate him or her for the rising electricity price); as opposed to this, under the direct tax treatment, the tax amount is directly subtracted from the participant's budget. Behavioural economics research has shown that losses "loom" larger than equivalent gains (Kahneman and Tversky, 1979). This psychological effect is known as *loss aversion*. Hence, if the transfers associated with the CO2 tax are perceived as gains and the deductions involved by the direct tax are perceived as losses, we would expect $WTP_{CO2tax} > WTP_{direct}$. We will also test $WTD_{CO2tax} > WTD_{direct}$. It should be noted, however, that in the individual-choice scenario the CO2 tax cannot be designed in a mathematical equivalent way (see Section 3.2 for details). Note also that the fiscal illusion and loss aversion are expected to be less pronounced in the individual-choice scenario, where taxes and subsidies, respectively, are held constant.

- Neither in the public-choice scenario nor in the individual-choice scenario, there is exogenous variation of the tax rate. Therefore, *crowding-out effects* are tested indirectly by additional data collected with a post-experimental questionnaire (see Section 3.3). Exogenous variation of the subjectively felt tax burden is introduced at the between participants level by asking them to estimate the share of electricity taxes dedicated to the subsidization of green electricity. The working hypothesis is that there is a negative correlation between the estimated tax share and the WTP and WTD, respectively, that is, we surmise that private contributions are crowded out at least partially. Note that Menges

[7] Sausgruber and Tyran (2005) showed that the fiscal illusion can lead to an excessive increase of taxes. Eckel et al. (2005) reported zero crowding-out of voluntary contributions due to compulsory contributions when participants were not aware of the tax mechanism, whereas crowding-out was close to 100% when participants were informed about the tax mechanism. See also Sutter and Weck-Hannemann (2004) and Tyran (2004).

et al. (2005) found crowding in below and crowding out above a certain threshold level. Hence, we will also test for a nonlinear relationship between subjectively felt tax burden and willingness to spend on green electricity.

Table 3: Descriptive Statistics of Mean WTP and WTD

Scenario	Payment vehicle			
	Direct tax	*Indirect tax*	*CO2 tax*	*All*
Public choice (WTP)	6.507 (0.673)	5.931 (0.629)	6.050 (0.605)	6.164 (0.366)
Individual choice (WTD)	1.189 (0.065)	1.200 (0.060)	0.916 (0.049)	1.102 (0.035)
All	3.848 (0.418)	3.535 (0.380)	3.483 (0.385)	3.619 (0.227)

Table Notes. First row: average WTP/WTD per kW h of green electricity in cents of the Euro. Second row: standard errors.

4 Results

A group of 20 participants (5.7% of the sample) was not willing at all to support green electricity, 76 participants (21.8%) revealed payments below 1 ct. Table 3 lists the mean values of average WTP and WTD per kW h of green electricity. In the aggregate, participants paid about 3.6 cents per kW h of green electricity. Descriptive analysis of the individual payments with respect to our (2 x 3) treatment structure shows large differences between the public-choice scenario and the individual-choice scenario: on average, WTP exceeded WTD by 5 cents. At a first glance, it seems that participants did not react comparably strong to the different payment vehicles.

Table 4: Testing for Treatment Effects

Test	Treatments	Mean difference	T-value
Free riding	*All (P vs. I)*	5.062***	13.777
	Direct tax (PD vs. ID)	5.318***	7.863
	Indirect tax (PI vs. II)	4.730***	7.490
	CO2 tax (PT vs. IT)	5.134***	8.460
Fiscal Illusion	*All (PD & ID vs. PI & II)*	-0.323	0.572
	Public Choice (PD vs. PI)	0.576	0.625
	Individual Choice (ID vs. II)	-0.012	0.133
Loss Aversion	*All (PD & ID vs. PT & IT)*	0.365	0.641
	Public Choice (PD vs. PT)	0.456	0.504
	Individual Choice (ID vs. IT)	0.273***	3.337

Table note: Significant mean differences are marked with one (two, three) asterisk(s) if $p \leq 0.10$ ($p \leq 0.05$, $p \leq 0.01$).

Table 4 contains the results of testing on the influence of the treatment variables. The test of *free-riding* is given by comparing the mean values of WTP and WTD. The respective T-test yields significant mean differences in the aggregate (all treatments) as well as disaggregated with respect to the payment vehicles (direct tax, indirect tax, and CO2 tax). This result clearly confirms our first hypothesis ($WTP \geq WTD$).[8] Table 3 already indicated that the *fiscal-illusion* hypothesis is not confirmed by our data. All mean differences reported in Table 4 are insignificant at conventional levels.[9] The test of *loss aversion* shows that the hypothesis $WTP_{CO2tax} > WTP_{direct}$ is not confirmed at the aggregate level and when only the public-choice scenario is considered. However, the individual-choice scenario exhibits a significant mean difference between direct tax and CO2 tax, but the test exhibits the wrong sign. This could be due to the fact, that the electricity price (which was much higher in the CO2 tax treatment than in the direct tax treatment) was more prominent[10] than the transfer/tax amount.

The test of *crowding-out* is displayed in Table 5 which contains the correlation between the WTP/WTD and the estimated green electricity tax share. The crowding-out hypothesis is not confirmed for the individual-choice case. This is a reasonable result, because the price mechanism in the individual-choice scenario is not directly related to issues of taxation and public finance. However, a significant crowding-in effect can be identified for the public-choice case (except for the CO2 tax).

Table 5: Correlation between WTP/WTD and Estimated Tax Share for the Promotion of Green Electricity

Scenario	Payment vehicle			
	Direct tax	*Indirect tax*	*CO2 tax*	*All*
Public choice (WTP)	*0.230	**0.298	0.128	***0.209
Individual choice (WTD)	0.179	-0.029	0.196	0.095
All	0.019	0.147	-0.005	0.050

Table notes. Pearson's correlation. Significant correlations are marked with one (two, three) leading asterisk(s) if $p \leq 0.10$ ($p \leq 0.05$, $p \leq 0.01$).

In order to investigate the relationship between WTD/WTP (measured in Cent/kW h of green electricity) as the endogenous variable and the different treatment variables (representing the 2 x 3 treatment structure) as well as the participants' attitudes and personal characteristics as the exogenous variables, we set up a linear regression model. Table 6

[8] $WTP \geq 0$ and $WTD \geq 0$ are obvious, given the very small standard errors reported in Table 3.
[9] If at all, there is slight evidence for the fiscal illusion in the public-choice scenario in terms that the mean difference is 0.588 cents higher than in the individual choice treatments. Yet, even this difference is insignificant (Welch-test, T=0.635, p=0.528).
[10] On the prominence hypothesis see Tversky et al. (1988).

contains the final results of this regression, that is, we report only those coefficients that turned out to be significant at least at the 10% level. In light of the usual noise in experimental data, the overall fit of the regression (report at the bottom of the table) is satisfactorily high as it explains about half of the variance of the endogenous variable.

Table 6: OLS-Regression

Variable	Coefficient	T-value
Constant	4.647***	6.034
Individual-choice scenario	-3.098***	5.088
(Estimated tax share x public choice)	0.356***	3.627
(Estimated tax share x public choice) squared	-6.672E-3**	2.545
Household size	-0.263**	2.156
OECD equivalent income	0.917E-3***	3.450
Age squared	-0.415E-3***	2.895
No religion	0.760*	1.707
Support phasing out nuclear energy	0.371**	2.579
Support liberalization of electricity markets	-0.318*	1.720
Cost should be borne by green electricity customers	-1.133*	1.863
F=24.419, p(F)<0.01, R=0.482		

Table notes. Dependent variable: average WTD/WTP per kW h of green electricity in cents of the Euro. Total n=348. Pairwise exclusion of missing values. Stepwise regression, an exogenous variable is included if p(F)≤0.1. Significant coefficients are marked with one (two, three) leading asterisk(s) if p≤0.10 (p≤0.05, p≤0.01).

The regression supports the results obtained from the analysis of treatment effects displayed in Table 4. The dummy variable for the individual-choice scenario is highly significant. The respective coefficient indicates a large extent of free-riding: the average WTD is more than 3 ct lower than the average WTP assessed in the public-choice scenario. None of the other treatment variables are significant. Consequently, the regression analysis confirms our previous observation that the hypotheses concerning the fiscal illusion and loss aversion have to be rejected.

In Table 5 we reported a significant positive correlation between the average WTP in the public-choice scenario and the estimated tax share for the promotion of green electricity, that is, a *crowding-in effect*. As noted earlier, this analysis was incomplete, because we did not test for nonlinearities as observed, for example, in an earlier paper by Menges et al. (2005). We therefore include the estimated tax share as well as its square in the regression analysis. In order to take into account that crowding-in effects were only observed in the public-choice scenario, we interact these two variables with a dummy for the public-choice scenario. The regression analysis confirms the result concerning the linear component, indicating a significant crowding-in effect. Interestingly enough, the coefficient of the squared component is negative, indicating *crowding out* for higher estimated tax shares. In order to further analyze this, let β denote the estimated tax share in percent for the promotion of green electricity and ΔWTP the differential WTP, that is, the additional WTP that is due to crowding in. Using the figures reported in Table 6, the differential WTP is given by $\Delta WTP = 0.356 \cdot \beta - (6.672E-3) \cdot \beta^2$. This function has two roots at $\beta = 0\,\%$ and $\beta = 53.37\,\%$. It reaches its maximum of $\Delta WTP_{\max} = 4.75$ cents per kW h at $\beta = 26.69\,\%$. Hence, we observe crowding in for estimated tax shares smaller than 26.69 % and crowding out for estimated tax shares larger than that value.

The significant variables of the regression model covering sociodemographics are interpreted as follows: WTP/WTD decreases with household size. This observation reflects our remark that the experimental design may induce small (large) households to underestimate (overestimate) the cost of increasing the green electricity share at the national level. Income entered the regression as "OECD equivalent income", that is, the participants' household incomes were adjusted for household size using the OECD equivalence scale in order to allow for intra-household economies of scale.[11] The coefficient is significant and exhibits a positive sign. This result suggests that the participants perceive their contributions to the environment as a *superior good*. An increase of the equivalent income by 1 Euro increases the average WTP/WTD roughly by 0.001 Cent. The significant negative coefficient of "age squared" indicates that WTP/WTD decreases with increasing age of participants. Somewhat surprisingly, not belonging to a religious group involves significantly higher payments than being a member of a religious group.

It remains to comment on the participants' attitudes with regard to their influence on WTP/WTD. Individual payments are positively affected by the support of government policies to phase out nuclear energy. Apart from ideological issues, this result reflects economic rationality: WTP/WTD corresponds to the marginal utility of green electricity, which must be higher for those who seek to substitute nuclear by renewable energy. The negative coefficient of the dummy variable "Support liberalization of electricity markets" highlights that participants exhibiting a negative attitude towards the market reveal higher payments for green electricity. A general distrust towards market mechanism appears also in the negative coefficient of the dummy variable "Costs should be borne by green electricity customers". As pointed out in Section 3.3, participants had to state whether the costs of

[11] The OECD equivalence scale assigns a weight of 1 to the first household-member, a weight of 0.7 to the second household member and a weight of 0.5 to every further person in the household.

financing green electricity should be covered by all customers (public-pays), by non-renewable customers (polluter-pays) or by green electricity customers (benefitor-pays). The regression analysis shows that the proponents of the more market-oriented benefitor principle revealed significantly lower WTP/WTD for green electricity as compared to the other participants.

Summarizing, we find strong empirical support for the hypothesis that people's WTP for green electricity is higher when they decide collectively about the national level of the public good environmental quality and the individual tax burden as compared to a scenario where the promotion of green electricity is done at the individual level. Even although we control for the supply effect of fixing the level of green electricity promotion at the national level in the public-choice scenario, ruling out the possibility to free-ride on the contributions of other individuals increases the willingness-to-pay by more than 3 cents per kW h of green electricity. Furthermore, the regression analysis shows that individual payments for green electricity are very sensitive to both general attitudes towards energy taxes and subjective knowledge about the actual tax burden involved by the promotion of green electricity. We find crowding-in as well as crowding-out effects.

5 Conclusion

In this paper, we have presented an experimental investigation of individual preferences for the consumption of green electricity under alternative payment vehicles for the promotion of renewably energy. The experiment involved a two-factorial design comprising of six different treatments. In the individual-choice scenario participants acted as market participants, while the public-choice scenario was designed as a majority vote on the preferred level of green electricity. Both the individual-choice and the public-choice scenarios were split into three different payment vehicles for the promotion of green electricity: a direct tax, an indirect tax, and a CO2 tax. The experimental design enabled us to investigate the extent of free-riding in the sample, the impact of different payment vehicles on the participants' willingness to pay, and crowding-out effects of private willingness to pay due to public promotion of green electricity.

The data analysis revealed a strong treatment effect concerning the decision mode: under the public choice treatments, participants were willing to pay far higher contributions to green electricity than under the individual choice treatments. This observation highlights the large extent of free-riding in the private provision of the public good "environmental quality". On the other hand, it also demonstrates that many household are willing to contribute voluntarily even if free-riding is possible. A standard explanation for this result is impure altruism, that is, people draw additional utility from the very act of giving ("warm glow of giving", Andreoni, 1989).

Another central result of this study is that we found a nonlinear relationship between the participants' willingness-to-pay and their subjectively estimated tax burden due to the financing of green electricity. Below a certain threshold, participants were willing to spend significantly more on green electricity; above that level the relationship was reversed. Again, a standard explanation for the non-neutrality of taxes is the impure altruism model, where taxes and private contributions are not perceived as perfect substitutes. These results are well in line with an earlier experimental study by Menges et al. (2005)[12] and the empirical literature on charitable donations (see, for example, Brooks, 2000). The supplementary analysis of the participants' attitudes and characteristics indicated that people who were willing to contribute relatively high amounts to the promotion of green electricity were generally more sceptical with respect to the ability of the market to maximize social welfare.

In contrast to other authors (Sausgruber and Tyran, 2005; Eckel et al., 2005), we did not find evidence of the fiscal illusion, that is, differences in the perception of indirect and direct taxes. We attribute this result to the fact that we made both taxes very transparent[13] and that we applied a between-participants design. Furthermore, our experimental analysis did not support the loss aversion hypothesis, possibly due to prominence of the price increase in the subsidy treatment.

Combining the results with respect to free-riding, crowding-out effects, and the distrust in the market, the conclusion may be drawn that the private willingness to pay for green electricity is rather limited. This is also reflected in actual green electricity market shares, which are below 2 percent, indicating that not more than 500,000 German customers switched to green electricity suppliers (Sunderer, 2006). Our experimental evidence indicates that people interpret the promotion of green electricity – the provision and improvement of environmental quality – mainly as a public duty to be financed from tax revenue. Although

[12] The approach chosen in Menges et al. (2005) differs with respect to some essential details from the present paper: Menges et al. (2005) involved a within-participants design, that is, all participant were exposed to the same set of ten treatments in order to assess individual demand functions for green electricity based on the participants' WTP for discrete quantity changes in green electricity consumption. In contrast to this, the present experiment uses a between-participants design, where participants are randomly assigned to a single treatment (chosen from a set of six treatments) and act as price takers. The between-participants design of the present experiment enables us to estimate the participants' average WTP for green electricity under different treatments.

[13] It is a common point in public economics that increasing fiscal transparency helps to prevent distorted fiscal choices of voters and taxpayers, which otherwise contribute to an excessive public sector (see, for example, McGillivray and Morrissey, 2001).

the "greenness" of electricity products in the last years became a major issue on liberalised energy markets, our results suggest that individuals prefer binding collective contributions rather than individual market-driven activities in this field. This result might be interpreted in light of the more general conclusion of political economy, that voters prefer an improvement of the environment by means of regulations and prohibitions instead of market-driven activities. However, in terms of political economy, voters' behaviour is reducible to a certain kind of *cost-illusion*, that is, voters prefer regulations because they expect that environmental improvements are to be achieved without reducing the income of the average citizen (Kirchgässner and Schneider, 2003). The results of our study doubt this argument of cost-illusion, because participants were willing to bear a reduction of income when they voted for regulation.

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