The Behavioral Effects of Carbon Taxes – Experimental Evidence

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Abstract

Carbon taxes are a prominent policy instrument for decreasing the consumption of CO_2-intensive goods in order to reduce the negative external effects involved in the production or consumption of such goods. A tax leads to higher consumer prices, which typically lowers consumption. However, in this paper we provide evidence from laboratory experiments that carbon taxes may be less effective than assumed because of unintended behavioral effects. Especially earmarking the revenues of a carbon tax for environmental purposes—a practice that is popular with voters and policy makers—can crowd out consumers' intrinsic motivation to avoid negative externalities. If this is the case, the tax not only increases consumer prices but also raises consumers' willingness to pay for the taxed good. This, in turn, can offset the price effect and lowers the intended consumption-reducing effect of the tax. Our results suggest that such unintended behavioral effects can be avoided by not earmarking the tax revenue.

Keywords: carbon tax, green tax, negative externality, tax effectiveness, earmarking, intrinsic motivation, moral motivation, pro-environmental behavior, crowding-out, moral licensing

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1 Introduction

The production and consumption of many goods causes negative environmental externalities. Burning fossil energy, for instance, leads to greenhouse gas emissions such as CO_2. These emissions constitute a negative externality that is not reflected in market prices leading to an overconsumption of externality-causing goods compared to the socially optimal level. According to Pigou (1920), consumption can be brought down to the socially optimal level by internalizing the negative externality via a tax mirroring the social and environmental damages caused by the externality. Whereas calculating the exactly correct amount of a Pigou-tax is almost impossible in practice, green taxes or environmental levies, that simply aim at reducing the consumption of externality-causing goods, are frequent (see, e.g., Carl & Fedor, 2016).

Carbon taxes, specifically, are an increasingly prominent policy instrument aimed at decreasing the consumption of CO_2-intensive goods and services. By introducing such taxes and decreasing the consumption of these goods, policy makers aim to reduce the negative external effects involved in the production and consumption of such goods. According to basic microeconomics, a tax typically leads to higher consumer prices, which then lowers the demand. In this paper, we consider the non-standard behavioral effects of carbon taxes. Specifically, from a behavioral economics perspective two questions arise: First, what does levying a carbon tax mean for consumers' personal motivation to reduce negative externalities voluntarily? Can such a tax crowd out consumers' intrinsic motivation to avoid negative externalities in their consumption decisions (Frey, 1999; Nyborg, 2010)? Second, does the effect on consumers' personal motivation depend on the framing of the tax, and especially on the purposes the tax revenue is used for?

In practice, there are different ways in which tax revenues may be spent. First, tax revenues may be used for compensating third parties experiencing damages because of a negative externality. Tax revenues could be earmarked to curb the negative effects of the externality either now or in the future (e.g., CO_2 compensation projects or green spending in general). There are a number of green taxes in different countries with revenues flowing into some sort of green spending. Examples are Japan's tax for climate change mitigation, the French energy consumption tax, or part of the revenues generated by the CO_2 levy on fossil fuels in Switzerland (see Carl & Fedor, 2016, for an overview). Second, in order to avoid that a steering levy increases governments' general tax revenues and thus the tax burden for citizens, tax revenues might be redis-

tributed to consumers. An example is again the Swiss CO_2 levy on fossil fuels, where two thirds of the revenues generated by the tax are redistributed to tax payers. Finally, the tax revenues could be used to finance regular government activities.

The use of revenues created by green taxes, for instance on CO_2 emissions, is an important topic in the political and public debate on a possible introduction of such tax schemes. Indeed, research shows that voters' acceptance of a green tax depends crucially on how the accrued tax revenue is spent, and that acceptance can be increased if the tax revenues are earmarked for green investments or for compensating the environmental damages caused by the consumption of the taxed good (Baranzini & Carattini, 2017; Beiser-McGrath & Bernauer, 2019; Carattini et al., 2017; Kallbekken et al., 2011).

From a behavioral economics perspective, the decision on how the tax revenues are spent may be relevant for the effectiveness of the tax. The spending purpose may impact on the extent to which the tax reduces the consumption of the taxed good and thus the amount of negative externalities caused by that consumption. Specifically, "moral licensing" may occur when the tax revenues are explicitly earmarked for environmental purposes. Moral licensing in this context means that paying a green tax that partially internalizes the negative externalities of a polluting activity, makes people feel "licensed" to engage in this activity more often. The tax may thus crowd out people's intrinsic motivation to avoid negative externalities (see also Frey, 1992a, 1999; Nyborg, 2010; Nyborg et al., 2006). In the end, the effect of earmarking the tax revenues may be counterproductive and even increase the amount of behaviors triggering negative externalities.

Previous empirical studies have shown that voluntary participation in carbon offsetting programs can lead to such licensing or crowding-out effects (Harding & Rapson, 2013; Jacobsen et al., 2012). It seems as if—at least for some consumers—carbon offsetting can work as a mechanism to assuage "guilt" and to justify engaging in polluting activities (see also Lange et al., 2014; Lange & Ziegler, 2017).[1] Compared to voluntary offsetting programs, a compulsory carbon tax touches a lot more people. Yet, it is ex-ante unclear whether such a tax leads to similar behavioral mechanisms as voluntary offsetting. From a researchers' point of view it therefore matters to investigate whether an earmarked tax has similar licensing effects. From a policy-makers' perspective it is

[1] It is important to note, however, that the availability of offsetting possibilities does not necessarily lead to an increase in consumption of the polluting good and that the net effect of offsetting possibilities on emissions does not have to be negative. The latter mainly depends on the effectiveness or the price of the offsetting technology (see Lange & Ziegler, 2017, for a theoretical model).

equally important to understand such potential unintended behavioral effects of a carbon tax. Moreover, policy-makers might be particularly interested in the design of a tax that avoids such effects.

To test the unintended behavioral effects of carbon taxes, we designed an incentivized laboratory experiment in which participants made decisions about whether or not to buy a consumption good that causes a negative externality in the form of CO_2 emissions (see Berger & Wyss, 2021, for a similar approach). By comparing experimental treatments with and without carbon tax, and by comparing different forms of handling the tax revenues ("burning" it, redistributing it to participants, or earmarking it for environmental purposes), the experiment aims at answering two main research questions: Can carbon taxes have unintended effects by providing a justification for people to engage more in polluting activities? And does this effect depend on how the tax revenues are used?

Our results indicate that indeed a tax with earmarked revenues for environmental purposes (CO_2 compensation projects specifically) seems to crowd out participants' intrinsic motivation to avoid negative externalities. Hence, the effectiveness of the tax is reduced. We do not observe such an effect when the tax revenues are not earmarked.

We further tested the effectiveness of carbon taxes in two different decision environments: an individual decision making set-up, in which participants in the role of consumers make individual buying decisions without interacting with each other, and a market set-up in which the externality-causing good is traded between buyers and sellers in a double auction. We find that earmarking fully eliminates the consumption-reducing effect of the carbon tax in the individual decision making set-up, leading consumption to revert back to the levels of a no-tax baseline. In the market set-up, the earmarked tax even backfires leading to a higher level of consumption than in the no-tax baseline.

The paper proceeds as follows: Section 2 briefly summarizes and discusses related literature; section 3 describes the experimental design in detail; section 4 presents behavioral hypotheses; section 5 describes the results and section 6 discusses the implications of our results and concludes.

2 Related Literature

Many pro-environmental behaviors are voluntary and involve a cost for the individual (e.g., in the form of effort or a reduction in comfort) without yielding a direct tangible benefit. Moral motivations and intrinsic motivation are therefore particularly relevant in this domain (see, e.g., Steg, 2016; Turaga et al., 2010, for overviews). There are various studies showing that engaging in pro-environmental behaviors depends to a large extent on people's intrinsic or moral motivation (see, e.g., Bamberg & Möser, 2007, for a meta-analysis). Some studies show that moral motivation predicts the extent to which participants are willing to decrease their car use (Eriksson et al., 2008) or that moral motivation is the strongest predictor of recycling behavior (Saphores et al., 2012). In line with this, Taufik et al. (2015) argue that acting in a pro-environmental way is intrinsically rewarding and yields a "warm glow" like other altruistic behaviors.[2]

Since many decades, the concept of intrinsic motivation is well established and very influential in social psychology. It is typically used to distinguish between *intrinsically motivated* actions that people take out of their pure free will and *extrinsically motivated* actions that they take because of external forces such as rewards, punishments or restrictions (see, e.g., Deci & Ryan, 1985; Ryan & Deci, 2000). By the nature of their discipline, economists tend to emphasize the power of external incentives. Yet, in the meantime, the importance of intrinsic motivation has been recognized and integrated into behavioral economics approaches (e.g., Bénabou & Tirole, 2003; Frey, 1992b, 1997; Le Grand, 2003).

In our case, the intrinsic motivation to avoid negative externalities harming other people or the environment is closely related to the idea of social preferences and moral considerations. The importance of such social preferences has been increasingly studied by (behavioral) economists in the last three decades (see, e.g., Fehr & Schmidt, 2006, for an overview). For instance, Andreoni (1990) has coined the term "warm glow" to explain why people—in contrast to the predictions of the rational and selfish actor ("homo oeconomicus") model—engage in altruistic actions that do not have a direct benefit to themselves. Moral motivation in the sense that people want to do the morally right thing has been studied increasingly and its importance has been recognized for situations when individual choices cause positive or negative externalities for other people

[2]Taufik et al. (2015) find that study participants who were told that they had acted environmentally-friendly actually perceived the current room temperature to be higher than participants who were told that they had acted environmentally-unfriendly; thus a "literal warm-glow."

or the environment (e.g., Bénabou et al., 2018a,b; Bénabou & Tirole, 2006; Brekke et al., 2003).

An important and frequently discussed issue is the possibility that extrinsic incentives can crowd out intrinsic motivation. The concern is that the introduction of external rewards or punishments can weaken people's intrinsic motivation. Specifically, crowding-out of intrinsic motivation might occur when people feel externally controlled or when people feel that an intervention liberates them from their personal responsibilities (Frey & Jegen, 2001). Several empirical studies have documented such crowding out effects in various domains (see, e.g., Frey & Jegen, 2001 for a general overview or, for instance, Gneezy & Rustichini, 2000a,b; Mellström & Johannesson, 2008; Pellerano et al., 2017, for specific cases).

As discussed above, intrinsic motivation seems particularly important in the environmental domain. Hence, it is crucial to understand the relationship between intrinsic and extrinsic motivation when designing policy instruments in the environmental area (Bowles & Hwang, 2008; Frey, 1999). Directly speaking to our research questions, Nyborg (2010) has discussed the possibility that the introduction of green taxes could undermine people's intrinsic moral motivation to behave in an environmentally-friendly way. Based on a theoretical model, Nyborg et al. (2006) have shown that if a green tax is perceived as reducing individuals' responsibility for environmental outcomes, it might crowd out consumers' moral motivation to act pro-environmentally. In line with this conjecture, Lanz et al. (2018) find that a price increase framed as a Pigouvian tax is less effective in reducing the consumption of externality-causing goods than a neutral price increase that is not linked with a tax (see also Perino et al., 2014).

Our paper builds on this literature and advances it by providing an experimental test of whether and under which circumstances the introduction of a carbon tax can indeed reduce consumers' intrinsic motivation to avoid negative externalities caused by their consumption decisions. We provide a new aspect to this discussion by studying whether the possible crowding-out effect depends on the specific design of the tax, notably on the spending purpose the tax revenue. We hypothesize that earmarking tax revenues for environmental purposes leads to crowding-out as it weakens consumers' responsibility for a negative externality. Given the current political and public debate on the introduction of green tax schemes, for instance to reduce CO_2 emissions, and on how the revenues from such schemes should be used, this is a particularly relevant topic.

3 Experimental Design

To study the unintended behavioral effects of carbon taxes and the conditions under which they emerge, we developed a novel laboratory experiment, in which participants were presented with the choice to purchase an (abstract) good with a (monetary) consumption value to the buyer. Yet, the purchase also leads to an increase of CO_2 emissions into the atmosphere, thus entailing a negative externality for the environment. We implemented the negative externality by buying and subsequently retiring a number of CO_2 certificates on the European Market for Emission Trading.[3] The number of retired certificates depended on the trading and buying decisions of the participants in the experiment, so that it was possible to specify the marginal impact of each buying decision on CO_2 emissions. Specifically, we retired one fourth of a certificate (corresponding to 0.25 t of CO_2) *less* for each purchase of the good in the experiment. In research conducted in parallel to ours, Berger & Wyss (2021) have documented the validity of this approach for implementing decisions causing CO_2 externalities in experimental studies.

The experiment consisted of a 4x2 between-subjects design, in which we implemented four different experimental tax treatments: a no-tax baseline; a tax that was collected but "burnt" (corresponding to revenues being used in the general budget); a tax that was redistributed to participants, and a tax that was earmarked for environmental purposes. The four experimental tax treatments were conducted in two types of decision environments: an individual decision making set-up and a competitive market set-up. In the following, we first describe the two decision environments and then the four experimental tax treatments.

3.1 Decision Environments

Similar to Kirchler et al. (2016),[4] who studied the effectiveness of different policy instruments for promoting pro-social behavior, we investigated the behavioral effects of different forms of a carbon tax in two different decision environments. In one setting, participants indicated their willingness to pay (WTP) for purchasing the good using a

[3] We first intended to buy and retire certificates on the Swiss market for emissions trading. However, as the Swiss market was linked with the European market for emission trading on January 1st, 2020, we finally bought the certificates on the European market.

[4] We are grateful to Kirchler et al. (2016) for sharing their experimental materials and software files with us.

price list similar to the Becker-DeGroot-Marschak mechanism (Becker et al., 1964). The second setting was a competitive market setting, in which the good was traded between buyers and sellers in a double auction. The individual decision making set-up serves to measure the pure effect of a tax on people's individual willingness to pay for the taxed good, in the absence of any strategic or competitive considerations. The market set-up extends the perspective by considering that most goods are bought by consumers in competitive markets, which may have an effect on moral considerations that are potentially relevant for goods that carry negative externalities (see, e.g., Bartling et al., 2015; Falk & Szech, 2013). We describe the two set-ups in more detail below.

Individual Decision Making: Price Lists. The individual decision making set-up serves to measure participants' WTP for buying the experimental good or, inversely, their WTP to avoid the emission of 0.25 t of CO_2. Participants had to choose between two options in 26 decision pairs. Each decision pair constituted of the following two options: Not buying the good (option A) vs. buying the good (option B). The consumption value of the good, which was realized when a participant chose to buy the good was always 50 CHF. However, the price for buying the good (in option B) varied and decreased by 1 CHF per decision pair, starting at a price of CHF 35 and going down to CHF 10 in the no-tax baseline. In the tax treatments a tax of 5 CHF was added to the purchase price in each decision pair. As the price decreased, the monetary payoff a participant could receive from choosing to buy the good (option B) increased by 1 CHF per decision pair (starting from 15 CHF in the first pair and going up to 40 CHF in the no-tax baseline, and from 10 CHF up to 35 CHF in the tax treatments). The monetary payoff associated with choosing not to buy the good (option A) remained constant across all decision pairs and was always 15 CHF. The decision screen showed the monetary profit made for both options in each decision pair and the CO_2 emissions caused by the option. The experiment was run for ten periods. For each participant, one decision pair in one of the ten periods was randomly selected and the choice made by the participant in that selected pair was implemented and relevant for the participants' payout and for the CO_2 emissions. Participants were made aware of this procedure in the instructions. As the decision pair and thus the price to be paid for the good was determined randomly, participants could not affect the price of the good by strategically altering their WTP. This procedure thus ensures that we we elicited individual participants' true WTP for buying the good (Becker et al., 1964).

Markets: Double Auctions. In the market environment, participants were randomly assigned to the role of either a buyer or a seller of the good and were matched with each other in markets of four buyers and five sellers each. Each buyer or seller could buy or sell a maximum of one unit of the good. As there were more sellers than buyers in each market, the markets were competitive and one seller would typically not be able to trade. Trading took place in 10 periods, with each period lasting for three minutes during which trading was possible. Trades were made in a double auction format, where buyers could enter buying offers specifying the maximum price they were willing to pay (bid offers) and sellers could enter selling offers specifying the minimum price at which they were willing to sell (ask offers). A trade was concluded if a buyer accepted a selling offer from a seller or, conversely, if a seller accepted a buying offer from a buyer. Each concluded trade caused a negative externality of 0.25 t of CO_2 as explained above. For sellers, the monetary profit associated with trading corresponded to the price sellers' received. For buyers, the profit amounted to the consumption value of the good (50 CHF, as in the individual decision making treatments) minus the price paid in the trade. In the no-tax baseline, the price sellers received was equal to the price buyers paid. In the tax treatments, a tax of 5 CHF was collected per trade, which meant that the price buyers had to pay was always 5 CHF higher than the price sellers received. If participants (both sellers or buyers) did not conclude a trade, they earned a no-consumption outside option worth 15 CHF (identical to the payoff of not buying the good in the individual decision making treatments). As in the individual decision making treatments, one period was randomly selected and the trades made (or not made) in that period were relevant for participants' payouts and for the CO_2-emissions.

3.2 Tax Treatments

As described above, we implemented four different tax treatments in each of the two decision environments.

Base: No Tax. In the baseline treatment no tax was levied on the externality-causing good.

Burnt: Tax Collected and "Burnt". In this treatment a tax of 5 CHF was added to the purchase price. The tax revenue was not used in any further way, i.e., the collected amount was simply destroyed. However, the tax and its purpose of reducing con-

sumption was made salient to participants. Specifically, participants were told in the instructions that "to reduce emissions, a CO_2 tax of CHF 5 is levied on the good" (note that the same wording was also used in the other tax treatments that are described below). Apart from the price effect, the Burnt tax treatment thus also contains the moral signal that goes together with a tax.

Redistributed: Tax Collected and Revenue Redistributed to Participants. Also in this treatment a tax of 5 CHF was levied on the good. The tax revenue was fully redistributed to participants. The redistribution occurred within groups of 9 participants (corresponding to the size of one market in the market treatments). Each participant thus received one ninth of the collected tax revenue, independent of whether the participant consumed (or traded) the good or not. This treatment corresponds to a frequently used form of environmental levies (e.g., the CO_2 levy on fossil fuels in Switzerland), for which (parts of the) tax revenues are redistributed evenly to the population in order to ensure that the tax has a steering effect, while not increasing the overall tax burden in the economy.

Earmarked: Tax Collected and Used for CO_2 compensation. Again a tax of 5 CHF was levied on the good. In this treatment the tax revenue was earmarked for environmental purposes. Specifically, participants were informed that the tax revenue would be used "to finance existing projects, which aim to reduce global CO_2 emissions." Participants did not receive any information about the effectiveness of these projects. They were simply informed that the money collected through the tax in the experiment would be donated to myclimate, a Swiss NGO specialized in CO_2 compensation projects. Participants were provided with two examples of such projects (moorland renaturation in Switzerland and the financing of efficient cooking stoves in Kenya), without going into further details. This treatment corresponds to the frequent call of earmarking carbon taxes for environmental purposes in order to make them more attractive to voters (e.g.. Baranzini & Carattini, 2017; Beiser-McGrath & Bernauer, 2019; Carattini et al., 2017; Kallbekken et al., 2011).

3.3 Data Collection and Procedure

The experiment was conducted in November 2019 at the Decision Science Laboratory at ETH Zurich and was implemented by using the software zTree (Fischbacher, 2007).

In total, we had 215 participants in the individual decision making treatments (number of participants per tax treatment: Base: $n = 54$, Burnt: $n = 54$, Redistributed: $n = 54$, Earmarked: $n = 53$) and 279 participants in 31 markets in the market treatments (number of markets per tax treatment: Base: $n = 8$, Burnt: $n = 8$, Redistributed: $n = 8$, Earmarked: $n = 7$).[5] The ETH Decision Science Laboratory recruited participants for the experiment from the participant pool for economic and behavioral experiments at ETH Zurich and the University of Zurich using the software hroot (Bock et al., 2014), following standard procedures in the lab. We did not specify any exclusion restrictions (e.g., based on study subject) for the recruitment. The participant pool consists mainly of students at ETH Zurich and the University of Zurich. In the individual decision making treatments participants' mean age was 22.06 years ($sd = 2.67$) and 55.81% of participants were women. In the market treatments mean age was 22.97 years ($sd = 5.08$) and 57.35% of participants were women.

Tax treatments were randomly assigned to participants within an experimental session, whereas the decision environment (individual decision making vs. markets) was randomly assigned to sessions. Random assignment to tax treatments (within a session) was conducted by participants drawing their seat-number out of a bag. We aimed at having 36 participants per session, but because of no-shows, the actual session size varied between 27 and 36 participants.[6] Sample sizes had been determined in advance based on statistical power calculations using the results from pilot sessions.

Participants received detailed written instructions at the beginning of every experimental session and had to answer correctly several control questions before the experiment was started. While the participants read the instructions, they had the possibility to ask comprehension questions, which were answered in private. In the market treatments, subjects participated in one trial period that did not have any payoff consequences, in order to familiarize themselves with the market set-up and the trading interface. In the individual decision making environment, no such trial period was conducted, as the set-up was more straightforward. Finally, a summary of the instructions was read aloud

[5]Note that for the market treatments, we treat a market as the independent unit of observation, as participants interacted with each other within a market. To account for this, in the statistical analyses we cluster standard errors at the market level in the market treatments (as is customary in the literature, see, e.g., Bartling et al., 2015; Kirchler et al., 2016). In the individual decision making treatments participants made decisions independently from each other and we can thus treat participants as the independent unit of observation. Where appropriate, we cluster standard errors at the participant level in the statistical analyses.

[6]No-shows are also the reason why we have only seven markets for the Earmarked Tax market treatment instead of eight for which we had aimed.

before the experiment started. After the experiment, participants answered a short post-experimental questionnaire on their motivation behind their decision-making processes, environmental and political attitudes, demographics and their overall satisfaction with the experiment.

Participants earned on average 32.00 CHF in the individual decision making sessions and 31.60 CHF in the market sessions, always including a show-up fee of 10 CHF. An experimental session lasted for around 30 to 45 minutes for individual decision making and for around 60 to 75 minutes for markets. Note, however, that we invited participants for 75 minutes for all sessions in order to avoid any selection effects based on the duration. To implement the negative externalities, we bought and retired CO_2 certificates corresponding to 30.25 t of CO_2 on the European market of emissions trading.[7] If no purchases had occurred at all in the experiment, we would have bought and retired certificates corresponding to 84.75 t of CO_2.[8] The participants' decision in the experiment thus increased the potential maximum of emissions by 54.5 t of CO_2. To implement the earmarking, we donated the tax revenue of 295 CHF from the randomly selected choices and periods in the Earmarked Tax treatments to myclimate, a Swiss NGO, for CO_2 compensation projects.

4 Behavioral Hypotheses

The introduction of a tax is a standard policy tool when trying to reduce the consumption of a particular good that causes negative externalities. As long as neither demand or supply are perfectly price-inelastic, a tax will have an effect on the demand side and reduce consumption because it increases the price, which consumers have to pay.

In this paper, however, we want to extend the perspective of how the introduction of a carbon tax affects consumption decisions by considering not only the above-described price effect of a tax but also potential non-standard psychological effects. In particular, building on the perspective of Frey (1999) and Nyborg et al. (2006), we hypothesize that levying a green tax can affect consumers' intrinsic motivation to avoid consum-

[7] We thank Compensators e.V., a German NGO, for handling these transactions for us.

[8] If all 215 participants in the individual decision making set-up had chosen not to buy the good in the randomly selected decision, we would have retired $215 \times 0.25 = 53.75t$ of certificates. In the market set-up, there were 31 markets with 4 buyers each. If none of these $31 \times 4 = 124$ buyers had bought the good in the randomly selected period, we would have retired $124 \times 0.25 = 31t$ of certificates. Thus, in total the maximum number of certificates we would have retired (if none of the participants' decisions had caused an externality) would have corresponded to $53.75 + 31 = 84.75t$.

ing goods that cause a negative externality (e.g., carbon emissions in the case of our experiment). To illustrate how this process may work, consider the following utility function of a decision maker who needs to decide whether or not to consume an externality-causing good. The consumption utility (U_{Cons}) of the decision maker who decides whether or not consume a unit of the good is given by:[9]

$$U_{Cons} = v - p - t - \theta x \tag{1}$$

In this utility function v corresponds to the consumption value of the good, which was implemented as a monetary benefit in our experiment (fixed at 50 CHF), p is the (market) price the consumer pays for the good, and t is a possible tax that increases the amount a consumer has to pay for the good (note that $v \geq 0$, $p \geq 0$, $t \geq 0$). The variables v, p, and t are the determinants of the consumption decision according to standard economics, with a rational decision maker choosing to consume the good, whenever $v - p - t$ is more attractive than the non-consumption alternative (wich was fixed at 15 CHF in our experiment). The variable x captures the extent of the negative external effect the consumption has on the environment (in our case this corresponds to the negative environmental effects of the emission of 0.25 t of CO_2, e.g., in terms of global warming), and the parameter θ ($\theta \geq 0$) captures an individual's concern about (or felt "guilt" because of) this negative externality. Parameter θ thus determines the extent by which the fact that their consumption decisions have a negative external effect on the environment reduces the decision makers' overall utility from consuming the good. In a first step, one can think of θ as being relatively large for people with a high concern for the environment and of being zero for people who do not care at all about the environment and the negative external effects their consumption decisions have. Note that $\theta = 0$ corresponds to the standard homo oeconomicus case of pure self-interest, reducing consumption utility to $U_{Cons} = v - p - t$.

The utility function defined in (1) captures the consumption reducing effect of a tax. Whenever a tax $t > 0$ is introduced, consumers will buy less of the good.[10] This holds also for consumers who care for the environment, i.e., consumers with $\theta > 0$, as long

[9]Note that, corresponding to the decision making situation in our experiment and to simplify the exposition, we reduce the analysis to a binary decision between consuming or not consuming one unit of the externality-causing good.

[10]Note that in a market setting the tax burden is shared by buyers and sellers such that the increase in the price buyers pay is only in special cases equal to the full tax amount (notably when supply is perfectly elastic). For the qualitative result that the consumption utility decreases and consumption becomes less likely, it only matters, however, that the price increase because of the tax is positive, i.e. $t > 0$.

as we assume that θ does not depend on t. We assume that this case corresponds to our Burnt Tax treatment.

Hypothesis 1 *In the Burnt Tax treatment, the consumption of the externality-causing good is lower than in the no-tax Baseline.*

Most interesting in our experiment is, however, the possibility that the levying of a carbon tax may actually reduce people's concern about or felt guilt because of the externality. Specifically, we hypothesize that earmarking the tax revenue for environmental purposes can actually assuage the (intrinsic) disutility felt about causing the negative externality. Participants may believe that because of the earmarked tax something positive will be done to cope with the externality. As the extent of the externality x remains constant, in terms of the utility function defined in (1), this would correspond to a dependency of θ on the presence and size of the tax: $\frac{\partial \theta}{\partial t} < 0$. Ceteris paribus, a decreasing concern about the externality θ, means that the consumption option is better than the no-consumption outside option for higher prices than before. Thus, a decrease in the concern about the externality, i.e., a decrease in θ, should manifest itself via a willingness to pay higher prices for the externality-causing good.

Hypothesis 2 *The WTP for buying the externality-causing good is greater in the Earmarked Tax treatment than in the no-tax Baseline and in the Burnt Tax treatment.*

Given a possible decrease of the concern for the externality, and the accompanying increase of the WTP for buying the good in the Earmarked Tax treatment, the effect of the Earmarked Tax treatment on consumption (compared to the no-tax Baseline) is ambiguous. It depends on the relative size of the price effect and the decreasing concern effect. Given that the tax amount is the same in the Burnt and the Earmarked Tax treatments, we can formulate a hypothesis for the difference in consumption between these two treatments. As we hypothesize that the Burnt Tax does not affect the concern about the negative externality, whereas we expect the Earmarked Tax to decrease this concern, we have:

Hypothesis 3 *The consumption of the externality-causing good is lower in the Burnt Tax treatment than in the Earmarked Tax treatment.*

Note that we have so-far not formulated a hypothesis for the Redistributed Tax treatment. There is no apparent reason to believe that the redistribution of the tax revenue

affects the participants' intrinsic concern about the negative externality of their consumption. Nevertheless, redistribution may affect the consumption choice. To see why, let us extend the consumption utility from (1) to include the redistribution component:

$$U_{Cons} = v - p - t - \theta x + \frac{nt}{N} \tag{2}$$

The added component $\frac{nt}{N}$ captures the amount a consumer receives from the redistribution scheme. N is the number of people in the group within which the redistribution occurs and n is the number of people in that group who consumed the good and paid the tax. Whereas N is fixed and can be known by the consumer, the individual consumer can only guess what the other consumers' decisions are and does therefore not know the exact number n. However, the marginal effect of a given consumer's consumption decision on the amount the consumer gets out of the redistribution scheme is t/N and is independent of the other consumers' consumption decisions (and therefore also independent of n). Nevertheless, compared to the Burnt Tax treatment, the redistribution element makes consumption more attractive, as it reduces the negative effect of the tax on consumption utility by the marginal effect of an individual's consumption on the individual's receipts from redistribution (t/N). Thus, similar to Hypothesis 3, we can expect that also the Redistributed Tax will lead to higher consumption levels than the Burnt Tax:

Hypothesis 4 *The consumption of the externality-causing good is lower in the Burnt Tax treatment than in the Redistributed Tax treatment.*

Note that in our experiment the number of consumers within a redistribution group was $N = 9$ and corresponded to the number of participants in the Burnt Tax treatment in a given experimental session. Compared to most real-life applications of redistribution schemes, such as for instance the redistribution scheme for the CO_2 tax on fossil fuels in Switzerland, the parameter $N = 9$ in our experiment is very small. This is a relevant difference, because as N grows larger, the marginal effect of the individual's consumption decision on the proceeds the individual consumer gets from the redistribution system (t/N) gets smaller and becomes much less relevant. Therefore, if we did find in our experiment that redistribution hurts the effectiveness of the tax, we would need to be careful to extrapolate this finding to real-life tax redistribution schemes in which the number of people among which redistribution occurs is much larger. Nevertheless, by looking at an extreme case, our results are still informative as they establish

an upper bound of how much revenue redistribution may hurt the effectiveness of a carbon tax.

In general, the Redistributed Tax treatment is an interesting treatment for a comparison with the other tax treatments (Burnt and Earmarked). The redistribution of tax revenue is a relevant policy option and a possible alternative to earmarking when it comes to making a carbon tax a viable option in the political process. In particular, it ensures that tax revenue is not used to finance general government activity, which may help garner support from voters and political parties concerned with the expansion of government activity.

5 Results

As outlined in Section 3 describing the experimental design, we have examined the effects of a gren tax in two different decision environments. In the first environment, the individual decision making set-up, participants made individual decisions on their own in a price list format, without any interactions with other participants. In the second decision environment, the market set-up, participants interacted with each other within competitive markets (four buyers and five sellers). The externality-causing good was traded within these markets and prices as well as trades were determined in a double auction format. In each of these decision making environments we implemented four different tax treatments (no-tax Baseline, Burnt Tax, Redistributed Tax, and Earmarked Tax). Below we first describe the results of these tax treatments in the individual decision making set-up and then the results in the market set-up.

5.1 Individual Decison Making: Price List Treatments

We start by analyzing whether and how the willingness to pay (WTP) for the externality-causing good differed between tax treatments, thus testing our Hypothesis 2 about the potential crowding out of the intrinsic concern for the negative externality by an earmarked carbon tax. We then turn to the analysis of how the WTP translated into consumption levels in the different tax treatments, thus testing Hypotheses 1, 3, and 4.

In line with Hypothesis 2, the top panel of Figure 1 shows that participants' WTP for buying the externality-causing good differed by tax treatment in the individual decision making set-up. While the tax increased prices by design (by 5 CHF), it also seems to

have increased participants' WTP for buying the good, especially in the Earmarked Tax treatment. In column (1) of Table 1, we report the results from OLS regression analyses with the WTP for buying the good as the dependent variable on which treatment dummies were regressed. The Base treatment is the omitted baseline category represented by the constant. As the regression results show, in line with Hypothesis 2, earmarking the tax led to a significant increase in the WTP for the good compared to the no-tax baseline ($p < .01$).[11] Post-estimation tests based on the regression results reported in column (1) of Table 1 reveal that also the differences in WTP between the Earmarked and the Burnt ($p = .04$) and the Earmarked and the Redistributed Tax ($p = .02$) treatments were statistically significant, indicating that it was the earmarking that was the important element for increasing the WTP. The differences with respect to the no-tax baseline were not statistically significant for the Burnt Tax ($p = .30$) and for the Redistributed Tax ($p = .42$), even though there was also a directional increase in the WTP in these two tax treatments.

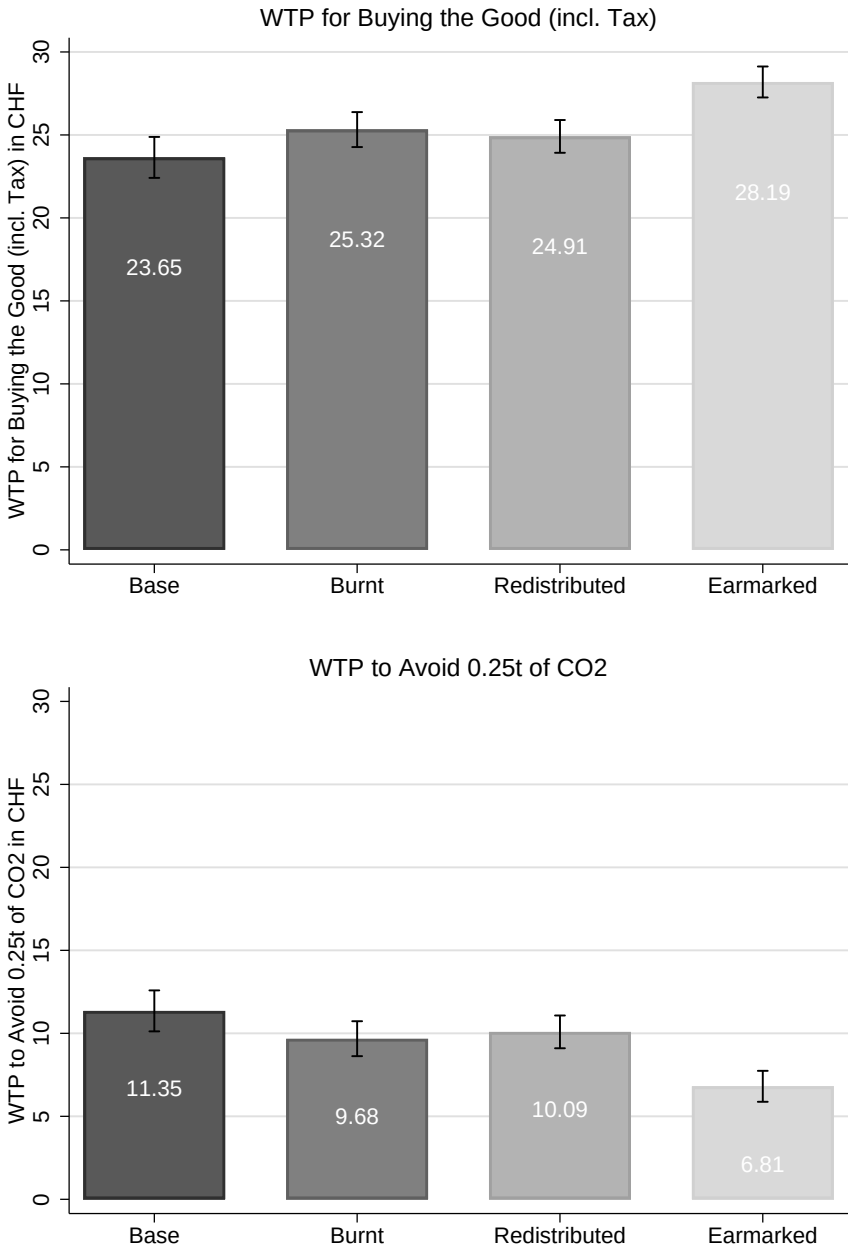
Another way of looking at this result is to consider the amount of money participants were willing to give up to avoid the negative externality, i.e., to avoid that 0.25 t of CO_2 were going to be emitted because of their consumption decision. We can thus frame this amount as the WTP to avoid 0.25 t of CO_2. The bottom panel of Figure 1 shows the corresponding results, which were, by design, perfectly symmetric to the WTP for buying the good that is displayed in the top panel of Figure 1. This perspective illustrates the hypothesized mechanism through which the tax affected the WTP: the tax seems to have lowered participants' concern about the CO_2 emissions their consumption would cause. In particular, in the Earmarked Tax treatment participants were less willing to give up money by refraining from buying the good in order to avoid causing the negative externality compared to all other treatments. We summarized this point, which is in line with our Hypothesis 2, in our first result.

Result 1 *The earmarked carbon tax reduced people's willingness to pay to avoid the negative externality caused by their consumption decision and increased their willingness to pay for buying the externality-causing good.*

Figure 2 shows the development of the WTP for buying the good across the ten decision periods of the experiment in the individual decision making set-up. The results indicate that in all individual decision making treatments, the WTP did not change much across

[11] Note that all p-values reported in this paper are for two-tailed significance tests.

Figure 1: Average WTP for Buying the Good or Avoiding the CO_2 Emission in Individual Decision Making Treatments



Note: The figure shows the average maximum WTP for buying the good (top panel) and the corresponding average WTP for avoiding avoid the negative externality of 0.25 t of CO_2 (bottom panel). Error bars represent plus/minus one standard error of the mean clustered by participant (as every participant made 10 decisions). Number of participants per treatment: Base: $n = 54$, Burnt: $n = 54$, Redistributed: $n = 54$, Earmarked: $n = 53$.

Table 1: Regression Results Individual Decision Making Treatments

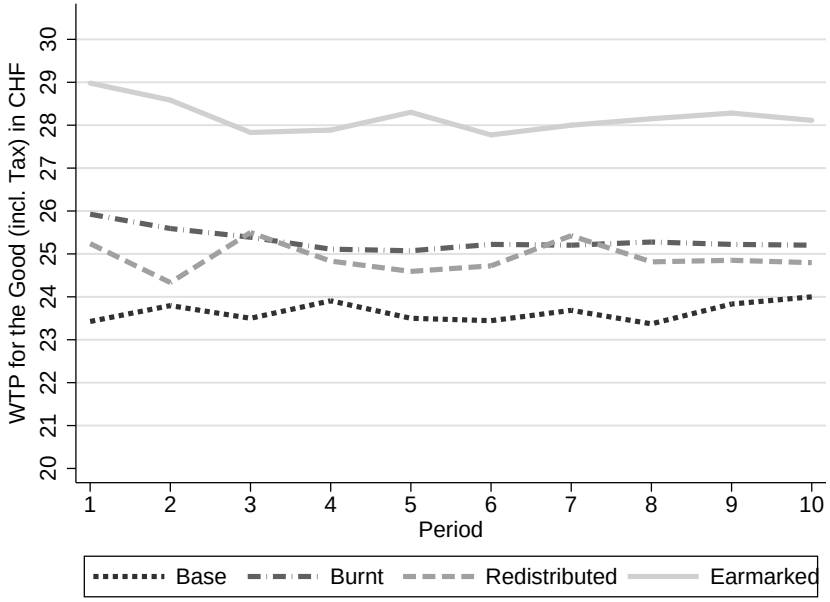
	(1) WTP for Good	(2) Relative Consumption Frequency
Burnt	1.68	–0.13**
	(1.61)	(0.06)
Redistributed	1.26	–0.14**
	(1.57)	(0.06)
Earmarked	4.54***	–0.02
	(1.54)	(0.06)
Constant	23.65***	0.56***
	(1.23)	(0.05)
R^2	0.04	0.04
Observations	2150	2150

$^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$

Notes: OLS estimates. Standard errors, clustered by 215 participants, are in parentheses (as every participant made 10 decisions). In model (1), the dependent variable is the WTP for the good (in CHF) including the tax in the tax treatments. In model (2) the dependent variable corresponds to the percentage of the 26 decision pairs in a period in which a participant preferred buying the good to not buying the good. The independent variables are treatment dummies. The Base condition without a tax is the omitted baseline category represented by the constant.

periods and that decisions remained relatively stable. Additional regression analyses, not reported here, confirm that there were no significant time trends overall nor in any individual treatment ($p > .10$).Moreover, the WTP was not significantly different in the final period compared to the first in all treatments ($p > .10$).

Figure 2: Average WTP for Buying the Good across Periods in Individual Decision Making Treatments



Note: The figure shows the average maximum WTP for consuming the good for each of the 10 decision periods separately. Number of participants per treatment: Base: $n = 54$, Burnt: $n = 54$, Redistributed: $n = 54$, Earmarked: $n = 53$.

So far, we have established that apart from raising prices carbon taxes can also increase the WTP for buying an externality-causing good. As this increase in the WTP countervails the increase in the purchase price, the effect of a tax on consumption levels becomes ambiguous. What was the overall effect of the tax on actual purchases in our experiment? Speaking to our Hypotheses 1, 3, and 4, Figure 3 shows consumption decisions, or more precisely, the relative frequency with which participants decided to purchase the good. This frequency can be calculated simply as the number of times in which a participant preferred to buy the good to not buying the good divided by the total number of decisions. In each of the 10 periods, there were 26 decision pairs (thus 260 in total across the entire experiment) in which participants had to indicate whether they wanted to buy the good at a certain price (option B) or whether they wanted to refrain from buying the good (option A). The tax was implemented as an increase in

the prices reflected in option B, such that participants' consumption utility for option B was always lowered by 5 CHF in all decision pairs in the tax treatments compared to the baseline treatment.

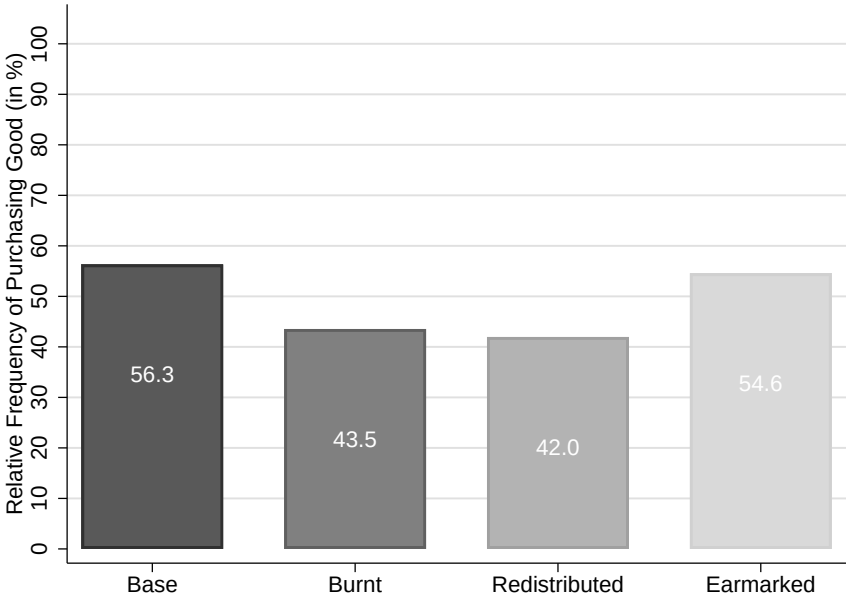
The results displayed in Figure 3 show that in line with Hypothesis 1 the Burnt Tax reduced the consumption compared to the no-tax baseline. The same holds for the Redistributed Tax. However, because of the increase in the WTP, the Earmarked Tax was ineffective and did not lower the relative consumption frequency compared to the baseline. The regression results reported in column (2) of Table 1 provide the corresponding significance tests. Both in Figure 3 and in column (2) of Table 1 the dependent variable is a participant's relative frequency of buying the good, i.e., the number of times in the 26 decisions per period the participant chose to buy rather than not to buy the good. In line with Hypothesis 1, the regression results show that the Burnt Tax led to a significant decrease in consumption compared to the no-tax baseline ($p = .04$). A similar effect occured for the Redistributed Tax ($p = .02$). The Earmarked Tax turned out to be ineffective, however, as there was no significant decrease in consumption compared to the baseline ($p = .77$). Comparing the consumption between the different tax treatments, we find, in line with Hypothesis 3, that the Burnt Tax led to a significantly lower consumption of the externality-causing good than the Earmarked Tax of the same size ($p = .04$ in a post-estimation test based on the regression results reported in column (2) of Table 1). We do not find support for Hypothesis 4, however. The Redistributed Tax did not reduce consumption by less than the Burnt Tax ($p = .77$). In fact, the Redistributed Tax also reduced the consumption by more than the Earmarked Tax ($p = .02$). These results indicate that earmarking the revenue made the tax ineffective for reducing consumption, whereas redistribution proved to be unproblematic.

Result 2 *In the individual decision making set-up, the Earmarked Tax did not lead to a decrease in consumption compared to the no-tax baseline. The earmarking increased people's willingness to pay higher prices caused by the tax. As the Burnt and the Redistributed Tax did not increase the willingness to pay, they were successful in reducing consumption.*

5.2 Market Behavior: Double Auction Treatments

In the market treatments, prices were determined in a double auction. In case of tax treatments, the prices paid by the buyers were always 5 CHF higher than the prices the sellers received, as the tax was deducted from the purchase price. Unlike in the individual decision making treatments, it was thus ex-ante not clear by how much the

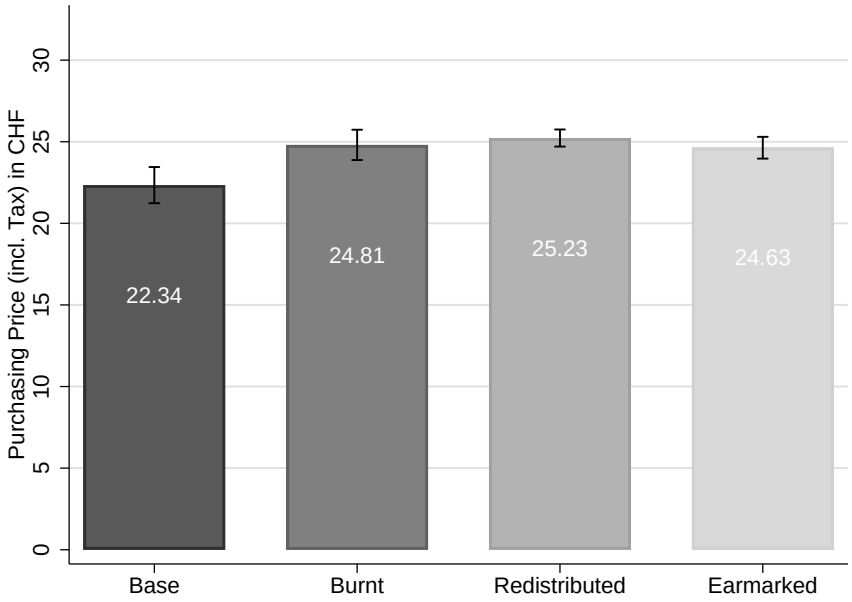
Figure 3: Average Relative Frequency of Buying the Good in Individual Decision Making Treatments



Note: The figure shows the average relative frequency of purchasing the good for an average participant in each individual decision making treatment. The relative frequency is derived from dividing the number of choices in which a given participant indicated he or she preferred buying the good to not buying the good divided by the total number of such choices made in each period. Number of participants per treatment: Base: $n = 54$, Burnt: $n = 54$, Redistributed: $n = 54$, Earmarked: $n = 53$.

tax would increase the purchase prices for the consumers, even though the tax was of the same size. Figure 4 shows the results of the double auction treatments. As expected, the tax did increase purchase prices in all tax treatments compared to the baseline. Regression results reported in column (1) of Table 2 show that the increase in purchase prices compared to the no tax baseline was at least marginally significant in all three tax treatments ($p = .08$ in Burnt, $p = .02$ in Redistributed, and $p = .07$ in Earmarked).

Figure 4: Average Purchase Price Buyers Paid in Market Treatments



Note: The figure shows the average purchasing price buyers paid in the four double auction treatments (including the tax in the tax treatments). Error bars represent plus/minus one standard error of the mean clustered by market. Number of markets per treatment: Base: $n = 8$, Burnt: $n = 8$, Redistributed: $n = 8$, Earmarked: $n = 7$.

Figure 5 displays the development of prices across auction periods in the market treatments. Unlike for the WTP in the individual decision making treatments there were some noticable trends in the development of purchase prices across periods. The figure indicates that purchase prices increased across periods in Base, whereas they decreased in all three tax treatments. Additional regression analyses, not reported here, show that when "period" is treated as a continuous regressor, the increase in prices over periods in Base nor the decrease in Burnt are statistically significant ($p = .20$ and $p = .18$ respectively). In the Redistributed Tax treatment the decrease over periods is marginally significant ($p = .07$) and in the Earmarked Tax treatment it is highly significant ($p < .01$). When comparing prices in the first to the final period, we find that the increase in prices

Table 2: Regression Results Market Treatments

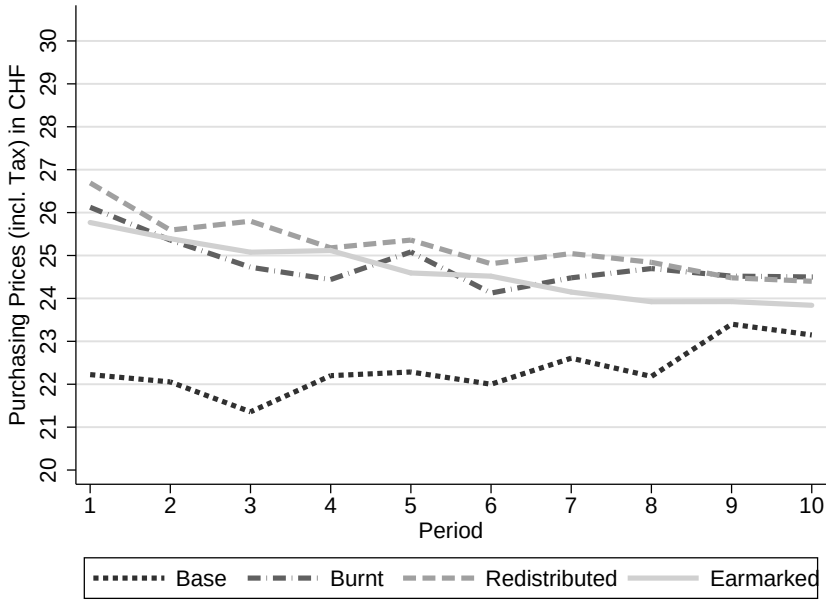
	Purchase Price	Relative Consumption Frequency	
	(1)	(2)	(3)
	OLS	OLS	Probit
Burnt	2.47*	−0.08	−0.26
	(1.38)	(0.08)	(0.28)
Redistributed	2.89**	−0.03	−0.10
	(1.17)	(0.08)	(0.30)
Earmarked	2.29*	0.12**	0.69**
	(1.23)	(0.06)	(0.27)
Constant	22.34***	0.82***	0.92***
	(1.05)	(0.06)	(0.22)
(Pseudo-)R^2	0.11	0.04	0.04
Observations	1021	1240	1240

$^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$

Notes: Standard errors, clustered by 31 markets, are in parentheses. In model (1), the dependent variable is the purchasing price paid by the buyers (in CHF) including the tax in the tax treatments. The number of observations corresponds to the total number of trades in the experiment. In model (2) the dependent variable is an indicator variable taking on value 1 if a possible trade was concluded and taking on value 0 if it was not concluded. The number of observations corresponds to the total number of possible trades in the experiment. The independent variables are treatment dummies. The Base condition without a tax is the omitted baseline category represented by the constant.

is not significant in Base ($p = .35$). In contrast, in all tax treatments there was a significant decrease from first to final period ($p = .05$ in Burnt, $p = .04$ in Redistributed, $p < .01$ in Earmarked). Despite these statistically significant developments over time, we focus the following analyses on the data pooled across periods. We do so because in this paper we are mostly interested in the tax effectiveness, i.e., in the consumption-reducing effect of carbon taxes, and in assessing how unintended behavioral effects can lower the tax' effectiveness. Given the trends displayed in Figure 5, pooling the data across periods, means that our results show a higher consumption-reducing effect of carbon taxes than the individual lines do. This means that we underestimate the countervailing behavioral effect of a tax (assuming that this effect remains constant across periods). We prefer this approach in order to provide a conservative estimate of the behavioral effect of a carbon tax.

Figure 5: Average Purchase Price Buyers Paid across Periods in Market Treatments

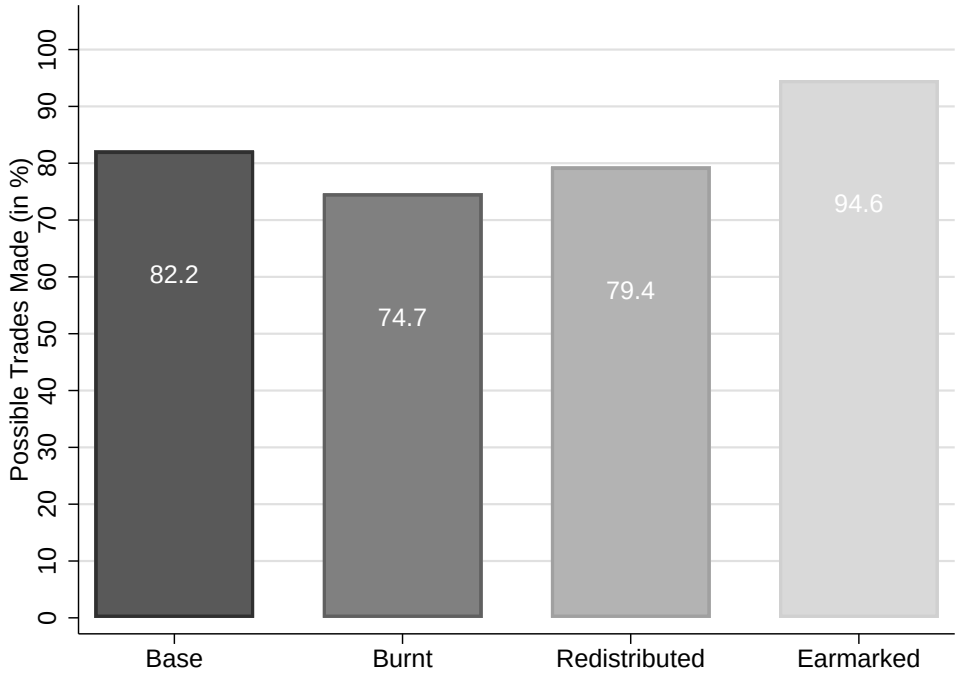


Note: The figure shows the average purchasing price buyers paid for each of the 10 decision periods separately. Number of markets per treatment: Base: $n = 8$, Burnt: $n = 8$, Redistributed: $n = 8$, Earmarked: $n = 7$.

In the individual decision making treatments, we saw that the Earmarked Tax raised consumers' WTP for buying the good. Given this increase in the WTP because of the tax, it is again an open empirical question how much the price increase due to the tax affected consumption levels in the market set-up. To assess the effects of the tax

treatments on consumption, and thus to test Hypotheses 1, 3, and 4 in the market set-up, Figure 6 plots the average relative frequency of realized trades (in percent of all possible trades). This relative frequency indicates how likely it was that a given buyer made a trade and bought the good. Directionally in line with Hypothesis 1, the results show that the Burnt Tax seems to have reduced consumption compared to the no-tax baseline. As in the individual decision making case, the Redistributed Tax also seems to have decreased the consumption. However, in the market set-up, the Earmarked Tax resulted not only in a higher relative frequency of consumption than the other two tax options but even led to a higher consumption frequency than the baseline.

Figure 6: Average Possible Trades Realized in Market Treatments



Note: The figure shows the average average relative frequency of a trade being made in each treatment (in percent of all possible trades). The relative frequency is derived from dividing the number of trades in a market by the number of possible trades. Number of markets per treatment: Base: $n = 8$, Burnt: $n = 8$, Redistributed: $n = 8$, Earmarked: $n = 7$.

Columns (2) and (3) of Table 2 provide the corresponding regression results using an OLS and a probit specification respectively.[12] The dependent variable is an indicator

[12]We provide the OLS results in the sense of a linear probability model (see, e.g., Moffitt, 1999; Angrist & Pischke, 2009, pp. 94-99; Wooldridge, 2010, pp. 561-565) to ensure direct comparability with Figure 6.

variable taking on a value of 1 if a possible trade was concluded and a value of 0 if it was not. The results show that there was only directional support for Hypothesis 1 in the market set-up, as the decrease in trade (and thus in consumption) between the no-tax baseline and the Burnt Tax treatment was not statistically significant ($p = .34$ with OLS, $p = .35$ with probit). The decrease in consumption was also not significant for the Redistributed Tax compared to the baseline treatment ($p = .74$ with OLS and probit). However, the increase in consumption caused by the Earmarked Tax compared to the no-tax baseline was statistically significant ($p = .05$ with OLS, $p = .01$ with probit). Moreover, in line with Hypothesis 3, post-estimation tests (based on the regression results reported in columns (2) and (3) of Table 2) show that the Earmarked Tax led to higher levels of consumption than the Burnt Tax ($p < .01$ with OLS and probit). The same holds for the comparison of the Earmarked Tax with the Redistributed Tax ($p = .02$ with OLS, $p < .01$ with probit). Thus, the earmarking of the tax led to an increase in consumption compared to the other two versions of the tax we tested. There was again no support for Hypothesis 4, as consumption did not differ between the Redistributed and the Burnt Tax treatment ($p = .35$ with OLS, $p = .56$ with probit).

Result 3 *In the market set-up, the Earmarked Tax led to an increase in consumption compared to the no-tax baseline. The Burnt and the Redistributed Tax led to a (non-significant) reduction of consumption compared to the no-tax baseline.*

6 Discussion and Conclusions

In this paper we have reported the results from a laboratory experiment testing unintended behavioral effects of green taxes. We focused on the example of a carbon tax, a prominent policy instrument for curbing CO_2 emissions and fighting climate change. The intention of carbon taxes is to lower the demand for CO_2-intensive goods by increasing prices. Yet, previous literature has conceptually discussed and theoretically analyzed the idea that such taxes may also have unintended behavioral effects by crowding out consumers' intrinsic moral motivation to act in an environmentally-friendly way (Frey, 1999; Nyborg, 2010; Nyborg et al., 2006). Our experimental results provide empirical evidence to support this hypothesis. Crowding-out can actually harm the effectiveness of a carbon tax.

Our results are more nuanced, however, and provide clear directions to policy makers on how to design a carbon tax that is effective in reducing the consumption of CO_2-

intensive goods. Specifically, we find that earmarking tax revenues for green purposes leads to significant crowding-out effects that make the tax less effective. If the revenues of a carbon tax are not earmarked (either simply put into the general governmental budget or redistributed back to participants), the price effect of the tax clearly dominates and the tax is effective in reducing the consumption of goods with negative externalities.

The framing of a carbon tax, specifically the purposes for which the revenues generated by the tax are used, seems to be relevant to ensure the effectiveness of such a tax. Our results suggest that in order to reduce the consumption of a good that causes negative externalities, it is more effective to impose a tax for which revenues are either redistributed to the consumers or flow into the ordinary government budget. Making the explicit link between a tax and green spending does not seem advisable, as it may trigger crowding-out dynamics.

Our results do not mean that green spending per se, e.g., in the form of investing into research aimed at developing environmentally-friendly technologies or other projects that reduce CO_2 emissions in the future, is in general ineffective. The revenues collected by the earmarked tax in our experiment went into projects that will have a positive impact on mitigating the effects of CO_2 emissions. However, our results show very clearly that green spending should not be directly linked to green taxes. It would be more effective to reduce both the consumption of CO_2-intensive goods and to invest into additional measures such as CO_2 compensation projects or technology development projects without linking the two. In principle, this can be easily accomplished by introducing a tax that is not earmarked but simply flows into the ordinary government budget from which green spending can then be financed.

A remaining question is how to ensure politicians' and voters' support for the introduction of carbon taxes given that the popular option of earmarking proves to make a tax less effective. Answering this question was not the key focus of our study. However, we can offer the observation from our experiment that the redistribution of the tax revenues to participants did not affect the effectiveness of the tax. We obtained this result even though the redistribution occurred within very small groups in our experiment. In reality, redistribution takes place within far larger groups, which makes it even less likely that redistribution has problematic effects that impair the effectiveness of a tax. This is good news as the redistribution of a tax can be a way to garner political support for the introduction of carbon taxes. The results by Beiser-McGrath & Bernauer (2019)

who find that using the revenue from a carbon tax to finance general tax rebates also increases support for a carbon tax to a similar extent as using the revenue for green spending, suggest that this may indeed be a feasible option (see also Carattini et al., 2017).

We hope that our results can provide a constructive input on how to design effective carbon (and other green) taxes that reduce the consumption of CO_2-intensive goods and thus contribute to the goal of substantially decreasing global CO_2 emissions. Carbon tax schemes have recently gained popularity in the political and public debate and are likely to be introduced or extended in many countries in the years to come. It is important that these schemes are designed in the most effective way possible. Our results show that policy makers should pay attention to the framing of these schemes in order to avoid unintended behavioral effects and to ensure optimal effectiveness.

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References

Andreoni, J. (1990). Impure altruism and donations to public goods: A theory of warm-glow giving. *The Economic Journal*, *100*(401), 464–477.

Angrist, J. D. & Pischke, J.-S. (2009). *Mostly Harmless Econometrics*. Princeton University Press.

Bamberg, S. & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, *27*(1), 14–25.

Baranzini, A. & Carattini, S. (2017). Effectiveness, earmarking and labeling: testing the acceptability of carbon taxes with survey data. *Environmental Economics and Policy Studies*, *19*(1), 197–227.

Bartling, B., Weber, R. A., & Yao, L. (2015). Do markets erode social responsibility? *The Quarterly Journal of Economics*, *130*(1), 219–266.

Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science*, *9*(3), 226–232.

Beiser-McGrath, L. F. & Bernauer, T. (2019). Could revenue recycling make effective carbon taxation politically feasible? *Science Advances*, *5*(9), eaax3323.

Bénabou, R., Falk, A., & Tirole, J. (2018a). Eliciting moral preferences. *Working Paper*.

Bénabou, R., Falk, A., & Tirole, J. (2018b). Narratives, imperatives, and moral reasoning. *National Bureau of Economic Research, NBER Working Paper No. 24798*.

Bénabou, R. & Tirole, J. (2003). Intrinsic and extrinsic motivation. *The Review of Economic Studies*, *70*(3), 489–520.

Bénabou, R. & Tirole, J. (2006). Incentives and prosocial behavior. *American Economic Review*, *96*(5), 1652–1678.

Berger, S. & Wyss, A. M. (2021). Measuring pro-environmental behavior using the carbon emission task. *Journal of Environmental Psychology*, 101613.

Bock, O., Baetge, I., & Nicklisch, A. (2014). hroot: Hamburg registration and organization online tool. *European Economic Review*, *71*, 117–120.

Bowles, S. & Hwang, S.-H. (2008). Social preferences and public economics: Mechanism design when social preferences depend on incentives. *Journal of Public Economics*, *92*(8-9), 1811–1820.

Brekke, K. A., Kverndokk, S., & Nyborg, K. (2003). An economic model of moral motivation. *Journal of Public Economics*, *87*(9-10), 1967–1983.

Carattini, S., Baranzini, A., Thalmann, P., Varone, F., & Vöhringer, F. (2017). Green taxes in a post-Paris world: are millions of nays inevitable? *Environmental and Resource Economics*, *68*(1), 97–128.

Carl, J. & Fedor, D. (2016). Tracking global carbon revenues: A survey of carbon taxes versus cap-and-trade in the real world. *Energy Policy*, *96*, 50–77.

Deci, E. L. & Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*. New York: Plenum Press.

Eriksson, L., Garvill, J., & Nordlund, A. M. (2008). Interrupting habitual car use: The importance of car habit strength and moral motivation for personal car use reduction. *Transportation Research Part F: Traffic Psychology and Behaviour*, *11*(1), 10–23.

Falk, A. & Szech, N. (2013). Morals and markets. *Science*, *340*(6133), 707–711.

Fehr, E. & Schmidt, K. M. (2006). The economics of fairness, reciprocity and altruism–experimental evidence and new theories. In S.-C. Kolm & J. M. Ythier (Eds.), *Handbook of the Economics of Giving, Altruism and Reciprocity*, volume 1 (pp. 615–691). Elsevier.

Fischbacher, U. (2007). z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental economics*, *10*(2), 171–178.

Frey, B. S. (1992a). Pricing and regulating affect environmental ethics. *Environmental and Resource Economics*, *2*(4), 399–414.

Frey, B. S. (1992b). Tertium datur: Pricing, regulating and intrinsic motivation. *Kyklos*, *45*(2), 161–184.

Frey, B. S. (1997). *Not just for the money*. Edward Elgar Publishing.

Frey, B. S. (1999). Morality and rationality in environmental policy. *Journal of Consumer Policy*, *22*(4), 395–417.

Frey, B. S. & Jegen, R. (2001). Motivation crowding theory. *Journal of Economic Surveys*, *15*(5), 589–611.

Gneezy, U. & Rustichini, A. (2000a). A fine is a price. *The Journal of Legal Studies*, *29*(1), 1–17.

Gneezy, U. & Rustichini, A. (2000b). Pay enough or don't pay at all. *The Quarterly journal of economics*, *115*(3), 791–810.

Harding, M. & Rapson, D. (2013). Do voluntary carbon offsets induce energy rebound? a conservationist's dilemma. *Working Paper*.

Jacobsen, G. D., Kotchen, M. J., & Vandenbergh, M. P. (2012). The behavioral response to voluntary provision of an environmental public good: Evidence from residential electricity demand. *European Economic Review*, *56*(5), 946–960.

Kallbekken, S., Kroll, S., & Cherry, T. L. (2011). Do you not like Pigou, or do you not understand him? tax aversion and revenue recycling in the lab. *Journal of Environmental Economics and Management*, *62*(1), 53–64.

Kirchler, M., Huber, J., Stefan, M., & Sutter, M. (2016). Market design and moral behavior. *Management Science*, *62*(9), 2615–2625.

Lange, A., Schwirplies, C., & Ziegler, A. (2014). On the interrelation between carbon offsetting and other voluntary climate protection activities: Theory and empirical evidence. *Joint Discussion Paper Series in Economics, Working Paper*.

Lange, A. & Ziegler, A. (2017). Offsetting versus mitigation activities to reduce co2 emissions: A theoretical and empirical analysis for the us and germany. *Environmental and Resource Economics*, *66*(1), 113–133.

Lanz, B., Wurlod, J.-D., Panzone, L., & Swanson, T. (2018). The behavioral effect of pigovian regulation: Evidence from a field experiment. *Journal of Environmental Economics and Management*, *87*, 190–205.

Le Grand, J. (2003). *Motivation, agency, and public policy: of knights and knaves, pawns and queens*. Oxford University Press.

Mellström, C. & Johannesson, M. (2008). Crowding out in blood donation: was Titmuss right? *Journal of the European Economic Association*, *6*(4), 845–863.

Moffitt, R. A. (1999). New developments in econometric methods for labor market analysis. In O. C. Ashenfelter & D. Card (Eds.), *Handbook of Labor Economics*, volume 3, Part A (pp. 1367 – 1397). Elsevier.

Nyborg, K. (2010). Will green taxes undermine moral motivation. *Public Finance and Management*, *110*(2), 331–51.

Nyborg, K., Howarth, R. B., & Brekke, K. A. (2006). Green consumers and public policy: On socially contingent moral motivation. *Resource and Energy Economics*, *28*(4), 351–366.

Pellerano, J. A., Price, M. K., Puller, S. L., & Sánchez, G. E. (2017). Do extrinsic incentives undermine social norms? Evidence from a field experiment in energy conservation. *Environmental and Resource Economics*, *67*(3), 413–428.

Perino, G., Panzone, L. A., & Swanson, T. (2014). Motivation crowding in real consumption decisions: Who is messing with my groceries? *Economic Inquiry*, *52*(2), 592–607.

Pigou, A. (1920). The economics of welfare.

Ryan, R. M. & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54–67.

Saphores, J.-D. M., Ogunseitan, O. A., & Shapiro, A. A. (2012). Willingness to engage in a pro-environmental behavior: An analysis of e-waste recycling based on a national survey of us households. *Resources, Conservation and Recycling*, *60*, 49–63.

Steg, L. (2016). Values, norms, and intrinsic motivation to act proenvironmentally. *Annual Review of Environment and Resources*, *41*, 277–292.

Taufik, D., Bolderdijk, J. W., & Steg, L. (2015). Acting green elicits a literal warm glow. *Nature Climate Change*, *5*(1), 37–40.

Turaga, R. M. R., Howarth, R. B., & Borsuk, M. E. (2010). Pro-environmental behavior: Rational choice meets moral motivation. *Annals of the New York Academy of Sciences*, *1185*(1), 211–224.

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data* (Second ed.). Cambridge, MA; London, UK: MIT Press.