Behavioral Sources of the Demand for Carbon Offsets: An Experimental Study

Kai-Uwe Kühn
Centre for Competition Policy
School of Economics
University of East Anglia

Neslihan Uler
Agricultural and Resource Economics
University of Maryland

CCP Working Paper 17-1

Abstract

Voluntary carbon offset schemes have sprung up in the last decade offering individuals opportunities to neutralize their own carbon footprint. These schemes strongly appeal to the personal responsibility of individuals in reducing the carbon emissions they cause. In this paper we report on a controlled laboratory experiment to better understand the behavioral motivations driving the purchase of carbon offsets, i.e., payments towards the reduction of damages to the environment. We show that the opportunity to offset damages does not affect the total damages created by the individuals when individuals trade in competitive markets. At the same time, we find a stable demand for carbon offsets when the price is sufficiently low. Therefore, introduction of carbon offsets increases efficiency by eliminating some of the damages ex-post. Behavior, however, is very heterogeneous. Individuals with a high (low) personal-responsibility index increase their offset purchases as their own damage (total damages) increases, but do not condition their offsetting behavior on the total damages (own damages) created.

Contact Details:
Kai-Uwe Kühn K.Kuhn@uea.ac.uk

ISSN 1745-9648

Behavioral Sources of the Demand for Carbon Offsets: An Experimental Study*

Kai-Uwe Kuhn† Neslihan Uler‡

March 1, 2017

*We thank Li Liao, Ambrish Amaranathan, Jonathan Yu and Andrew Card for research assistance. Yesim Orhun provided valuable comments. We also thank the audiences at the 2014 ESA Meetings and the 2014 LAGV Meetings. Experiments were run at the Institute of Social Research at University of Michigan. Subject payments were financed by a grant from the Erb Institute at University of Michigan.

†School of Economics, University of East Anglia e-mail: k.kuhn@uea.ac.uk

‡Agricultural and Resource Economics, University of Maryland e-mail: neslihan@umd.edu

Abstract

Voluntary carbon offset schemes have sprung up in the last decade offering individuals opportunities to neutralize their own carbon footprint. These schemes strongly appeal to the personal responsibility of individuals in reducing the carbon emissions they cause. In this paper we report on a controlled laboratory experiment to better understand the behavioral motivations driving the purchase of carbon offsets, i.e., payments towards the reduction of damages to the environment. We show that the opportunity to offset damages does not affect the total damages created by the individuals when individuals trade in competitive markets. At the same time, we find a stable demand for carbon offsets when the price is sufficiently low. Therefore, introduction of carbon offsets increases efficiency by eliminating some of the damages ex-post. Behavior, however, is very heterogeneous. Individuals with a high (low) personal-responsibility index increase their offset purchases as their own damage (total damages) increases, but do not condition their offsetting behavior on the total damages (own damages) created.

1 Introduction

In recent years many organizations have been created to make individuals and businesses aware of their carbon footprint (emissions resulting from everyday activities like driving, travelling and heating one's home), take actions to reduce it, and buy "carbon offsets" to finance carbon emissions reducing activities. Carbon offset programs have been offered by organizations like myclimate.org, carbonfootprint.com, carbonfund.org, terrapass.com and many others.[1] Alongside these developments, we have witnessed the establishment of centralized trading institutions, like the Chicago Climate Exchange, and of private companies serving as aggregators for small scale carbon offset supplies, which are often typical in agriculture.

These schemes are very different from internalizing carbon emissions externalities in industrial production as in the electricity industry, which limit the aggregate amount of carbon emissions and allow pollution permits to be traded on formalized exchanges. In these schemes the reduction of carbon emissions is mandated and trade occurs as a consequence of profit maximizing incentives.

Carbon offsets, in contrast, rely on the belief that carbon reduction should start with the personal responsibility of individuals for the emission they cause themselves. Carbon offset programs aim at changing the preferences of individuals by making them aware of the externalities they cause and rely on their willingness to reduce these externalities by either avoiding externality causing activities or financing carbon emissions reducing investments elsewhere (e.g., supporting energy efficient projects and tree planting).

In this paper we assess the potential for such behavioral motivations to generate private

---

[1]See also Capoor and Ambrosi (2009) and Peters-Stanley and Yin (2013) for overviews of the state of carbon markets.

demand for carbon offsets in a laboratory experiment.[2] In the experiment we choose to refrain from using environmental terminology in order to mitigate framing and experimenter demand effects. We talk about damages and damage offsets, instead of environmental damages and carbon offsets. We show that damage offset purchases are closely linked to the damages caused by the specific trading of a subject, which we interpret as motivations connected to personal responsibility. Subjects are heterogeneous in these incentives, but an index for survey questions closely linked to personal responsibility appears to control well for this heterogeneity. In the treatment where this responsibility variable has a large effect, contributions to the public good of damage reduction also has a much more persistent effect than is typical for public goods experiments.

Interestingly, the possibility for damage offset purchases does not substantially change trading incentives, so that opportunities for damage avoidance through restrictions on trading are not taken up.

Existing experimental research on behavior in anonymous competitive markets appears to confirm that the traditional economic view that explicit monetary incentives through taxation are necessary to internalize externalities. A classic experiment by Plott (1983) has shown that in a competitive market (modeled as a double auction), individuals ignore the externalities arising from their transactions and trading achieves the inefficient competitive equilibrium. An optimal tax to internalize the externality led reliably to efficient solutions. In contrast, Harrison et al (1987) have shown in the same setting that allowing side contracting in face to face Coasian bargaining between all subjects generated efficient solutions. Arguably, the transaction costs of Coasian bargaining over issues like carbon emissions are

[2] Controlled laboratory experiments have been used to evaluate economic behavior and environmental policy for several decades. Early examples of testbedding include Plott and Hong (1982) and Grether, Isaac and Plott (1981). For surveys see, for example, Mestelman (2000), Sturm and Weimann (2006), Ehmke and Shogren (2008), Cason (2010), Friesen and Gangadharan (2013), Noussair and van Soest (2014).

prohibitive, so that this setting does not appear realistic for the issue of carbon emissions.

The results of Plott (1983) do not necessarily imply that damage offsets would have no impact on correcting externalities. In a double auction market (typical in anonymous markets) it may be cognitively difficult to develop altruistic or warm glow giving motivations in contrast to pure public good settings where such behavior has been observed.[3] The explicit introduction of offset payments may have the potential to modify individual behavior because they may make the externalities more tangible for the individuals trading in a double auction market. With damage offsets individuals are confronted with the damages caused by their trading and those of other buyers after completing a transaction in a double auction market and are given the opportunity to undo the damages.

For this reason, this paper examines a setting in which subjects first trade in a double auction market similar to the one in Plott (1983) and then are given the opportunity to contribute to damage reduction for all buyers in the market.

The second stage therefore resembles a classic public goods game. Several research studies have documented that individuals may have other-regarding preferences and contribute to public goods at much higher levels than predicted by standard theory (i.e., Andreoni, 1989, 1990; Ledyard, 1995; Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000; Andreoni and Miller, 2002; Charness and Rabin, 2002). Another major finding in this literature is that contributions decline and free-riding increases with repetition (Ledyard, 1995; Chaudhuri, 2011). Nevertheless, contributions usually stay above the complete free-riding equilibrium prediction.

The setting in this paper differs from the previous literature by studying the impact of the behavior in the double auction on behavior in the second stage public good game

[3]In fact, it has been argued by several recent studies that markets might erode socially responsible behavior (e.g., Sandel, 2012; Kube, Marechal and Puppe, 2012; Falk and Szech, 2013).

as well as the feedback effect from the opportunity to purchase damages offsets to trading behavior. There are several potential reasons why behavior may differ from typical public goods games. First, the degree to which a public good problem exists depends on the degree of trading in the first period. Second, behavioral motivations in the second stage (damage offset stage) may be quite different than in a public goods game. Subjects may treat damages caused by themselves and those caused by others very differently. While altruism or warm-glow motivations may play a role, we have the new feature that the personal contribution to the damage problem is observable by subjects and may affect decisions regarding how much they contribute to damage offsets. We show that many subjects act based on their original contribution to the damage: they increase their offset purchases as their share in total damages increases–a behavior that we will call "personal responsibility" driven contributions.

We show that personal responsibility driven contributions occur among the set of subjects who have a high personal-responsibility index. This index is based on survey responses concerning activities such as engaging in non-monetary, time-consuming projects like volunteering.

Secondly, we also study the impact of the presence of the opportunity to buy damage offsets on the behavior in the double auction market. In a double auction with external effects, altruism may not be observed because a given individual's effect on others is not very visible and, in addition, involves a complex tradeoff by requiring that fewer privately advantageous trades are completed. Cognitively, it may therefore be more difficult to compare costs and benefits of altruistic behavior in a double auction setting in contrast to a public goods game.

The mere presence of a mechanism to make offset payments may therefore activate the type of other regarding preferences that we see in a public goods game. Making the external effect of trading more salient through an offset market may also trigger norm activation for norms requiring the avoidance of causing damage to others.[4] If these effects are present, then

[4]To get a general overview on how social norms may shape economic behavior, see Elster

the availability of offset payments could modify the behavior in the initial double auction compared to the results of Plott (1983). However, our experiments show little evidence of such behavior. Trading in the double auction market does not seem to vary with the presence of the opportunity to purchase offsets nor with the cost at which damage offsets can be acquired. This seems to indicate a strong tendency for mental accounting where externalities are ignored in trading, but make a difference when considering damage offset later on.

A closely related paper to ours is by Bartling, Weber and Yao (2015) that studies the extent to which markets erode socially responsible behavior in two laboratory experiments. In a competitive market set-up sellers decide on a price and on which type of product they want to offer for sale. Sellers can either choose to produce a product that imposes negative externalities on others or choose to produce a green product that does not impose negative externalities but has a higher production cost. Consumers decide whether to buy and which product to buy. While standard theory predicts only the cheaper good will be produced and traded, Bartling et al. find that, in an experiment conducted in Switzerland, a significant proportion of products traded are socially responsible. In addition, in a second experiment conducted in China, they find that low-cost production is significantly more prevalent compared to Switzerland.

Our paper also relates to recent empirical papers that study the impact of green products on energy consumption (i.e., Gillingham, Kotchen, Rapson and Wagner, 2013). For example, Jacobsen et al. (2012) finds that households participating in a green-electricity program above the minimum threshold level do not change their electricity consumption, but those participating at the minimum threshold increase electricity consumption 2.5 per-

(1989). In addition, Henrich et al. (2001, 2005) demonstrate how market integration may affect social norms of cooperation in a cross-cultural study with 15 small-scale societies. Vandenbergh and Steinemann (2007) have argued that norm activation for an emerging norm for carbon neutrality could have a major impact on reducing carbon emissions.

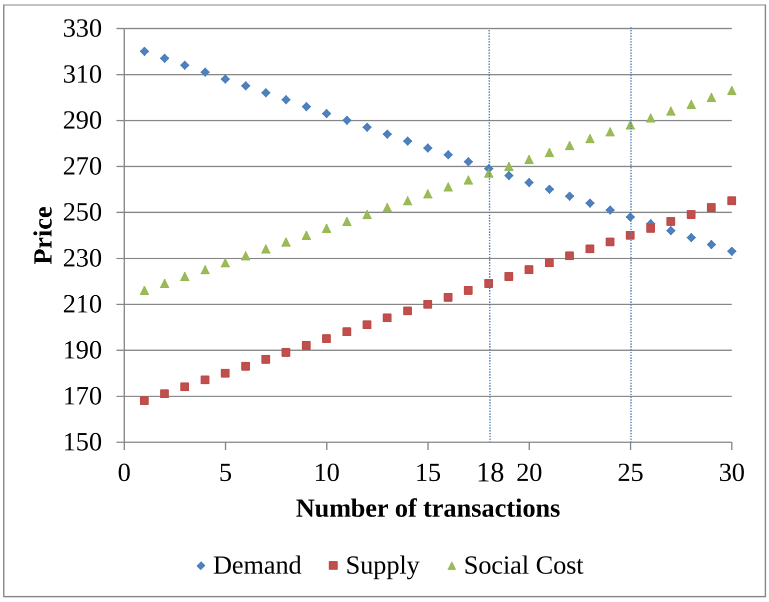
cent after enrolling in the program (buy-in mentality or rebound effect). Despite this buy-in mentality, the net effect for the switch to green-electricity for the buy-in households is a reduction in pollution emissions, as the behavioral response is not large enough to offset the environmental benefit of the green-electricity purchase. To our knowledge, the only other paper that systematically analyzes the introduction of a voluntary carbon offset program on household consumption behavior is Harding and Rapson (2014). By using data from Pacific Gas and Electric's ClimateSmart Program, the authors show that many individuals who voluntarily sign up for a carbon offsets program increase their electricity consumption following adoption. Our paper complements the Harding and Rapson's paper by being able to test questions that are hard to answer in the field. For example, in the ClimateSmart Program, customers choosing to opt-in to this program pay an extra charge per kilowatt-hour. Therefore, how much energy they consume and the volume of offset purchases they make are a joint decision and cannot be isolated from each other. However, in many carbon offset settings, individuals can choose whether to buy offsets as well as how much to buy. In addition, a laboratory set-up can provide additional control that is not available in the field. For example, in our experiment, individuals know exactly the externalities they create on others as well as total externalities created by everyone. To summarize, our paper is novel in several aspects. We study whether damage offsets increase efficiency as well as the channel by which it improves efficiency. We investigate how individuals with differing personal-responsibility measures behave differently when deciding how much carbon offsets to purchase.

In section 2 we introduce our two-stage trading environment. The experimental design and procedures are presented in Section 3. We provide our experimental findings for the second stage of damage offset purchases in Section 4, while Section 5 explores the impact of an anticipated damage offset purchases on trading in stage 1. Section 6 concludes the paper.

2 A Simple Model of Trade and Carbon Offsets

Consider a two-stage environment. In the first stage agents trade in a competitive market environment where trade generates a negative external effect for others. We use for this stage the double auction with externalities employed by Plott (1983) and Harrison et al. (1987).[5] There are 6 buyers and 6 sellers. Each agent can trade up to 5 units. Each trade causes a damage of 4 tokens for each of the 12 individuals, i.e., 48 tokens of damage in total. The inverse demand function for buyers and private marginal cost function for sellers are given in Figure 1. Figure 1 also shows the social marginal cost function, which is 48 tokens higher than the private marginal cost function.

Figure 1: Demand, Supply and Social Cost



In the second stage, after the trading stage has concluded, agents are eligible to purchase

[5]Double auction experiments are very successful in creating a market environment, and they have been widely used in experimental papers on environmental regulation (i.e., Plott (1983), Harrison et al. (1987), Ledyard and K. Szakaly-Moore (1994), Muller and Mestelman (1994), Godby et al (1997)).

carbon offsets at a price $\frac{1}{12} < p < 1$. A unit of carbon offset purchased (independent of who purchased it), reduces the total damages by 1 token. Each individual benefits from this reduction equally–the individual return from a unit of carbon offset purchase is $\frac{1}{12}$. If enough damage offsets have been purchased to eliminate all damages, individuals cannot benefit from purchasing more offsets.[6]

In stage 2 it is therefore socially efficient to purchase a damage offset since $p < 1$. However, without behavioral preferences purchasing damage offsets is not individually rational since $p > \frac{1}{12}$. The damage offset costs more than the benefit to an individual from the associated damage reduction.

With individuals who maximize monetary payoff there should be no impact from introducing damage offsets. Such individuals do not buy any offsets for prices greater than 1/12 and therefore should not contribute to ex-post damage reduction. In agreement with the Plott (1983) results, subjects should be trading at competitive prices in stage 1, ignoring negative externalities with price at 244 and quantity at 25.[7]

3 Experimental Design and Procedures

Our experiment took place at the Institute for Social Research at the University of Michigan. Subjects were students at the University of Michigan coming from a diverse range of disciplines and were randomly assigned into treatments. The experiment was programmed

[6]It is easy to see in this set-up that individuals are contributing towards an environmental public good. However, this public good is not a standard voluntary contribution mechanism since individuals themselves created damages in the first stage which might impose personal responsibility to offset it. In addition, contributions towards the public good can benefit individuals only up to the total damages created.

[7]While demand and supply intersects at quantity 26, because of the damage of 4 units, agents would not trade that last unit.

and conducted with the software z-Tree (Fischbacher, 2007). Sessions took approximately 1 hour and 45 minutes. Subjects earned experimental currency (tokens) every period. The total earnings of each subject is the sum of the earnings from each period. The total earnings were converted at the conclusion of the session into US dollars (100 tokens = 1 US dollar). The average payment of subjects was approximately 31 dollars. The experimenter read the instructions aloud at the beginning of each session to create common knowledge. Our experiment does not use an "environmental terminology." In the experiment we talk about damages and damage offsets, instead of environmental damages and carbon offsets.

We have conducted three treatments with three sessions per treatment. All three treatments consist of three parts. The first and third parts are identical across treatments.

In part 1, the "trading period", 6 sellers and 6 buyers trade for 5 consecutive periods without an opportunity to offset damages. The trading institution is chosen as a double auction and it is based on Plott (1983). This part of our experiment allows subjects to learn about the procedures of the double auction.

Part 2 adds the damage offset game and consists of 10 periods. After the conclusion of Part 1 there is a break in which new instructions are given, which depend on the treatment the experimental group is facing. We consider three treatments. In the BASELINE treatment, subjects play the double auction for another 10 periods (without any opportunity to offset damages). This treatment controls for restart effects of the break after period 5 and measures the impact of treatments against a baseline. In the second and third treatments, subjects are provided with an opportunity to offset the damages created during the trading stage (as described in Section 2). In our HIGH treatment, the price (p) of one unit of carbon offset is $\frac{1}{2}$, while in our LOW treatment, the price is equal to $\frac{1}{6}$.

Part 3 of our experiment consisted of the administration of a questionnaire, which is explained in more detail in section 4.[8] The following explains the design and the procedures of Parts 1 and 2 in more detail.

In each trading period each subject can trade up to 5 units. At any time during the trading period, any buyer is free to submit a "bid" (offer to buy a unit at the price specified in the bid). Similarly, any seller is free to submit an "ask" (offer to sell a unit at the price specified in the ask). All bids and asks pertain to trading one unit. It is not possible to sell/buy two units as a package. All active bids and asks are listed on a computer screen that is in front of each subject. The computer requires subjects to improve on the highest bid (buyers) or lowest ask (sellers) currently posted. At any point in time buyers can accept the lowest ask price posted on the screen and sellers can accept the highest bid price posted.

When a buyer (seller) accepts the lowest ask price (highest bid price) posted he receives the value (pays the cost) corresponding to that unit. The value to the buyer or the cost to a seller depends on how many units the subject has traded previously. If a bid/ask is accepted, a binding contract has been closed for a single unit and the buyer and seller see their corresponding earnings on their computer screens. After each contract is closed, all previous bids and asks are automatically withdrawn before any new ones can be made.

Before the experiment took place, for each trading period, we randomly selected the values and costs of buyers and sellers from the values and costs listed in Figure 1. In other words, for a given session, buyers and sellers faced randomly selected values and costs for each period. However, these values and costs were kept the same across all treatments and sessions to make sure any differences we see across treatments can be attributed to treatment effects and are not due to differences in the distribution of values and costs across treatments.

All buyers and sellers have anonymous identification numbers. Computers always report the ID number of the buyer or seller posting a bid/ask. The roles of buyers and sellers were

[8]Instructions for our experiment are provided as supplementary material.

kept constant through out the experiment.

At the beginning of each period subjects receive 100 tokens (to cover possible losses due to damages). The surplus, s_{ij}, from each trade is computed by taking the difference between the unit value/cost and the price of subject i when trading unit j, where $j = (1, \ldots, 5)$. The total surplus, S_i, of each subject is the sum of the surplus from all trades.

Every completed trade causes a damage of 4 tokens for everyone in the experimental session. The damages incurred by each subject is equal to $D = 4n$, where n denotes the total number of trades by all 12 subjects in a given session. The earnings of subject i in a given period are then given by:

$$E_i = 100 + S_i - D.$$

In Part 2 of HIGH and LOW treatments each of the 10 periods consists of 2 stages. The first stage is exactly the same as a trading period in Part 1. In the second stage, the "damage offset stage", there is an opportunity for each subject to buy damage offsets. This allows subjects to reduce the damages that have been created in the trading stage.

Buying damage offsets is entirely voluntary and 1 unit of damage offset costs $\frac{1}{2}$ token in the HIGH treatment and $\frac{1}{6}$ token in the LOW treatment. Any subject may buy damage offsets and reduce the damages up to the total number of damages that were created in the trading stage. Each subject decides how many damage offsets, x_i, to purchase without knowing the decisions of others. The total number of damage offsets purchased is denoted by X.

A unit of damage offset purchased (independent of who purchased it), reduces the total damages by 1 token. Each subject benefits from this equally. So, each subject receives a damage rebate of $\frac{1}{12}$ token. The same is true for all the units purchased up to the total number of damages ($TD = 12D$). If enough damage offsets have been purchased to eliminate all damages subjects do not benefit from purchasing additional offsets.

The earnings of subject i are equal to his earnings from the trading stage minus his payment for damage offsets plus the damage rebate (when $X \leq TD$):

$$E_i = (100 + S_i - D) - px_i + \frac{1}{12}X.$$

However, if X is more than the total damage, TD, then the earnings of subject i are given by

$$E_i = (100 + S_i - D) - px_i + \frac{1}{12}TD = 100 + S_i - px_i.$$

In this experiment, social optimality requires that subjects offset all damages in the second stage. However, the socially optimal level of trade depends on the treatment. It is 18 units for the BASELINE treatment, 22 units for the HIGH treatment and 25 units for the LOW treatment.[9] Note that throughout the paper when we say a trade is efficient, we refer to a trade being efficient according to a social planner (i.e., only the units that lead to highest possible social surplus are efficient).

Classical theory would predict that externalities will be ignored in the double-auction stage and there will not be a demand for offsets (since price of the damage offset is greater than the private return). However, there are possible other theories which we test against the classical theory and which differ depending on the stages we look at.

In the trading stage there are three possible theories about behavior:

1. Mental accounting: Subjects will ignore externalities in the first stage, but buy damage offsets in the second stage.

[9]In the baseline treatment, 18 units corresponds to the level that demand and social cost function intersect. In the High treatment, it is efficient to trade 4 extra units since the surplus from these units would be more than enough to offset the extra damages. In the Low treatment, trading at the competitive equilibrium level becomes efficient since all damages created can be cheaply offset in stage 2.

2. Rebound effect: Subjects will trade more in the first stage since buying offsets will crowd-out intrinsic motivations and lower guilt levels.

3. Social preference activation: In the long run players learn that damage avoidance is cheaper through avoided trade and less trade occurs in the double auction in the long run than when damage offsets are not offered.

In the second stage the following effects may lead to the purchase of offsets:

1. Altruism or warm-glow giving: Subjects by a larger amount of offsets, the larger the total damage.

2. Personal Responsibility: Subjects will buy an increasing number of offsets when the damages caused by their own trading increase.

3. Fair sharing of trading surplus: Subjects contribute more to damage reduction when their surplus from trading is greater.[10]

We start below with the effects in the second stage since the hypothesis in the first stage depend on the anticipated behavior in this stage.

4 The Determinants of Damage Offset Purchases

In this section we first analyze the behavior of subjects in the damage offset stage of the experiment. This stage looks like a public goods game. However, the difference is that trade may be history-dependent in the sense that total damages incurred and individual damages caused will vary and be determined in the trading stage. This makes this game very different

[10]In particular, subjects with very small rent from transaction are less likely to buy offsets. This means that damage reduction is done by those who should not reduce damages through refraining from trade, but those who have small surplus from trade neither refrain from trading nor buy damage offsets.

from public goods games because the way that subjects perceive the public goods game may depend on the behaviours that generated its parameters. In particular, in this game subjects can distinguish between the total damage that can be alleviated by contributing to a public good as well as their own contribution to the damages. So in addition to altruism or warm-glow giving, subjects may be motivated by responsibility for their own actions. In particular, subjects may treat damages caused by themselves and those caused by others very differently.

In this section we first present the basic average treatment effects from introducing the damage offset stage and then explore the potential motivating factors for the purchase of damage offsets as well as the heterogeneity between subjects.

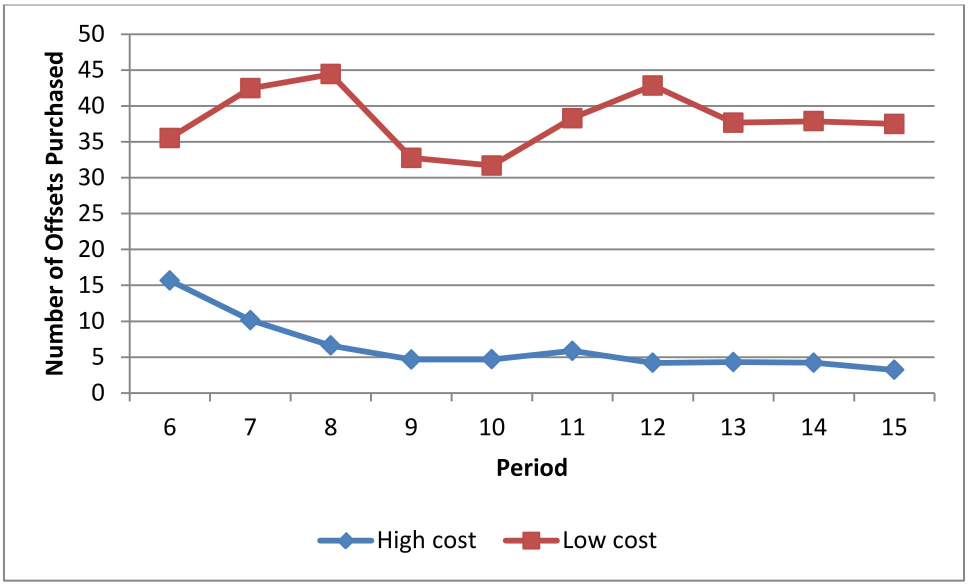
We now consider the average treatment effect of offering damage offset purchases at different prices. Figure 2 shows large differences in the amount purchased.[11] The average (standard error) offset purchase in the low price treatment is 38.09 (5.64) while it is 6.36 (1.38) in the high price treatment. The difference is significant at the 5% level ($p - value < 0.050$). We also observe the typical decay over time in the HIGH treatment, replicating the well-known result from most public goods experiments.

However, a first indication that the observed behavior in our setting is quite different from standard public good experiments comes from the fact that we do not observe any such decay in the LOW treatment. On average the total damages with which subjects start the second stage in the LOW treatment is 1192. The average number of total offset purchases is 457.13. The percentage of damages offset in the LOW treatment is stable over time and on average at 38.35% per trading period.

In a standard public goods game the only relevant information subjects have is about the total damage (total benefit) and the cost to themselves to contribute to the damage

[11]Period variable in Figure 2 takes values from 1 to 15 including the trading periods of Part 1. Keep in mind that offset purchases start take place only during Part 2, corresponding to periods 6-15.

Figure 2: Mean Offset Purchases per Period



reduction. For a given cost of contribution, giving therefore only depends on how much of the public good (here total damage reduction) is achieved. In the second stage game we analyze here, individuals know what share of total damages they themselves contributed, how much others have contributed and how much surplus the subject obtained from the trades that generated the damage.

These different pieces of information make it possible that very different motivations generate the contributions to damages reductions in contrast to the usual public goods games in the literature. To use simple terms we call behavior that is based on the total damage "altruism", representing the same motivation that we see in typical public goods experiments. When the purchase of damage offsets is generated from the damages created by the trading of a subject, we will call this "responsibility". Finally, we associate damage offset purchases explained by the surplus generated from trade as "fairness" driven.

Furthermore, we would expect there to be considerable heterogeneity in the degree to which individuals exhibit responsibility, altruism, and fairness in their damage offset purchases. In particular, there may be a negative correlation between behavior that conditions on own contribution to damages (responsibility) and behavior that is driven by total damages (altruism). In this case it may be difficult to identify the average effect of total and individual damage as well as trading surplus, because the motivations of altruism and personal responsibility may be negatively correlated and the effects may cancel each other out on average. We therefore construct indices from our survey data, that we would expect to be correlated with notions of responsibility and altruism to attempt to control for the heterogeneity in the population. We find that these indices have very significant explanatory power for damage offset purchases.

The dependent variable in our regression is the level of damage offsets purchased by a subject in a period. As explanatory variables we use the three observed features of the outcome of first stage trading: (1) the surplus of a subject from the trading stage: *Surplus*, (2) the total damages created by the subject in a given period: *DamagesCaused*, and (3) the total damages created by *all* subjects in a given period: *TotalDamages*.

We then construct a variable from our survey with which we attempt to capture the heterogeneity in the weight on the variable *DamagesCaused* between different subjects. The idea is to capture the notion of responsibility. The variable *Responsibility* is equal to the personal-responsibility index we derive using the questionnaire data. The index is a measure of how much a subject puts effort and time towards public goods provision, and it relies on three different questions from the questionnaire. Subjects are asked how often they donated blood during the last 3 years, how often they have done any kind of volunteer work in the past 12 months and how often they reuse or recycle. The personal-responsibility index is a summation of the scores from these three questions. It takes values between 3 and 15. Higher scores correspond to higher levels of dedicating time towards public goods. We interpret such reported behavior as a subject being more *personally* responsible in taking an action that improves public goods. While there may be questions that could capture notion of responsibility more directly, the most important feature of this variable is that it is highly significant in explaining the relative degree to which damage offset purchases depend on the damages generated by a subject's trades in contrast to the total damages in the trading period.

As further controls we allow for a time trend to capture the typical trend in public good experiments towards smaller contributions over time. It is captured by the variable *Period* (taking values between 1 to 10). We also allow for differences between sellers and buyers using the dummy variable *Seller* that takes value 1 for a seller and 0 for a buyer.

To control for other heterogeneity in the level of damage offset purchases, we allow for demographic variables from the survey: *Age* (age of the subject in years), *Female* (1 if the subject is female and 0 otherwise), *MajorEcon* (1 if the subject is an economics major and 0 otherwise), and *FamilyIncome* (categorical variable that takes values from 1 to 4, where 1 correspond to the lowest income class).

In addition to the variable *Responsibility* we include variables that capture heterogeneity in normative judgements of subjects: *PoliticalView* (categorical variable that takes values 1 (conservative), 2 (moderate), and 3 (liberal)), *Religion* (from "not important" (1) to "very important" (4)), *GiveHomeless* (donations to homeless people in the past 12 months from none (1) to more than once a month (5)), *SocialPolicy* (a measure of how much a subject cares for social policies for the provision of public goods with values between 3 and 15)[12], *Unemp_vs_Env* (agreement with statement "If we want to combat unemployment in this country, we shall just have to accept environmental problems" from strong agreement (1) to strong disagreement (5))[13], and finally *Trust* ("Most people can be trusted", strong dis-

[12]This is constructed from the summation of the scores from two different questions from the questionnaire. Subjects were asked whether they would accept higher prices to protect the environment and whether they agree with the statement "Those in need have to take care of themselves." It takes values between 2 and 10. Higher scores correspond to higher levels of agreement with social policies towards public goods provision.

[13]*Unemp_vs_Env* captures the valuation between two public goods: employment and environment. Given that our experiment has a neutral framing, it is not surprising that this

agreement (1) and strong agreement (5)). The summary statistics for these variables are provided in Table 1.

Table 1: Summary Statistics per Treatment

Variables	BASELINE			LOW			HIGH		
	mean	min	max	mean	min	max	mean	min	max
Damage offsets	-	-	-	38.1	0	200	6.4	0	100
				(41.4)			(13.3)		
Surplus	162.7	36	327	164.6	15	335	164.5	67	343
	(55.9)			(56.7)			(48.0)		
DamagesCaused	202.1	48	240	198.7	96	240	201.3	96	240
	(38.6)			(41.1)			(36.7)		
TotalDamages	1212.8	1104	1344	1192	1104	1248	1208	1152	1344
	(52.6)			(43.1)			(51.3)		
Female	0.47	0	1	0.61	0	1	0.39	0	1
	(0.51)			(0.49)			(0.49)		
Age	21.5	18	29	21.7	18	26	21.7	19	29
	(2.3)			(1.8)			(2.2)		
MajorEcon	0.11	0	1	0.06	0	1	0.14	0	1
	(0.32)			(0.23)			(0.35)		
FamilyIncome	2.1	1	4	2.0	1	4	2.1	1	4
	(1.1)			(1.0)			(0.8)		
PoliticalView	2.4	1	3	2.4	1	3	2.4	1	3
	(0.73)			(0.6)			(0.6)		
Religion	2.1	1	4	2.1	1	4	2.3	1	4
	(1.1)			(1.1)			(1.2)		
PersonalRespon.	7.4	4	11	7.8	4	13	8.0	5	13
	(1.7)			(1.7)			(2.0)		
GiveHomeless	2.3	1	5	2.3	1	5	2.4	1	5
	(1.0)			(1.2)			(1.2)		
SocialPolicy	5.5	2	8	5.6	3	9	6.0	4	8
	(1.5)			(1.6)			(1.3)		
Unemp_vs_Env	3.5	1	5	3.8	1	5	4.0	1	5
	(1.1)			(1.1)			(0.9)		
Trust	3.3	1	5	2.8	1	5	3.0	1	5
	(1.0)			(1.2)			(1.1)		

Table 2 shows the OLS regressions of damage offset purchases on these explanatory variables.[14] The first two columns present the results for pooled data (from LOW and HIGH treatments) with and without the additional controls for demographic and value judgements.

---

variable does not have any explanatory power in behavior.

[14]Since offset purchases are censored from below, we also provide Tobit regression analysis in the Appendix as a robustness check

The third and fourth (fifth and sixth) column show the results for LOW (HIGH).

The regressions show a general decline of damage offset purchases, but only for the HIGH treatment is there a strong and statistically significant decline. There is no statistically significant effect of the *Surplus* variable in either treatment.[15]

For the LOW treatment, *DamagesCaused* and *TotalDamages* are both significant, as are the interactions of these variables with *Responsibility* and the *Responsibility* variable itself. First, it should be noted that the interaction between *Responsibility* and *DamagesCaused* is positive while the interaction between *Responsibility* and *TotalDamages* is negative. This confirms the intuition that the dependence of damage offset payments on damages caused by own trades and total trades is negatively correlated between subjects. In other words, subjects are either "altruism" motivated or "responsibility" motivated. It should also be noted that interactions with *TotalDamages* and *DamagesCaused* do not exist for other control variables such as *GiveHomeless*, *Unemp_vs_Env* and *SocialPolicy*, which gives further credence to our interpretation of heterogeneity being primarily dependent on differences in the relevance that personal responsibility has for decision making.

Although the regressions for the HIGH treatment have such low levels of damage offset payments that it is unlikely to generate any significant effects, these are not totally absent. As in the LOW treatment, the cross effects of *Responsibility* with the *TotalDamages* and *DamagesCaused* variables are statistically significant (although only weakly) and the signs are consistent with the LOW treatment regressions. However, other controls for heterogeneity differ between the two treatments. In the LOW treatment, both students with a major in economics and women buy significantly fewer damage offsets. The first is a common result

[15]In the pooled regressions when all controls are added, there is a weak evidence that surplus is positively correlated with higher offset purchases.

Table 2: OLS Regressions

Dependent var = Damage offsets	ALL	ALL	LOW	LOW	HIGH	HIGH
Surplus	0.28	0.37*	0.51	0.66	0.07	0.08
	(0.21)	(0.21)	(0.40)	(0.40)	(0.07)	(0.08)
*Resp*Surplus*	-0.03	-0.04	-0.05	-0.06	-0.01	-0.01
	(0.02)	(0.02)	(0.04)	(0.04)	(0.01)	(0.01)
DamagesCaused	-0.55**	-0.49**	-0.96**	-0.96**	-0.29	-0.27
	(0.24)	(0.22)	(0.45)	(0.38)	(0.20)	(0.18)
*Resp*DamageC*	0.07**	0.06**	0.12**	0.11**	0.03*	0.03*
	(0.03)	(0.02)	(0.05)	(0.04)	(0.02)	(0.02)
TotalDamages	0.41**	0.40**	0.98**	0.88***	0.10	0.10
	(0.16)	(0.16)	(0.43)	(0.30)	(0.07)	(0.07)
*Resp*TotalD*	-0.04**	-0.04**	-0.10**	-0.08**	-0.01	-0.01*
	(0.02)	(0.02)	(0.05)	(0.03)	(0.01)	(0.01)
Responsibility	39.40**	39.78*	101.35*	84.50**	8.77	8.88
	(19.61)	(20.08)	(54.64)	(38.44)	(7.89)	(6.94)
Period	-0.70	-0.70	-0.79	-0.90	-1.03***	-1.03***
	(0.48)	(0.48)	(1.04)	(1.09)	(0.33)	(0.34)
Seller		-0.73		-2.16		0.83
		(4.76)		(7.46)		(2.37)
Female		-5.14		-17.84*		-0.53
		(5.33)		(9.01)		(2.91)
Age		0.76		2.39		0.62
		(1.58)		(2.68)		(0.49)
MajorEcon		-8.18		-32.81*		-1.27
		(6.67)		(17.19)		(2.92)
FamilyIncome		0.18		-1.64		-0.37
		(2.11)		(3.26)		(1.50)
PoliticalView		-4.10		-5.95		-1.09
		(4.29)		(7.86)		(2.18)
Religion		-3.69		-6.31		-1.23
		(2.37)		(4.46)		(0.79)
GiveHomeless		1.24		4.08		1.98**
		(2.08)		(3.92)		(0.79)
SocialPolicy		3.03		5.06		0.74
		(2.48)		(4.70)		(0.95)
Unemp_vs_Env		-2.24		-5.56		-0.47
		(3.37)		(5.70)		(0.77)
Trust		2.50		4.65		-0.86
		(2.33)		(4.15)		(0.94)
Low	31.79***	32.78***				
	(4.67)	(4.62)				
Constant	-407.83**	-431.05**	-1,016.65**	-946.18**	-56.94	-77.98
	(186.67)	(179.46)	(484.22)	(351.62)	(75.13)	(64.30)
Observations	720	720	360	360	360	360

Standard errors are clustered at the individual level.
Robust standard errors are in parentheses.
*** denotes significance at 1 percent, ** denotes significance at 5 percent, * denotes significance at 10 percent

in public good games while the second result may be surprising.[16] In contrast, in the HIGH treatment only giving to homeless is significant. This is not too surprising. Overall giving is so low in this treatment that the usual effect of an economics major is unlikely to be identifiable. However, giving to the homeless is unconditional behavior that we might see to generally associated with altruistic behavior independently of the total damage or damages caused.

A closer look at the regressions for the LOW treatment also shows how important it is to control for the heterogeneity between subjects in the weight they are attributing to the total damages and the damages caused by the trades of the subject. If one evaluates the regression at the mean of the responsibility variable, the effects of increasing *TotalDamage* or *DamagesCaused* are both statistically not different from zero. This implies that around the mean there is no detectable effect owing to either variable. In fact, when these regressions are run without the *Responsibility* variable and its interactions no significant effects for *TotalDamage* and *DamagesCaused* can be found. The reason is that behavior is quite polarized. For values of the personal-responsibility index above the mean, *DamagesCaused* increase the purchase of damages offsets, while at lower values offset purchases increases in *TotalDamages*.

This fundamentally different behavior at the extremes of the *Responsibility* variable can be seen more clearly, when one divides the sample into three groups of personal-responsibility levels and runs the regressions without the Responsibility variable for each group separately.

Table 3 presents the analogue of regressions 1, 3, and 5 in Table 2, where the *Responsibility* variable and its interactions have been dropped. The results show that subjects characterized by a high personal-responsibility measure increase their offset purchases when their share in damages increases but do not react to total damages. Subjects characterized with low

[16]One possible reason for seeing lower contributions by females could be that, as we show in Table 3, females trade less at the 90 percent confidence level.

Table 3: OLS Regressions for Different Levels of Responsibility Measure

Dependent var = Damage offsets	Low Responsibility			Average Responsibility			High Responsibility		
	ALL	LOW	HIGH	ALL	LOW	HIGH	ALL	LOW	HIGH
Surplus	0.08	0.13	0.00	-0.02	-0.05	0.03	0.01	0.02	-0.00
	(0.08)	(0.14)	(0.03)	(0.04)	(0.05)	(0.07)	(0.07)	(0.10)	(0.02)
DamagesCaused	-0.09	-0.14	-0.06	0.01	-0.01	0.05	0.25***	0.34***	0.05*
	(0.08)	(0.15)	(0.07)	(0.06)	(0.11)	(0.09)	(0.07)	(0.09)	(0.03)
TotalDamages	0.12**	0.28	0.04	-0.03	0.05	-0.11**	-0.03	-0.05	0.01
	(0.06)	(0.17)	(0.03)	(0.05)	(0.11)	(0.04)	(0.06)	(0.17)	(0.02)
Period	-0.49	-1.18	-0.67	-0.17	0.25	-1.35	-1.14	-0.94	-1.40**
	(0.74)	(1.92)	(0.56)	(0.52)	(0.58)	(0.76)	(1.14)	(2.55)	(0.44)
Low	38.49***			15.32**			43.40***		
	(7.45)			(7.00)			(8.39)		
Constant	-132.61*	-276.81	-25.11	42.10	-24.88	138.65**	-8.79	39.63	-5.67
	(68.72)	(181.24)	(26.26)	(72.16)	(155.01)	(47.79)	(62.92)	(180.21)	(22.56)
Observations	290	130	160	220	120	100	210	110	100

Standard errors are clustered at the individual level.
Robust standard errors are in parentheses.
*** denotes significance at 1 percent, ** denotes significance at 5 percent, * denotes significance at 10 percent

personal-responsibility measure do not increase their offset purchases when their share in damages increases but they statistically significantly increase their offset purchases as total damages increase (when all data are pooled).

To summarize, we see clear evidence that there are individuals for whom the purchase of damage offsets is driven primarily by the damages caused by their own trading. We interpret these subjects being driven by personal responsibility concerns. Other subjects primarily react to the total damages arising via trading, which we interpret as the typical altruistic or warm-glow giving behavior observed in standard public goods games. We show that this behavior is highly correlated with a variable that measures the degree to which subjects report that they contribute their time, but not necessarily money, to public goods provision. We interpret this as a measure of personal responsibility since it can statistically identify individuals that respond more strongly in their damage offset payments to the damages they directly caused.[17]

[17]This result is in line with field data as well. Harding and Rapson (2014) also identify the

5 Does the Introduction of Damage Offsets Change Trading Decisions?

In this section we analyze whether the introduction of damage offset purchases in a second stage of the experiment affects the behavior in the double auction. In particular, any effect that would make the damages caused by trading more salient during the trading period should only have an effect on trading in the HIGH treatment, since it is the only treatment in which a reduction of trade is cheaper than buying damage offsets ex-post and the introduction of offset purchases can have an impact on the saliency of damages for the trading period.[18]

We again look at the average treatment effects first. The average number of trades is given in Table 4. We use session averages as our (independent) observations. When we conduct a Wilcoxon rank-sum test, we see that there are no differences in the number of trades across treatments in Part 1 ($p-values$ are larger than 0.500).[19] In all treatments the mean number of trades is higher in Part 2. This appears to be the case because the learning process about trading in the double auction has not converged in Part 1. However the slight increase in trading volume is significant only for the Baseline treatment ($p-value = 0.050$), not for the other two treatments ($p = 0.268$ for HIGH and $p-value = 0.825$ for LOW). In addition, Wilcoxon signed-rank tests show that, in Part 2, number of trades is not significantly different from 25 in any of the treatments ($p-values$ are larger than 0.593), suggesting that there is no impact on trading from the availability of damage offsets.

While we observe a lower number of trades in the HIGH treatment relative to the BASE-

---

extent to which a household is involved in the community and local charities to be a strong predictor of signing up for a green program (PG&E's ClimateSmart Program for carbon offsets).

[18]Remember that trading at the competitive levels at the LOW treatment is efficient.

[19]Throughout the paper, unless otherwise noted, all reported tests are two-sided.

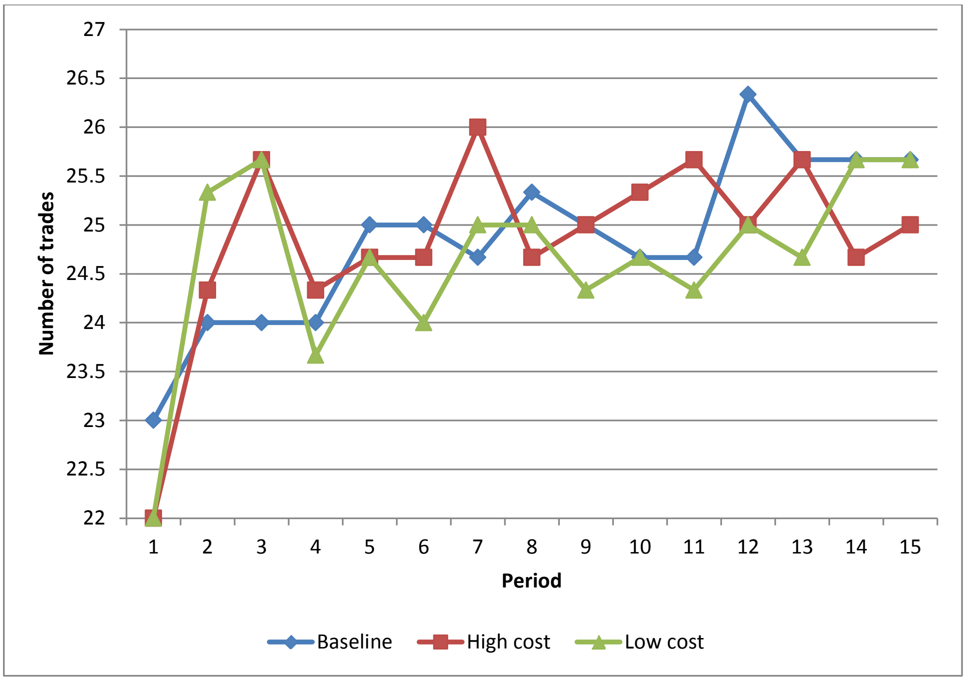
LINE and even lower number of trades in the LOW treatment, a pairwise comparison of treatments in Part 2 show that these differences are not significant ($p - values$ are larger than 0.513).

Table 4: The average number of trades in Parts 1 and 2

	Average # of trades in Part 1	Average # of trades in Part 2
BASELINE	24.00 (0.31)	25.27 (0.43)
HIGH	24.20 (0.80)	25.17 (0.48)
LOW	24.27 (0.53)	24.83 (0.35)
Standard errors are in parenthesis. There are 3 independent observations per cell.		

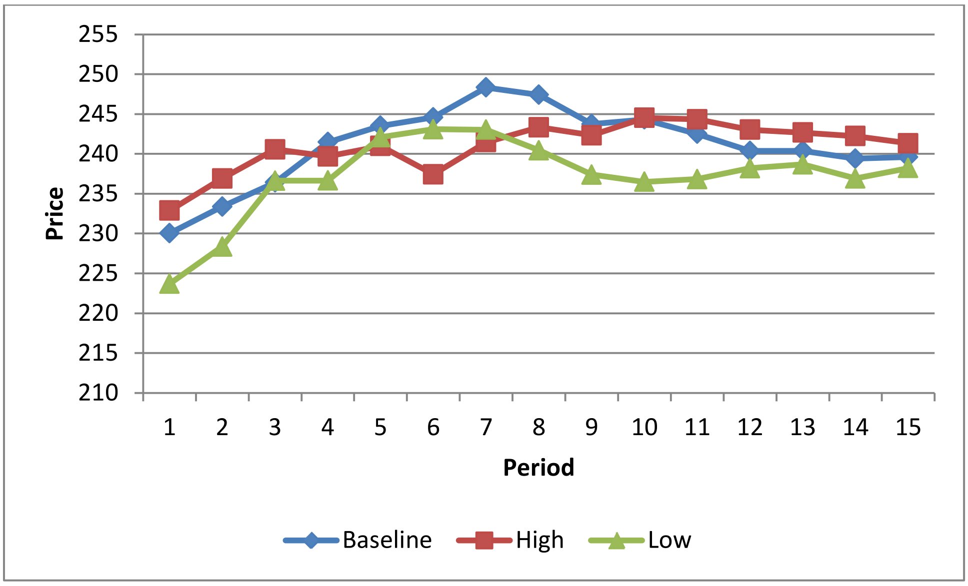
The similarity of trade patterns can also be seen in Figure 3.

Figure 3: Mean Trade per Period



Similarly we do not see an effect of treatments on prices. Figure 4 shows the average price per period for each treatment. Wilcoxon signed-rank tests show that prices are not significantly different than 244 in any of the treatments for both parts (all $p-values$ are larger than 0.109). Similarly, pairwise comparisons confirm that prices are not different across treatments (rank-sum tests; all $p-values$ are larger than 0.512 for part 1 and all $p-values$ are larger than 0.275 for part 2).

Figure 4: Mean Price per Period



The analysis so far suggests that, on average, there is no impact on the trading period whatsoever when damage offsets are introduced - neither in the form of norm activation nor in the form of a rebound effect.[20]

We now attempt to look more carefully into trade decisions by regression analysis including control variables. First, trades would obviously be affected by the achievable surplus. For example, a unit that has a production cost of 100 is more likely to be produced (sold)

[20]We cannot rule out the possibility that there are some subjects that show social preference activation and some with rebound effect but on average these two effects cancel each other out. In our between-subjects analysis, we compare the second stages of all treatments with each other in order to control for the re-start or order effects. While one could possibly look at trading behavior before and after the introduction of carbon offsets for a given individual, this would suffer from order effects.

compared to a unit that has a cost of 300. We create a variable, *GainMargin*, that gives the difference between value (or cost for a seller) and the competitive equilibrium price.[21] We also create a dummy variable, *Traded*, as our dependent variable and run Logit regressions. Specification 1 of Table 5 shows that the valuations/costs matter. In addition, trade generally increases significantly over time. Specification 2 shows that there is no aggregate effect of introducing the possibility to offset damages (i.e., the coefficients of LOW and HIGH are not significant).[22]

However, in specification 3 there is weak evidence that some impact on the trading period may be generated from the introduction of damage offsets: females trade less in Stage 1 (at the 10% significance level). We have also seen that females buy less damage offsets. However, it is unclear from the regressions whether there really is a causal link between the two observations. Furthermore, we also see that the value index of *SocialPolicy* is significant at the 10 percent significance level.

Note that individuals should only contribute to the public good of damage offsets in stage 2 if there is some social preference that values damage reduction either in proportion to damages personally caused or damages generally. This does not generally mean that subjects should reduce trading in stage 1 if the possibility of buying damages offsets triggers awareness of the external effect of trading. Only in the HIGH treatment is it privately (and socially) more efficient in the model to refrain from trading the last units if damage offset purchases are anticipated.

An outcome at the competitive equilibrium in the first stage and purchase of damage offsets in the second as we appear to observe here therefore is a sign of some sort of mental

[21]Here, the competitive equilibrium price is only for normalization. The important point is that the units are ranked according to their values/costs.

[22]As we have shown in Section 3, the socially optimal number of trades is different across treatments. Our regression results do not change when we control for efficiency as well.

Table 5: Determinants of Trade

Dependent var = *Traded*	1	2	3
GainMargin	0.18***	0.18***	0.19***
	(0.02)	(0.02)	(0.02)
Period	0.04**	0.04**	0.05**
	(0.02)	(0.02)	(0.02)
Low		-0.25	-0.21
		(0.38)	(0.38)
High		-0.06	-0.09
		(0.32)	(0.31)
Seller			0.01
			(0.30)
Female			-0.52*
			(0.27)
Age			-0.02
			(0.09)
MajorEcon			-0.10
			(0.23)
FamilyIncome			0.16
			(0.13)
PoliticalView			-0.10
			(0.22)
Religion			0.01
			(0.13)
Responsibility			-0.05
			(0.09)
GiveHomeless			0.03
			(0.11)
SocialPolicy			-0.15*
			(0.09)
Unemp_vs_Env			0.16
			(0.18)
Trust			-0.08
			(0.15)
Constant	-0.57***	-0.47	0.94
	(0.16)	(0.29)	(1.63)
Observations	5,400	5,400	5,400

Standard errors are clustered at the individual level.
Robust standard errors are in parentheses.
*** denotes significance at 1 percent, ** denotes significance at 5 percent, * denotes significance at 10 percent

accounting: individuals cannot think about trade and damage avoidance at the same time in the double auction. This can lead to inefficiency because the cost of ex-post damage reduction is greater in the HIGH treatment than for ex-ante damage avoidance through foregone trade (at least for the last units transacted at a competitive equilibrium). Subjects do trade at competitive equilibrium levels and then try to offset the damages in the early periods of part 2 in the HIGH treatment. This damage offset demand disappears over the experimental periods but is not compensated by reductions in trading in the trading period.

Finally, we have also investigated the determinants of the *number* of trades using several different specifications (not shown). We do not find any statistically significant effect of LOW and HIGH treatments on the number of trades ($p-values$ are larger than or equal to 0.498). We also do not find any correlation between offset purchases and number of trades ($p-values$ are larger than or equal to 0.281). Regarding the control variables, the only statistically significant control is being a female. Being a female decreases the number of trades by 0.14 which is significant at the 10% significance level.

6 Discussion and Conclusion

What do these results suggest about the possible effectiveness of voluntary damage offset programs? In the Baseline treatment subjects earned 162.7 tokens on average per period. Subjects earned 4.9 tokens more in the HIGH treatment but this is not statistically significant ($p-value = 0.446$). In contrast, subjects earn 33.6 tokens more in the LOW treatment compared to the BASELINE treatment and this difference is significant at the 99% confidence level ($p-value < 0.001$). This is an economically significant 20.7% increase relative to the Baseline treatment.

While our results suggest that the total damage done to the environment ex-ante does not change with the presence of damage offsets, individuals persistently reach higher efficiency levels with the presence of offset markets when offset technology provides a reasonably cheap way to offset damages. In contrast to other public goods games this difference in motivation also appears to lead to much more persistent contributions to the public good. It is clearly far less effective than a general Pigouvian tax as Plott (1983) has shown, but such campaigns can still have a substantial effect where it is politically difficult to implement measures like a general carbon tax.

Our paper also demonstrates the importance of the connection of carbon offset purchases to a personal responsibility motive. We find that subjects with high personal-responsibility index care about the damages caused by their own trading, and buy more offsets as their share in the damages increases. This has important policy implications for carbon markets. We do see an emphasis in carbon offset programs to link the purchases directly to own carbon emissions producing activities. The literature on the topic, for example, Vandenbergh and Steinemann, 2007, emphasizes that the personal responsibility for reducing own damages could improve the behavioral demand for carbon offsets. But not all subjects appear to be motivated by personal responsibility. Individuals with lower personal-responsibility index do not react to their share in damages. They tend to increase their offset purchases as total damages increase. It is an important topic for further research whether appeals to personal responsibility reduce the motivation for giving of such individuals and whether there are trade-offs for the effectiveness of campaigns for damages contributions that target different sources of individual motivation.

References

[1] Andreoni, James (1989). Giving with Impure Altruism: Applications to Charity and Ricardian Equivalence. The Journal of Political Economy, 97(6): 1447-1458.

[2] Andreoni, James (1990). Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow Giving. The Economic Journal, 100: 464-477.

[3] Andreoni, James, and John Miller (2002). Giving According to GARP: An Experimental Test of the Consistency of Preferences for Altruism. Econometrica, 70 (2): 737-753.

[4] Bolton, G. E., and A. Ockenfels (2000): A Theory of Equity, Reciprocity and Competition, American Economic Review, Vol. 90, 166-193.

[5] Capoor, K. and Ambrosi, P. 2009 State and Trends of the Carbon Market 2009 World Bank, Washington DC.

[6] Cason T. 2010 What Can Laboratory Experiments Teach Us About Emissions Permit Market Design? Agricultural and Resource Economics Review, Vol. 39, No. 2, pp. 151-161.

[7] Charness, Gary, and Matthew Rabin (2002), Understanding social preferences with simple tests. Quarterly Journal of Economics, 117: 81769.

[8] Chaudhuri, A. 2011. Sustaining Cooperation in Laboratory Public Good Experiments: A Selective Survey of the Literature. Experimental Economics, 14:47-83.

[9] Elster, Jon (1989), Social Norms and Economic Theory, The Journal of Economic Perspectives, Vol. 3, No. 4, pp. 99-117

[10] Ehmke, M. and J. F. Shogren. 2008. Experimental Methods for Environment and Development Economics, Environment and Development Economics, Vol. 00, pp. 1-38.

[11] Falk, A. and N. Szech (2013) Morals and Markets, Science, 340, 707-711.

[12] Fehr E., and Schmidt K.M. (1999), A Theory Of Fairness, Competition, and Cooperation, Quarterly Journal of Economics, Volume 114, Number 3, 817-868.

[13] Fischbacher, Urs. 2007. z-Tree: Zurich Toolbox for Ready-made Economic Experiments, *Experimental Economics* 10(2): 171–178.

[14] Friesen, L. and Lata Gangadharan, Environmental Markets: What Do We Learn From the Lab? Journal of Economic Surveys, Vol. 27, No. 3, pp 515-535, 2013.

[15] Gillingham, Kenneth, Matthew Kotchen, David Rapson, and Gernot Wagner. 2013. The Rebound Effect is Over-played. Nature 493: 475-476.

[16] Grether, David M., R. Mark Isaac, Charles R. Plott (1981) " The Allocation of Landing Rights by Unanimity Among Competitors" The American Economic Review, Vol. 71, No. 2, Papers and Proceedings of the Ninety-Third Annual Meeting of the American Economic Association (May, 1981), pp. 166-171

[17] Godby, Robert W., Stuart Mestelman, R. Andrew Muller, and J. Douglas Welland (1997) Emissions Trading with Shares and Coupons when Control over Discharges Is Uncertain, Journal of Environmental Economics and Management, 32, 359-381

[18] Harding M. and D. Rapson (2014) Do Voluntary Carbon Offsets Induce Energy Rebound? A Conservationist's Dilemma, working paper.

[19] Harrison, Glenn, Elizabeth Hoffman, E.E. Rutstrom, Matthew L. Spitzer (1987) Coasian Solutions to the Exteernality Problem in Experimental Markets, Vol. 97, No. 386, 388-402

[20] Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., McElreath, R., (2001). In Search of Homo Economicus: Behavioral Experiments in 15 Small-Scale Societies. AEA Papers and Proceedings 91(2), 73-78.

[21] Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., McElreath, R., Alvard, M., Barr, A., Ensminger, J., Henrich., N.S., Hill, K., Gil-White, F., Gurven, M., Marlowe, F.W., Patton, J.Q., Tracer, D., (2005). Economic Man in cross-cultural perspective: Behavioral experiments in 15 small-scale societies. Behavioral and Brain Sciences 28, 795-855.

[22] Jacobsen, G.D., Kotchen, M.J. and M.P. Vandenbergh (2012) The Behavioral Response to Voluntary Provision of an Environmental Public Good: Evidence from Residential Electricity Demand. European Economic Review, 56, 946-960.

[23] Kube, S., M. Marechal and C. Puppe. 2012 The Currency of Reciprocity: Gift Exchange in the Workplace. American Economic Review, 102, 1644-1662.

[24] Ledyard, J. O. and K. Szakaly-Moore (1994), Designing organizations for trading pollution rights, J. Economic Behavior and Organization. 25, 167-196.

[25] Ledyard, John (1995) Public Goods: A Survey of Experimental Research, in The Handbook of Experimental Economics. Roth and Kagel, eds. Princeton, NJ: Princeton University Press.

[26] Stuart Mestelman, 2000. "Environmental Policy: Lessons from the Laboratory," McMaster Experimental Economics Laboratory Publications 2000-01, McMaster University.

[27] Muller R. Andrew and Stuart Mestelman (1994) Emission Trading with Shares and Coupons: A Laboratory Experiment, The Energy Journal, 15(2), 195-211

[28] Noussair, Charles N. and Daan P. van Soest. 2014. Economic Experiments and Environmental Policy, Annual Review Resource Economics, Vol. 6, pp. 319-37.

[29] Peters-Stanley and Yin (2013), Maneuvering the Mosaic, State of the Voluntary Carbon Markets

[30] Plott, Charles (1983) Externalities and Corrective Policies in Experimental Markets, The Economic Journal, Vol. 93, No. 369, 106-127

[31] Plott, Charles and Hong (1982) Rate Filling Policies for Inland Water Transportation: An Experimental Approach. Bell Journal of Economics, 13, 1-19.

[32] Sandel, M. 2012. What Money Can't Buy. New York: Farrar, Strausand Giroux.

[33] Sturm, B. and Joachim Weimann, Experiments in Environmental Economics and Some Close Relatives, Journal of Economic Surveys, Vol. 20, No. 3, 2006

[34] Vandenbergh, Michael P. and Anne Steinemann (2007), "The Carbon-Neutral Individual, New York University Law Review, 82, pp. 1673 " 1745.

7 Appendix

Table 6: Tobit Regressions

Dependent var = Damage offsets	ALL	ALL	LOW	LOW	HIGH	HIGH
Surplus	0.40	0.53*	0.48	0.64	0.21	0.34
	(0.30)	(0.32)	(0.43)	(0.43)	(0.19)	(0.21)
*Resp*Surplus*	-0.04	-0.05	-0.05	-0.06	-0.02	-0.03
	(0.03)	(0.03)	(0.05)	(0.04)	(0.02)	(0.02)
DamagesCaused	-0.76**	-0.64*	-1.02*	-0.98**	-0.50	-0.47
	(0.37)	(0.35)	(0.52)	(0.42)	(0.38)	(0.38)
*Resp*DamageC*	0.09**	0.07*	0.12**	0.11**	0.05	0.05
	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)
TotalDamages	0.62**	0.59**	1.00**	0.88***	0.21	0.12
	(0.24)	(0.24)	(0.46)	(0.33)	(0.16)	(0.15)
*Resp*TotalD*	-0.06**	-0.06**	-0.10*	-0.08**	-0.03	-0.01
	(0.03)	(0.02)	(0.05)	(0.04)	(0.02)	(0.02)
Responsibility	63.81**	61.11**	98.74	81.24*	23.90	12.65
	(30.08)	(29.58)	(60.36)	(43.20)	(20.11)	(17.72)
Period	-1.55**	-1.55*	-1.15	-1.24	-2.15***	-2.27***
	(0.79)	(0.79)	(1.23)	(1.29)	(0.79)	(0.85)
Seller		2.95		-0.41		7.18
		(7.19)		(9.85)		(6.19)
Female		-5.73		-17.54*		2.85
		(7.32)		(10.35)		(6.37)
Age		2.67		2.32		3.09**
		(2.05)		(3.20)		(1.55)
MajorEcon		-23.89**		-33.76		-13.95
		(10.69)		(21.30)		(9.73)
FamilyIncome		-1.90		-2.21		-3.62
		(2.89)		(3.70)		(3.32)
PoliticalView		-4.23		-7.69		2.58
		(6.53)		(10.13)		(5.19)
Religion		-5.33		-7.07		-3.37
		(3.41)		(5.20)		(2.52)
GiveHomeless		4.04		4.50		4.44**
		(3.03)		(4.41)		(1.87)
SocialPolicy		2.27		4.92		-0.72
		(3.54)		(5.57)		(2.26)
Unemp_vs_Env		-1.63		-5.28		-1.54
		(5.08)		(7.84)		(2.41)
Trust		4.18		5.29		-1.81
		(3.49)		(4.80)		(3.00)
Low	52.82***	54.14***				
	(7.91)	(7.21)				
Constant	-657.05**	-717.98***	-1,023.89*	-946.67**	-181.20	-158.10
	(279.25)	(272.30)	(529.11)	(399.28)	(188.22)	(164.86)
Observations	720	720	360	360	360	360
Standard errors are clustered at the individual level. Robust standard errors are in parentheses. *** denotes significance at 1 percent, ** denotes significance at 5 percent, * denotes significance at 10 percent						

Table 7: Tobit Regressions for different Responsibility levels

Dependent var = Damage offsets	Low Responsibility			Average Responsibility			High Responsibility		
	ALL	LOW	HIGH	ALL	LOW	HIGH	ALL	LOW	HIGH
Surplus	0.08	0.10	0.02	-0.03	-0.09	0.05	0.00	0.02	-0.02
	(0.11)	(0.17)	(0.07)	(0.07)	(0.06)	(0.13)	(0.08)	(0.11)	(0.05)
DamagesCaused	-0.16	-0.18	-0.12	-0.04	-0.03	0.05	0.29***	0.35***	0.10
	(0.13)	(0.20)	(0.14)	(0.10)	(0.13)	(0.15)	(0.08)	(0.08)	(0.07)
TotalDamages	0.24**	0.34*	0.10*	-0.10	0.07	-0.31**	-0.01	-0.05	0.01
	(0.09)	(0.18)	(0.06)	(0.08)	(0.13)	(0.14)	(0.07)	(0.17)	(0.03)
Period	-1.71	-2.14	-1.47	-0.14	0.14	-2.16	-2.31	-1.06	-2.76**
	(1.58)	(2.73)	(1.38)	(0.76)	(0.68)	(1.55)	(1.56)	(2.63)	(1.09)
Low	67.17***			28.99**			62.48***		
	(13.60)			(12.29)			(11.75)		
Constant	-282.73**	-338.97*	-107.26	120.24	-45.60	360.49**	-46.49	34.69	-10.02
	(115.01)	(197.03)	(70.99)	(103.07)	(168.53)	(157.72)	(80.18)	(186.73)	(34.98)
Observations	290	130	160	220	120	100	210	110	100

Standard errors are clustered at the individual level.
Robust standard errors are in parentheses.
*** denotes significance at 1 percent, ** denotes significance at 5 percent, * denotes significance at 10 percent