The Effect of Buyout Options on Effort Contributions to Reduce Carbon Emissions*

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Abstract

A frequently cited argument against the use of market-based instruments like emission permit trading systems is that they diminish our sense of moral responsibility to be good environmental citizens. By changing pollution from a sin against nature remedied only by personal atonement into a commodity that can be bought and sold with no special social consequences, market-based instruments may weaken our resolve in dealing with environmental challenges. We report on the results of laboratory experiments designed to explore this idea. In particular, we look at how the personal effort exerted by subjects changes when other group members take advantage of an offer to buy out of their obligation to perform lab tasks that contribute toward carbon emission reductions. We find that on average subjects reduce their effort when their peers buy out. However, the aggregate result masks significant heterogeneity across individual responses. Those who choose not to buy out despite its expected profitability have no response to the treatment while those for whom it would simply not be profitable to buy out register larger reductions. The magnitude of these responses is increasing in the share of the group that accepts the buyout offer with an approximately 5-10% reduction in effort for every 10 percentage-point increase in the fraction of subjects who buy out if the response is linear. Thus a group in which half of subjects accepted the buyout would experience a 25-50% reduction in effort levels of those who did not buyout.

JEL Classification: C90, C91, H41, Q54

Key words: experimental economics, public goods, effort contribution, environment, climate change

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1 Introduction

A frequently cited argument against the use of market-based instruments like emission permit trading systems is that they diminish our sense of moral responsibility to be good environmental citizens. By changing pollution from a sin against nature remedied only through personal atonement into a commodity that can be bought and sold with no special social consequences, market-based instruments may weaken our resolve in dealing with environmental challenges.[1] In particular, use of market-based mechanisms may adversely affect the intrinsic motivation of those unwilling or unable to use this market.

In the inaugural issue of the *Review of Environmental Economics and Policy*, Geoffrey Heal laments that despite repeated demonstration of the potential for cost savings, cap-and-trade programs are still viewed with skepticism — particularly among environmental groups:

> They see this in moralistic terms rather than in terms of economic efficiency: they feel that we "ought" to reduce emissions in high-cost areas, almost in the same way that friars in the Middle Ages felt that penitence was not real unless accompanied by self-flagellation. (Heal 2007)

Heal is referring here to the response of environmental groups to the suggestion that the flexible mechanisms built into the Kyoto Protocol be used to discourage deforestation in developing countries. Similarly, the "supplementarity restrictions" written into the Kyoto Protocol are designed to ensure that emission reductions in Annex B countries take place primarily through domestic abatement efforts and that flexible mechanisms like permit trading are used only to "supplement" domestic reductions.[2] Limits on trading are difficult to justify on efficiency grounds. One possibility is that their inclusion was motivated by moral objections.

If this sort of resistance is an important determinant of the likelihood of adopting cap-

[1] Many have expressed this idea, although Michael Sandel (1997) is perhaps its most well-known advocate.
[2] See articles 6.1.d and 17 of the text of the Kyoto Protocol (1997).

and-trade policies or the emissions reductions that we can expect upon adoption, then it is important to understand how the mechanism works. One obvious concern is that those who voluntarily limit their impact on the environment are somehow made less enthusiastic about the cause by the introduction of a market-based regulation and reduce their effort. If these effects are large, they may undermine the effectiveness of new environmental regulations. Furthermore, by understanding the nature of the resistance to market-based policies, we can begin to explore environmental policy options that take these responses into account without sacrificing the cost savings that are associated with the use of flexible mechanisms.

A number of theoretical and empirical studies have looked at the general issue of motivational crowding — the idea that the introduction of an explicit price for performance may discourage voluntary effort to provide public goods. To our knowledge, however, none address the specific issue that we highlight here.

In this paper, we report on the results of laboratory experiments designed to explore a hypothesis implicit in Heal's observation that many people perceive a difference between making direct, personal contributions to the environmental cause and outsourcing one's responsibility through mechanisms like permit trade. Our working hypothesis is that distrust of market mechanisms may arise from the ability and willingness of some to "buy out" of an obligation to contribute time or effort to the provision of a public good, and that the act on the part of some group members of opting to buy out adversely affects the motivation of those who do not or cannot buy out.

In our experiments, subjects complete tasks to reduce carbon emissions in some rounds and complete tasks for money in others. In treatment sessions, we introduce the possibility of a buyout in emission-reduction rounds in which subjects can pay a fee that relieves them of the responsibility to reduce emissions and allows them to continue to work for money. We test our hypothesis by comparing effort levels of subjects who did not accept the buyout in treatment sessions to effort levels in control sessions in which no buyout was offered.

We identify a causal effect of introducing the buyout option on the effort level exerted

by our subjects. The aggregate effect is to reduce their effort. The mean reduction in effort among these subjects is approximately 5%. However, the aggregate result masks significant heterogeneity across individual responses. Those who choose not to buy out despite its expected profitability have no response to the treatment while those for whom it would simply not be profitable to buy out register larger (8%) reductions in effort. The magnitude of these responses is increasing in the share of the group that accepts the buyout offer with an approximately 5-10% reduction in effort for every 10 percentage-point increase in the fraction of subjects who buy out if the response is linear. Thus a group in which half of subjects accepted the buyout would experience a 25-50% reduction in effort levels of those who did not buyout.

Section 2 discusses related literature and our hypotheses. Section 3 describes the design of the laboratory experiments and Section 4 describes the results. Section 5 discusses some of the broader implications of our findings and offers suggestions for future research.

2 Related Literature and Hypotheses

2.1 Related Literature

A related idea — that market mechanisms may crowd out intrinsic motivation to provide public goods — has been studied in other contexts. The common theme running through the literature on motivation crowding is the idea that individuals may posses intrinsic motives for performing a task. Intrinsic benefits are those for which the individual receives no direct or external benefit from engaging in the activity. Extrinsic motives are those for which the individual does derive some form of compensation — monetary or otherwise — in exchange for performance.

The central finding of these studies is that the introduction of a price or other extrinsic rewards may crowd out intrinsic motivation to perform a task. In the labor market, for example, the introduction of performance-based pay may have the perverse effect of reducing

performance because it reduces workers' intrinsic motivation do a good job as payment may somehow diminish the sense of pride they felt in doing a good job in the absence of the external incentive. Gneezy and Rustichini (2000b) find a non-monotonic relationship between extrinsic motivation (the piece rate) and performance, with the introduction of a "too small" monetary payment reducing output. In an example from the environmental policy realm, Frey and Oberholzer-Gee (1997) find that introducing a scheme to compensate individuals for the placement of a hazardous waste disposal site close to the neighborhood in which they live made people *less* willing accept such sites than when they received no compensation because the introduction of compensation somehow reduces the sense of civic duty they feel. Similarly, Gneezy and Rustichini (2000a) find that parents of children enrolled at a daycare center increased the frequency with which they picked up their children late after a fee for late pick up was introduced, presumably because the fee somehow relieved them of the moral responsibility to arrive on time. See Frey and Jegen (2001) for a comprehensive survey of the empirical evidence on motivational crowding.

The extent to which the market participation of some adversely affects the intrinsic motivation of others may depend on the extent to which this latter group believes the good *ought* to be provided by a market. Roth (2007) discusses the idea that "repugnance" acts as a barrier to market formation in many contexts. He cites the absence of a well-functioning market for transplant organs as an example of repugnance. Despite the fact that both donors and recipients of organs could be made better off if donors could be compensated for supplying organs, no such market exists because the idea of individuals selling their organs for pay is simply not acceptable under current social norms.

The empirical studies cited above are generally either agnostic on the issue of *why* the crowding out occurs, focusing instead on identifying a causal effect, or hypothesize that it is the introduction of the price itself — the suggestion that one could or should be compensated for performance — that is the source of resistance and crowding out.

A number of theoretical studies develop alternative explanations as to why resistance to

market mechanisms and crowding out might occur. Bénabou and Tirole (2006) develop a theory based on signalling. They hypothesize that, in the absence of compensation, volunteer performance may clearly signal to others what type of person you are, with either extrinsic or intrinsic rewards to follow through the reputation you cultivate. The introduction of the price weakens the signal by making it more difficult for others to determine who is performing the task to signal their type and who is performing it to receive compensation. Thus performance may go down with compensation if the reduction in the value of the signal outweighs the value of the compensation.

Brekke, Kverndokk and Nyborg (2003) describe a theory in which people a) wish to adhere to the social norm based on Andreoni's (1990) warm-glow motive; and b) the introduction of a market changes that norm with potentially deleterious effects. If a tax is introduced to help with the public provision of a public good, the amount of private provision of the good that is proscribed by the social norm may fall as it become socially accepted that the good will be provided through public channels. In some circumstances, this may lead to a reduction in the aggregate level of the public good produced.

A final concern with market mechanisms to provide public goods may arise when the market exacerbates wealth or income inequality. Fehr and Schmidt (1999) develop a theory based on inequity aversion. People dislike unequal outcomes. Some mechanisms for exchange, such as bilateral negotiations, allow individuals to exert influence on how equitable the resulting equilibrium distribution of surplus. In others, such as competitive markets, the tyranny of competition leads to the result that even if market participants care about equity, they are powerless to preserve it. Thus people may resist the use of cap-and-trade systems and/or experience a reduction in performance due to the equity consequences of their implementation.

2.2 Hypotheses

To our knowledge, there is no study that follows up on the insight embodied in Heal's observation that many people perceive a difference between making direct, personal contributions

to the environmental cause and outsourcing one's responsibility through mechanisms like permit trade. Unlike in the literature on crowding of intrinsic motivation, the mechanism is not the mere introduction of compensation. Rather, it is the idea that those individuals providing their time and effort directly experience a loss of enthusiasm for the cause when they observe their peers buying their way out of service by paying a fee, even if the aggregate provision of the public good remains unchanged by the buyouts.

Based on this, our working hypotheses are that:

1. Distrust of market mechanisms may arise from the ability of some to "buy out" of an obligation to contribute time or effort to the provision of a public good, and that the act on the part of some group members of opting to buy out adversely affects the motivation of those who do not or cannot buy out.

2. The degree to which performance is adversely affected depends on the degree to which others in the group buy out, measured by the number or fraction of the group that elect to accept the buyout.

3 Experiment Design

Experiment sessions proceed in a series of five-minute rounds in which subjects have the opportunity to complete computer-based tasks. In **Earning Rounds**, the subject earns a piece rate for each task completed. In **Environment Rounds**, subjects are presented with a second task, and the experimenters purchase and retire one ton of carbon emissions for a set number of tasks completed. In **Buyout Sessions**, we introduce a buyout option in the final two Environment Rounds. Subjects accepting the buyout pay a buyout fee and are then presented with Earning tasks, with the buyout fee being used to purchase carbon permits. Our main comparison is the number of tasks completed by those who do not accept the buyout with the baseline sessions in which nobody was offered a buyout option.

We used two tasks: an encryption task and a counting task. Whether a task was earning

or environment varied between sessions, but was fixed within a session. For the encryption task, for the entire round a subject's computer screen displayed a table translating each letter of the alphabet into a unique 2-digit number. For each task, the subject's screen displayed 2 letters. The subject successfully completed the task by translating the letters into their numeric equivalent and entering the correct 4 numbers. For each counting task, a subject's computer screen displayed a table with 4 rows and 4 columns with either a 0 or 1 in each position. The subject successfully completed the task by correctly entering the number zeros. For both task types, the subject received the next task only after completing the current task.

The subject received 10 cents per completed encryption task when it was the earning task, and when it was the environment task we retired 1 permit per 150 completed tasks. When the counting task was the earning task, the subject received 7.5 cents per completed task, and when it was the environment task we retired 1 permit per 200 completed tasks.

At the start of each session, each of 16 subjects[3] was seated at a computer whose screen displayed a z-Leaf window for interacting with the experiment as well as an internet browser. Instructions (Appendix B) were read aloud. These instructions included mention of the internet browser to ensure common knowledge of its shirking potential. They also included information about the link between greenhouse-gas emissions and global warming, and how experimenters would purchase greenhouse-gas permits on the European Union Emission Trading System based on the number of completed environment tasks.

Prior to environment and earning rounds, sessions started with a one-minute practice round for each task. Subjects were then evenly and randomly allocated to either the Blue or Purple group. We do so for two reasons. First, we hypothesize that even weak group identity may make the actions of others—effort and buyouts in environment rounds—more salient (e.g., Chen and Li 2009). Second, in-group uncertainty may make a neighbor's audible keyboard effort less relevant.

At the beginning of each five-minute round, subjects were informed whether the round

[3]One baseline session had only 13 subjects.

was an Earning or an Environment round. Subjects did not know the total number of rounds, nor how many of each type of round. In practice, all sessions lasted five rounds and started with an Environment round, with rounds alternating between Environment and Earning.

At the end of each earning round, the subject's screen displayed the number of tasks she completed, as well as her earnings for the round. At the end of each environment round, her screen displayed the number of tasks she completed, as well as the number of tons of carbon emissions both she and her group averted. At all points in the experiment, a subject has access to a history box containing all previously revealed information.

3.1 Buyout Sessions

In Buyout Sessions, we surprised subjects with a Buyout Option at the start of the second Environment round (round 3) (see instructions in Appendix B.1). The Buyout Option enabled a subject to pay a Buyout Fee and complete earnings tasks (and thus earn money) in lieu of completing environment tasks. We informed subjects that the number of permits purchased by the Buyout Fee exactly replaced the average number of permits produced in the first Environment round. All subjects in an 8-subject group faced the same Buyout Fee and piece rate, with the earning-task piece rate set so that only half of the group would find the buyout profitable based on the number of tasks completed in the previous (earning) round. The Environment round proceeded as normal for those subjects not accepting the buyout. Subjects were also offered the Buyout Option in the final Environment round (round 5), with the only difference being that the earning-task piece rate was calibrated so that median round-4 earning task performance broke even with respect to the buyout fee.

When deciding whether to accept the buyout, each subject's monitor displayed information about the expected profitability of accepting the buyout option: the buyout fee; the piece rate if she accepts the buyout; the number of tasks she completed in the previous Earning round; and her net earnings if she accepts the buyout and completes the same number of tasks as in the previous Earning round (expected task earnings minus buyout fee). In addition, the subject receives information about the expected effect of her buyout on the

number of greenhouse gas permits retired. Her screen displays the exact number of permits that will be purchased with her buyout fee, as well as the exact number of permits retired as a direct result of the number of tasks she completed in the first Environment round.

After all subjects have decided whether or not to accept the buyout option for that round, a subject learns the number of group members accepting the option. She also learns the number of greenhouse-gas permits that will be bought with the buyout fees, as well as the number of greenhouse-gas permits "produced" in the first Environment round by subjects accepting the buyout.

After the final round (round 5), subjects completed a brief demographic questionnaire. We also asked questions taken from the Pew Research Center For The People & The Press, January 2009 Political Survey in which subjects rated the importance of various issues (including global warming) facing the U.S. Government.

3.2 Summary

Task Assignment:	**Buyouts Offered**	
{Earning; Environment}	**No**	**Yes**
{Counting; Encryption}	13	32
{Encryption; Counting}	16	32

Table 1: Number of Subjects per Treatment

We conducted sessions at Williams College. Approximately 16 students participated in a session, without duplication.[4] Table 1 details the treatments and subject participation. The experiment was programmed and conducted with z-Tree (Fischbacher 2007). Subjects earned $16.01 on average, which includes a $5 show-up fee. Sessions lasted approximately 60–75 minutes.

[4]Subjects were recruited through the online recruitment system ORSEE (Greiner 2004).

3.3 Identification

In testing our hypotheses, we keep in mind a couple of potential confounds. First, unless the buyout fee is personalized to exactly replace an individual's (expected) contribution, even a relatively fair buyout will alter the contributions of those accepting the buyout. Given that an agent's optimal effort contribution likely depends on the contributions of others, we take care to disentangle the change due to the aggregate level of contributions by others from the change arising from the manner in which others contribute (effort vs. money).

Second, the appropriate counterfactual is comparing the effort contribution of those who do not accept the buyout option with those who were not offered the option *and* would not have accepted it were it offered. In our between-subject experiment, our baseline sessions (without a buyout option) will include both those who would and would not have accepted the offer. It is easy to see that effort differences across these two groups will bias comparisons to the who do not buy out in the treated group. Thus, we must take care to control for those in the baseline session who might have accepted the buyout option.

4 Results

In this section, we report on the outcomes from the experiments. The key outcome measure we focus on is how the effort levels (proxied by tasks completed) of subjects who continue to work on the environmental task in Round 5 of the session is affected by the offer of the buyout option and the frequency with which their peers accept the buyout. After summarizing the buyout behavior in the sessions, we examine in the average treatment effect for these subjects as a whole and as well as for select sub-populations. This is followed by a formal regression analysis of the same outcomes.

4.1 Buyout Behavior

Table 2 describes the pattern of buyouts in rounds 3 and 5 for all of the treatment sessions we ran. For each of the eight-member groups that participated in buyout sessions, the second

column identifies which task subjects performed to earn permits. The next two columns indicate the number accepting the buyout in each of the buyout rounds. In the final column, we indicate the difference between the number of permits purchased with buyout fees and the number of permits produced in the first environment round by subjects accepting the buyout option in round 5.

	Environment	Buyouts		Round 5
Group	Task	Round 3	Round 5	E[Δ Permits]
1	Encryption	4	3	0.13
2	Encryption	2	1	-0.04
3	Encryption	2	1	0.02
4	Encryption	4	3	-0.05
5	Counting	2	0	0.00
6	Counting	2	2	-0.13
7	Counting	3	3	0.10
8	Counting	2	1	-0.08

Table 2: Number of subjects (out of eight) accepting buyout offer and expected permit change as a result of buyouts, per group.

The typical group registered more than one buyout per buyout round with buyouts ranging between zero and four subjects. There is no discernible difference in the number of buyouts by environment task. Slightly fewer subjects chose to buy out in Round 5 than in Round 3.[5] In summary, our experimental manipulation was successful in generating buyouts and variation in the number of buyouts across groups while not greatly affecting the expected number of permits these subjects may have provided.[6]

In Table 3, we present various subject characteristics by round-5 buyout status. We compare those who buyout with those who do not. We further distinguish in this latter group between those whose earnings would have (and would not have) been positive conditional on paying the buyout fee and replicating earning-task performance from the previous round. We focus on this distinction because one might expect that those subjects who refused the buyout

[5]Only 1 round-5 buyout did not buy out in round-3. This means 8 round-3 buyouts chose not to buyout in round 5. Only 2 of these 8 lost money in round 3.

[6]For the sake of comparison, in buyout sessions average round-1 performance was 50.9 encryption tasks (.34 permits) or 63 counting tasks (.32 permits).

E(Profit)>0:			**N**	**Y**
Buyout Accepted:	**Y**	**N**	**N**	**N**
Environment Task Index	1.040	1.014	0.994	1.039
	(0.359)	(0.141)	(0.141)	(0.140)
Earning Task Index	1.169	0.975	0.894	1.079
	(0.238)	(0.122)	(0.078)	(0.082)
E(Profit) if buyout	0.845	-0.136	-0.547	0.387
	(1.096)	(0.567)	(0.325)	(0.323)
Proportion E(Profit)>0	0.786	0.440	0.000	1.000
	(0.426)	(0.501)		
Buyout in Round 3	0.929	0.160	0.143	0.182
	(0.267)	(0.370)	(0.356)	(0.395)
n	14	50	28	22
Global Warming Importance	2.154	2.333	2.333	2.182
	(0.801)	(0.724)	(0.961)	(0.733)
n	13	48	27	22

Table 3: Subjects characteristics (means and standard deviations) by round-5 buyout status. Global warming importance is on a 0–3 scale, and excluded subjects choosing "I don't know."

and "left money on the table" by doing so might have different motives than those for whom the buyout was not profitable. In order to group together subjects completing different environment tasks, we create an index equal to the number of round-1 tasks completed divided by the median number of round-1 tasks completed amongst subjects faced with the same task. We construct a similar index for earning-task performance using round-4 output.

We make a few observations. In terms of performance in the first environment round, there are no significant differences across the populations. Unsurprisingly, there is a significant difference in round-4 earning-task performance between those who do and do not buyout in round 5 (Wilcoxon-Mann-Whitney test, $p = 0.0018$). In fact, profitability strongly predicts buyout acceptance. Perhaps surprisingly, the ranked importance of global warming does not predict buyout acceptance.

4.2 Results: Overall Effect of Buyouts

We focus on the second buyout round (round 5) as we find no difference between the first buyout round (round 3) and the corresponding baseline round. Table 4 describes the average change in performance on the environment task from Round 1 to Round 5 by treatment and control groups. The rows identify which of the two lab tasks was used as the environment task. The first two columns identify the treatment and control groups and the final column calculates the difference in the change in average performance across these groups as a percentage of the average tasks completed by control subjects in Round 5.[7] Each cell of the table describes the performance change ($\bar{\delta}$) and the number of observations (n).

	Buyout Available		**Δ as % of Round 5**
	No	**Yes**	**Control Tasks**
Both Tasks	$\bar{\delta} = 0.30$ *n=29*	$\bar{\delta} = -3.5$ *n=50*	-5.5
Just Encryption	$\bar{\delta} = -1.8$ *n=13*	$\bar{\delta} = -3.4$ *n=24*	-3.2
Just Counting	$\bar{\delta} = 2.0$ *n=16*	$\bar{\delta} = -3.6$ *n=26*	-8.5

Table 4: Mean Change In Effort by Treatment and Task: All Subjects.

$\delta_i = \text{Tasks}_{5i} - \text{Tasks}_{1i},\ i \in$ subjects who do not accept buyout.
$\bar{\delta} = \sum_i \delta_i / n =$ Treatment average.

$\bar{\delta}$ is defined as the difference between the tasks completed by subjects in rounds 5 and 1. Comparing this measure across treatment and control subjects allows us to examine how the treatment effect changed subjects' effort levels, controlling for the fact that differences in ability is likely to be a determinant of the decision to buy out and, therefore, the composition of the group that chooses not to buy out in the treatment sessions.

[7] Conceptually, we are calculating the number of Round-5 tasks completed by those not buying out if this group had the baseline's Round 1.

Treatment-subject output, and presumably effort, decreased relative to their Round-1 performance and relative to the performance change of control subjects across the rounds. This latter difference is weakly significant (Wilcoxon-Mann-Whitney test, $p = 0.0692$). Overall, this reduction in effort translates into a 5.5% reduction relative to the performance of control subjects in Round 5. The results are qualitatively the same when we break out the subjects by the lab task they performed but the magnitude of the reduction in effort is larger for the counting task than for the encryption task.

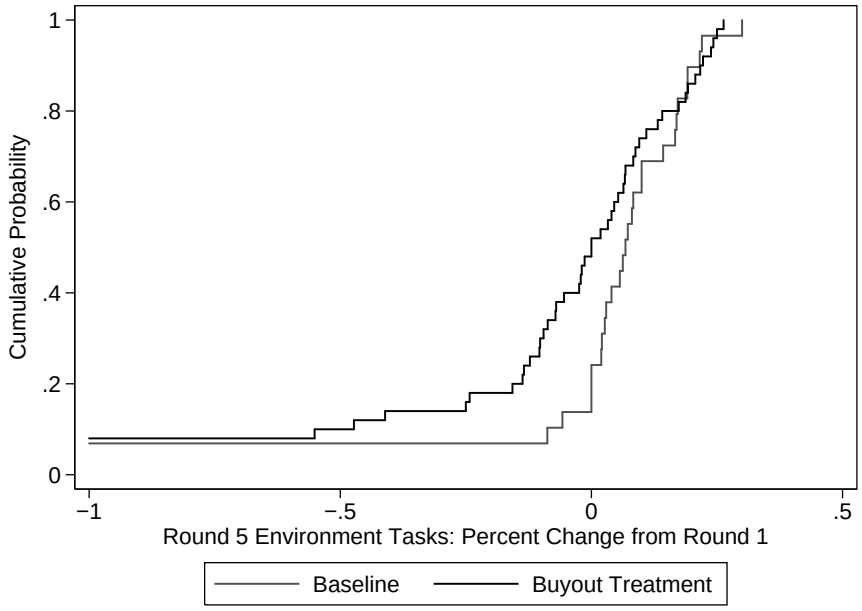

Figure 1: CDFs (by treatment) of percent change in Round 5 Environment tasks. (Excludes subjects accepting Round 5 buyout.)

The averages reported in Table 4 masks significant individual-level heterogeneity. In Figure 1, we depict, by treatment, cumulative distribution functions of δ_i divided by the Round-1 tasks completed by the individual. In both the baseline and treatment, a significant proportion of subjects increase output, consistent with learning and continued effort. However, the fraction of subjects decreasing output is markedly larger in the treatment group than in the baseline.

4.3 Results: Profitable versus Unprofitable Subjects

We now distinguish between the treatment subjects depending on whether or not they would be expected to profit from accepting the buyout based on their performance on round-4 earning tasks. We focus on this distinction because one might expect that those subject who refused the buyout and "left money on the table" by doing so might have different motives than those for whom the buyout was not profitable. Furthermore, subjects received explicit information on their expected profitability prior to the buyout decision. Table 5 presents results in a similar fashion as Table 4 but with subjects differentiated by those who were expected to be profitable or unprofitable. While treatment subjects were informed of the expected profitability of the buyout, we construct these groups *ex post* for the baseline using the same rule: subjects above the median performance in the preceding earning round are designated profitable. The different subjects are listed on the rows of table and we do not break out the results by the environment task that subjects performed.

	Buyout Available		**Diff as % of Round 5**
	No	**Yes**	**Control Tasks**
Unprofitable Subjects	$\bar{\delta} = -3.9$ *n=14*	$\bar{\delta} = -7.8$ *n=28*	-8.4
Profitable Subjects	$\bar{\delta} = 4.2$ *n=15*	$\bar{\delta} = 2.0$ *n=22*	-3.1

Table 5: Mean Change In Effort by Treatment and Expected Profit.

$\delta_i = \text{Tasks}_{5i} - \text{Tasks}_{1i},\ i \in$ subjects who do not accept buyout.
$\bar{\delta} = \sum_i \delta_i / n =$ Treatment average.

Unprofitable subjects reduced their effort in response to the treatment more sharply (-8%) than the group as a whole. Unprofitable subjects are significantly different than baseline subjects (Wilcoxon-Mann-Whitney test, p=0.0285). Profitable subjects also decrease (-3%) their effort in response to the treatment, although the differences are not significant

(Wilcoxon-Mann-Whitney test, p=0.9137). Thus, the aggregate results presented in Table 4 mask substantial heterogeneity across individuals.

At least two stories are consistent with this pattern of adjustment. First, profitable subjects who rejected the buyout offer may be revealing a strong preference for contributing to the environment good. These self-revealed "environmentalists" may respond differently to the treatment effect than the average subject in the experiment. However, these subjects do not report a higher importance on global warming in our post-experiment survey.

Second, the difference in behavior may reflect differences in the opportunity cost of continuing to perform well on the tasks. Profitable and unprofitable subjects differ, almost by definition, in their ability to perform the tasks. With diminishing marginal utility from permits retired and the same cost of effort function, the more efficient subject optimally puts in less effort than the less efficient subject. As a result, the less efficient subject may be more affected by changes in intrinsic motivation.

4.4 Regression Analysis

We now present a formal regression analysis of the data. This allows us to decompose the results along other dimensions and to introduce additional control variables. It also allows us to look at how the rate at which group members accept the buyout affects the performance of non-buyout subjects. Table 6 shows the results of this analysis. The dependent variable in all of the regressions is δ_i, the change from Round 1 to 5 in environment tasks completed. We present six different specifications of an ordinary-least-squares model in which we successively add more explanatory variables.

In specifications (1) and (2), we control for the number of subjects accepting the buyout. We first control only for the buyout rate, and then interact the buyout rate with the indicator for expected profitability. In both specifications, an increase in buyouts decreases final-round output although including the interaction term increases the precision of the estimate of the effect markedly ($p<0.01$). Assuming a linear response to the buyout rate would imply an approximately 5-10% reduction in effort for every 10 percentage-point increase in the fraction

δ_i	(1)	(2)	(3)	(4)
Intercept	-3.51	-3.47	-3.76	-6.12
	(7.21)	(7.24)	(7.30)	(12.67)
Count Round	-0.61	-0.68	-0.17	0.17
	(4.04)	(3.96)	(4.06)	(3.76)
Buyout Session	2.49	7.68	8.74	8.55
	(7.59)	(7.85)	(7.66)	(8.54)
Expected Buyout Profitability	8.03	8.03	8.05	7.37
	(6.71)	(6.76)	(6.80)	(10.31)
Profitability-Treatment Interaction	0.82	-10.71	-10.59	-10.03
	(8.15)	(9.38)	(9.36)	(11.45)
Buyout Rate	-0.31*	-0.56***	-0.60***	-0.60***
	(0.16)	(0.21)	(0.20)	(0.21)
Buyout-Profitability Interaction		0.61**	0.60**	0.60**
		(0.25)	(0.26)	(0.26)
Expected Aggregate Permit Change			25.07	24.30
			(31.72)	(31.92)
Round 1 Performance				3.98
				(27.32)
$n=$	79	79	79	79

Table 6: Regression Analysis.

Dependent Variable: $\delta_i = \text{Tasks}_{5i} - \text{Tasks}_{1i},\ i \in$ subjects who do not accept buyout.

Independent Variables: **Count Round** = 1 if environment task is counting task this round, else 0; **Buyout Session** = 1 if buyout is offered this session, else 0; **Expected Buyout Profitability** = 1 if subject expected to profit from buyout based on round 4 performance, else 0; **Profitability-Treatment Interaction** = interaction of **Buyout Session** and **Expected Buyout Profitability**; **Buyout Rate** = percentage of group that accepted the buyout this round; **Buyout-Profitability Interaction** = interaction of **Buyout Rate** and **Expected Buyout Profitability**; **Expected Aggregate Permit Change** = expected change in the aggregate permits retired this round based on round 1 performance and buyout pattern; **Round 1 Performance** = subject's round 1 performance relative to the max performance across all sessions.

******* — p<0.01, ****** — p<0.05, ***** — p<0.1.

of subjects who buy out. Thus a group in which half of subjects accepted the buyout would experience a 25-50% reduction in effort levels of non-buyout subjects. We also estimate a positive and weakly significant coefficient on the interaction term. The magnitude of this coefficient is such that it offsets the negative effect of the buyout rate of effort for profitable subjects, confirming our earlier finding that these subjects have essentially no effort response to the buyout.

When we include the buyout rate variables in the model, the dummy variable **Buyout Session** can be interpreted as capturing the effect of the buyout offer on subjects assuming none of the subjects actually accept the buyout. We find no effect here, suggesting that the mechanism through which the reduction effort works in our experiment is dependent on subjects observing their peers actually accepting the buyout offer.

One might expect that the expected change in the aggregate number of emission permits retired by the group due to subjects accepting the buyout might have an influence on the behavior of non-buyout subjects. We provided subjects with this information prior to their completing tasks in buyout rounds. Suppose, for example, that aggregate permits are expected to fall based on the buyout pattern. Assuming marginal utility decreasing in pollution abated and optimally chosen effort, this change would result in increased effort and thus number of tasks completed. Alternatively, a decrease in the permits provided by others might discourage a subject, inducing her to reduce her effort. In either case, we would be confounding the effect of the buyout itself with the effect that the buyout has on amount of public good provided by others. Specification (3) in the table controls for this possibility by including the expected change in aggregate permits — information that was given to subjects — as an explanatory variable in the model. Including it in the model makes no difference to our results.

One final test concerns the possibility that ability is correlated with the change in effort we observe in subjects across the rounds of the experiment. Our test of the treatment effect involves comparing the change in the number of tasks successfully completed from round 1

to round 5 for subjects that are either subjected to the buyout or not. Suppose that the change in tasks completed across the rounds depends on ability.[8] For example, high-ability people may register less of negative trend in their performance across the rounds because the opportunity cost of performing the tasks lower for these individuals. The effect that we observe in the control sessions will be based on the average-ability subject in the experiment. However, the effect we observe for *non-buyout* subjects in treatment sessions will be based on a self-selected group of subjects who have chosen not to accept the buyout offer. If buyout status is correlated with ability, then we might observe lower-than-average ability subjects in the pool of non-buyout subjects.[9] As a result, we may see a larger reduction in effort in the non-buyout treatment group not because they are responding to the introduction of the buyout by reducing their effort, but because the ability composition of the group is such that they reduce their effort more than the average subject in the control sessions.

This appears to be a legitimate concern based on our analysis of the difference in the responses of subjects by their expected profitability under the buyout — profitable (high ability) subjects did not reduce the effort relative to control subjects while unprofitable (low ability) subjects did. To control for this possibility, we include the performance of subjects in Round 1 (relative to the maximum performance of any subject) as an explanatory variables in specification (4) in Table 6. The coefficient on this variable is statistically insignificant and has little effect on the point estimates of the key explanatory variables in the model.

The estimated coefficients from the OLS models are consistent with the *average* change in performance decreasing in the number accepting the buyout. Figure 1 suggests that while the treatment does not greatly affect the likelihood of an increase in output, treatment increases the likelihood of more extreme output drops. As a robustness check we estimate probit models of decreases of 0%; 10% and 20% relative to round 1. For each dependent variable, we present in Appendix A estimates for 2 models: one controlling only for environment task

[8] In fact, looking only at baseline subjects, we cannot reject the hypothesis that δ_i and the number of round-1 tasks are independent (Spearman rank correlation test, $p = 0.5141$).

[9] Buyouts are highly correlated with earning task performance, and (first) earning task performance is positively correlated with (first) environment task performance (Spearman's $\rho = 0.4285$, $p = 0.000$).

and and indicator for the availability of buyouts, and a second with a full suite of controls (Table). In each case, results are consistent with the likelihood of a drop in performance increasing in the number of buyouts, but only for subjects unable to afford the buyout option.

5 Conclusion and Discussion

In 2007, it came to light that global-warming crusader Al Gore's gross carbon footprint was quite large. The former U.S. Vice President defended his lifestyle in part by pointing out his purchase of carbon offsets (Humphrey 2007). If the fact that Mr. Gore chooses to avail himself of market-based solutions to environmental problems results only in hurt feelings, then perhaps there is little to worry about. If these choices result in measurable changes in aggregate contributions to public goods, then they have the potential to alter the effectiveness of policy interventions.

In this experiment, we find that our buyout option decreases output, especially among those unable to afford the buyout option. While the existence of the buyout option *per se* increased the likelihood of decreased effort, responses were heterogeneous and the effects on average effort depended more strongly on the number accepting the offer.

While our experiment environment captures many of the salient aspects of real world buyout options, real-world environments will vary significantly, and we were thus forced to make a number of design choices. We consider how some of these differences between our environment and particular buyout opportunities might affect outcomes.

First, subjects likely felt little group identity and varied in their intrinsic concern for the public good (global warming). It is unclear whether changing these aspects would strengthen or weaken the effects found in the laboratory. For example, while increased group identity (or commitment to the public good) might increase the sting of others replacing effort with money, increased weight on the group's welfare might steel resolve despite this sting.[10]

[10]In fact, Chen and Li (2009) find experimental evidence that subjects are less likely to punish in-group members for misbehavior.

Characteristics of the public-good effort task may well affect willingness to reduce effort contribution when other replace effort with money. Our laboratory tasks were solitary and separable (i.e., there was no interaction with group members and no effort complementarities). While subjects reported little intrinsic motivation to complete the tasks, performance — both in terms of number of tasks and ultimate greenhouse-gas reduction — was measurable. Differences in any of these dimensions will plausibly affect willingness to continue to contribute an effort contribution to the public good while others contribute otherwise.

One aspect plausibly quite important is the fact that those accepting the buyout in our experiment were able to earn money. First, this increased earning inequality, and we therefore cannot rule out that inequity aversion contributed to our treatment effect.[11] In future experiments, we seek to untangle effects from income inequality from those arising from a loss of shared sense of responsibility. Second, it might just be irksome that some are earning money while others are expected to contribute their labors to the public good. In other contexts, someone accepting a buyout may be doing something "better" with his time, such as caring for family member, which may mitigate the perceived injustice.

We designed our buyout to be reasonably fair in terms of the effect on the public good. The buyout fee replaced an average effort contribution, and in fact the difference between permits bought with fees and what these individuals would likely have bought with their efforts was small and publicly announced. (In addition, the buyout fee reduced uncertainty about the contributions of others and took shirking off the table for those who bought out.) Outside of the laboratory, buyout fees might not be sufficient to replace lost effort, and there may be uncertainty about whether the fees are sufficiently large.

[11] While we did not share the earnings of those who did buyout, it would be reasonable for subject to infer both that the higher earners were more likely to buyout and these already high earners would be making more money.

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A Additional Results

VARIABLES	(1) drop	(2) drop	(3) drop10	(4) drop10	(5) drop20	(6) drop20
Count Round	-0.092	-0.059	0.003	0.001	-0.016	-0.017
	(0.111)	(0.125)	(0.090)	(0.092)	(0.079)	(0.075)
Buyout Session	0.341***	0.017	0.231***	-0.075	0.131*	-0.203
	(0.096)	(0.205)	(0.081)	(0.187)	(0.074)	(0.185)
Expected BO Profit		0.321		0.395		0.304
		(0.240)		(0.245)		(0.254)
Buyout Rate		0.024***		0.014**		0.013***
		(0.009)		(0.006)		(0.005)
Buyout Rate X Exp. Prof.		-0.031***		-0.018**		-0.017***
		(0.011)		(0.008)		(0.007)
Expected Permit Change		-0.681		-1.124		-0.805
		(0.993)		(0.706)		(0.586)
Rnd. 1 Tasks		-0.040		0.053		-0.225
		(0.478)		(0.410)		(0.323)
Observations	79	79	79	79	79	79
χ^2	9.573	18.47	5.665	14.51	2.489	14.05

Table 7: Probit models of large output reductions.

Dependent Variables: $\frac{\delta_i}{Tasks_{1i}} < 0, -.1, and -.2; i \in$ subjects who do not accept buyout.

Independent Variables: **Count Round** = 1 if environment task is counting task this round, else 0; **Buyout Session** = 1 if buyout is offered this session, else 0; **Expected Buyout Profitability** = 1 if subject expected to profit from buyout based on round 4 performance, else 0; **Expected Aggregate Permit Change** = expected change in the aggregate permits retired this round based on round 1 performance and buyout pattern; **Buyout Rate** = proportion of group that accepted the buyout this round; **Buyout-Profitability Interaction** = interaction of **Buyout Rate** and **Expected Buyout Profitability**; **Round 1 Performance** = subject's round 1 performance relative to the max performance across all sessions.

******* – significance at the 1% level; ****** – significance at the 5% level; ***** – significance at the 10% level.

B Session Instructions

Introduction

- You are about to participate in a session in which you will complete tasks at a computer. This is part of a study intended to provide insight into certain features of decision processes. I encourage you to follow the instructions carefully. You will be paid in cash at the end of the session.

- *During the session, I ask that you please do not talk to or otherwise communicate with (e.g., text messaging) each other.* If you have a question, please raise your hand and a session moderator will assist you.

- In consideration for others in the session, we do ask that you take a moment to make sure that the ringer on your cell phone is off.

- Your computer screen should have two open windows: an internet browser and a "Welcome to z-Leaf" window. If these two windows are not open on your screen, please raise your hand.

- During the session, you are free to use the internet browser on your computer. The session monitor will inform you when you are required to respond to the z-Leaf window.

- You should have a pen and two blank sheets of paper at your workspace. Please check to make sure the pen works. If you do not have these items, or if your pen does not work, please raise your hand.

- During this session, you are going to be assigned to a group. In some parts of this experiment, you and your group members will have the opportunity to complete computer-based tasks for the environment, where more tasks completed will lead to larger reductions in greenhouse-gas emissions, believed by most scientists to be a leading contributor to global warming. Before continuing with the more detailed session instructions, we would like to give you an idea of how this will work.

- **According to the Intergovernmental Panel on Climate Change:** Global atmospheric concentrations of greenhouse gas emissions have increased markedly as a result of human activities. Scientists have very high confidence that this process has caused increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising sea levels. The likely range for warming by the end of the 21st century is between 5 and 14 degrees F. The effects will last for centuries due to the long-lived nature of emissions. The longer-term magnitude of these effects and the impacts on different regions of the planet are less certain but will likely include widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones. While some changes might be beneficial (like longer growing seasons for agriculture), on balance scientists believe these changes will be damaging to humans. There is also some small risk that there could be catastrophic impacts, such as major reductions in polar ice that could result in approximately 15-20 feet of sea level rise.

- The tasks you and your group complete in the **Environment Rounds** directly reduce greenhouse gas emissions. The European Union Emission Trading System, which came into effect in 2005, caps the number of tons of greenhouse gas emissions EU member countries may produce in any year. In order to emit greenhouse gases, a polluter needs a permit, with the total number of permits equal to the total number of tons allowed. Based on the number of tasks you and your group complete in Environment rounds, session sponsors will purchase the appropriate number permits. We will retire these permits. That is, we will not sell these permits to emit greenhouse gases, and thus the number of tons of greenhouse gases emitted will decrease by this amount. Therefore, your effort in Environment rounds directly reduces greenhouse gas emissions.

- Driving a mid-size car from Palm Beach, FL to Williamstown, MA produces the equivalent of approximately .7 tons of carbon dioxide, a greenhouse gas.

Procedures

- At the start of the session, the computer randomly assigns one-half of participants to the Blue group and one-half to the Purple group. You remain in the same group for the entire session.
- This session will proceed in a series of 5-minute rounds.
- In **Environment Rounds**, you are presented with counting tasks in your z-Leaf window. At the end of the round, the computer adds up the number of tasks completed by members of your group. For each 200 counting tasks, the session sponsors will purchase and retire a permit to emit one ton of carbon dioxide, directly reducing global greenhouse-gas emissions by that amount. (If the total is not divisible by 200, the appropriate fraction of a permit will be purchased.)
- In **Earning Rounds**, you are presented with encryption tasks in your z-Leaf window. At the end of the session, you receive a cash payment of $0.10 (10 cents) for each encryption task you complete.
- **The Encryption Task:** In your z-Leaf window, there will be a table translating each letter of the alphabet into a unique 2-digit number. This table remains the same for the round. For each task, your monitor presents you with 2 letters. You complete a task by translating the 2 letters into their numeric equivalent, entering the correct 4 numbers (without spaces) into a box on your monitor, and clicking the **OK** button. Once you have entered the correct 4 numbers, your monitor presents you with the next 2 letters.
- **The Counting Task:** For each task, your z-Leaf window presents you with a table with 4 rows and 4 columns with either a 0 or 1 in each position. You complete a task by counting the number of zeros, entering the correct number into a box on your monitor, and clicking the **OK** button. Once you have entered the correct number of zeros, your z-Leaf window presents you with the next table.

- At the start of each round, your z-Leaf window will inform you whether the round is an Environment Round or an Earning Round.
- At the end of each Earning Round, your z-Leaf window will display the number of encryption tasks you completed and the amount of money you earned.
- At the end of each Environment Round, your z-Leaf window will display the number of counting tasks completed by you and your group as a whole. It will also display the number of tons greenhouse gas emissions your group has prevented.
- The experiment will start with two one-minute practice rounds (one encryption and one counting). The purpose of the practice rounds is to give you an opportunity to familiarize yourself with the computer interface. You will not earn money in the practice rounds, nor will greenhouse gas permits be purchased.
- At the end of the experiment, I will pay you, in cash, your participation fee plus your earnings from all Earning Rounds. I will also provide you with a web address where you may verify the purchase of greenhouse gas permits that your group earned. At the end of the calendar year, you may verify that all of the permits have been retired (that is, none have been resold).
- Are there any questions?

B.1 Buyout Instructions

You and everyone in your Group will be offered a Buyout Option this round. Please read carefully.

- If you accept the **Buyout Option**, you pay a **Buyout Fee**: a flat fee which session sponsors will use to purchase and retire as many greenhouse gas permits as possible.
- If you accept the Buyout Option, your computer will present you with earning (encryption) tasks. The amount you would receive per completed encryption task may be

different than in regular Earning Rounds. If you accept the Buyout Option, your earnings, which may be negative, would be the number of encryption tasks you complete times the amount per completed encryption task, minus the Buyout Fee.

- All members of your group are offered the same Buyout Fee, which you would pay only if you accept the Buyout Option. Also,all members of your group will be offered the same number of cents per completed encryption task.

- The Buyout Fee has been calculated to replace the average number of permits produced in the first Environment Round. Thus, if your 8 group members retired a total of 8 pollution permits in the first Environment Round, the calculated Buyout Fee will be exactly equal to the price of 1 pollution permit.

- If you do not accept the Buyout option, your Environment Round proceeds as usual. Your computer presents you with counting tasks, with the session sponsor purchasing and retiring 1 ton of greenhouse gas emissions for each 200 tasks.

- At the end of the round, the computer adds up:

    1. all Environments tasks completed by group members not accepting the Buyout option, with the session sponsor purchasing and retiring a permit for 1 ton of greenhouse gas emissions for each 200successfully completed Environment tasks; and

    2. the Buyout Fees collected from group members accepting the Buyout Option, with the session sponsor using these fees to retire as many greenhouse gas permits as possible.

- On the next screen, your monitor will display information which may be helpful in deciding whether to accept the Buyout Option:

    – the Buyout Fee;

  - the amount you will receive per encryption task if you accept the Buyout option;
  - your earnings if you complete as many encryption tasks as last round;
  - the number of greenhouse gas permits retired if you pay the Buyout Fee; and
  - the number of greenhouse gas permits retired as a result of the number of counting tasks you personally completed in the first Environment Round.

- Are there any questions?