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ORIGINAL PAPER

Emission Tax, Health Insurance, and Information: A Mechanism Design for Reducing Energy Consumption and Emission Risk

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Abstract
A major share of the energy demand in the United States and around the world is met by energy sources derived from conventional fossil fuels. Combustion of fossil fuels causes serious emission of greenhouse gases and particle pollution, that translates into health hazards. Consumption of renewable energy can help reduce the carbon footprint and cut down the health risk. In this study we present results from a lab experiment in which subjects participated in a context-rich, incentivized game with elements of an impure public good, risk, and intertemporal discounting. The subjects played the role of a household head to decide on how much to spend on energy saving technologies. The spending reduced the future energy cost and emission, as well as emission related health risk and associated medical costs for everyone in the group. The discounting was characterized by allowing to save with interest earnings across multiple rounds. Each subject played three sections (baseline, a treatment, and a repeated baseline) and each section was comprised of 30 rounds. The treatment had a threshold public good feature, where the emission tax level was dependent on the overall energy-saving investments made by the group. Subjects exhibited significant learning and wealth effect in adopting more energy saving technologies over time. Furthermore, subjected were given the option to purchase health insurance to mitigate risk. The result shows that the adoption rate is higher when the emission tax is framed as a reward rather than a punishment and average energy savings are crowded out with the option to purchase health insurance. However, on average subjects who decide to purchase health insurance also save more energy than those who refuse to purchase it.

Keywords Energy conservation · Health insurance · Information · Risk preference · Risk mitigation

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Introduction

Reduction in energy consumption can save the environment and energy costs (Rose et al. 2017; Dimanchev et al. 2019). Household use of energy-saving modern technologies (e.g., energy-efficient appliances) and installation of renewable energy sources (e.g., solar panels). According to (Chan and Kotchen 2014), these energy-saving products/technologies can be seen as impure public goods (IPGs) as its adoption reduce environmental impacts (public good) and energy costs (private good). Still, the adoption these products/technologies remains limited, most likely due to higher upfront costs compared to the conventional products/technologies.

To overcome these challenges, the economists often advocate for energy policies backed by the rational choice theory, which implies incentivizing efforts to reduce energy consumption (Gayer and Viscusi 2013; Gerarden et al. 2015). They either recommend increasing per unit cost of energy and/or decreasing per unit cost of energy-saving and renewable energy technologies (Bauwens 2019). However, the net aggregate benefits from these approaches are often ambiguous (Nurmi et al. 2019). Carbon tax, for example, levies a fee on the production, distribution, and use of fossil fuels. In Ireland, it is estimated that the total emissions can decrease by 861 k ton if carbon prices are raised from €21.50 per ton in 2012 to €41 per ton in 2025 (Di Cosmo and Hyland 2013). However, the price change comes at a cost of 0.21% reduction in GDP and a 0.08% decrease in employment. In the United States, the Energy Modeling Forum analyzed a set of illustrative policies which vary by the carbon tax rate (McFarland et al. 2018). The study has discussed different outcomes in terms of emissions, revenue, GDP, sectoral impacts, and welfare. Each model predicted modest economic costs either through decrease in GDP or loss of welfare.

Further, households' limited IPG adoption is driven by delayed benefits of energy-saving and renewable technologies. Oftentimes, people fail to recognize the value of future savings from IPG adoption in the present, and underestimate the present value of future returns from inconsistent and high discount rates (Gerarden et al. 2015; Zhu et al. 2017). Other reasons of limited IPG adoption include high transaction costs of searching for and processing information (Gillingham and Palmery 2014; Huang et al. 2014; Sallee 2014), sensitivity to changes (Wichman et al. 2016; Volland 2017) and the relative insignificance of energy costs as a proportion of total expenditure (Banfi et al. 2008; Takama et al. 2012). Therefore, in contrast to the direct cost and benefit comparisons, the behavioral choice theory emphasizes the implicit social and psychological aspects of the choice dynamics (Goulder and Parry 2008; Litvine and Wüstenhagen 2011; Börger and Hattam 2017; Farrow et al. 2017).

Building on our prior work (Chatterjee et al. 2021), we present in this paper the results of a context rich laboratory experiment in which we test if combining features of economic incentives and behavioral choice theory is effective in promoting energy efficient behavioral choices. Furthermore, we provide subjects with the option to purchase health insurance to mitigate risk. The subjects participated in four parallel incentivized games that encapsulated elements of public good, risk, intertemporal discounting, health insurance and information. Subjects play the role of household heads, deciding how much to spend on assorted energy saving technologies that will reduce the future energy costs. These decisions are tied to reduced risk of medical losses to represent environmental and health benefits. Discounting is symbolized by the ability to save and earn interest. Each subject makes decisions in three consecutive sections: the baseline, treatment, and repeated baseline; each section is comprised of 30 rounds. The subjects pay a uniform emission tax every round.

The treatment has a threshold public good where the emission tax level depends on the overall energy savings by the group. Subjects have a steep learning curve, adopting more energy saving technologies over time. They adopt sooner when the level of emission tax is proportional to group energy consumption. No change in behavior was found as subjects were informed of the choices made by other group members. The option to buy health insurance makes them save less energy. However, subjects who purchase a health insurance to cover medical costs save more energy on average than those who refuse to purchase health insurance.

Literature Review

In 2018, in the United States, approximately 62.9% of total energy was generated from fossil fuels, from coal and natural gas, predominantly.[1] The combustion of fossil fuels causes significant health hazards. In 2010 alone, in the United States, the particle pollution from coal plants caused 13,200 premature deaths, 9700 additional hospitalizations, and 20,000 heart attacks (Schneider and Banks 2010). Furthermore, the health-related damages cost more than $102 billion per year (Union of Concerned Scientists 2011).

Efforts to reduce energy consumption can be perceived as contributions to a public good two major reasons. Our efforts to reduce energy consumption make us feel better about ourselves and/or about the fact that others who we care about think of us favorably (Bernheim and Rangel 2012). Monetary incentives to inspire public contributions discourage the contributors who are motivated by the feeling of charitable contributions (Ariely et al. 2009). That is, incentives may crowd out intrinsic motivations to engage in sustainable energy behaviors. For example, regulations may require homeowners to buy "carbon offsets" to compensate for emissions. However, the psychological effects of monetization might increase emissions when no carbon offsets are in place. This happens due to the buy-in mentality as homeowners get free of the guilt of causing emissions by taking part in the green programs. In Memphis, Tennessee, households were given a choice to participate in a comparatively expensive green electricity program (Jacobsen et al. 2012). It was found that households who participated at the minimum threshold level increased their electricity consumption by 2.5%. Monetary incentives for conservation of energy and/or adoption of renewable energy technologies may cause analogous outcomes. Moreover, there are inter-linkages among energy conservation, poverty, and inequalities (Oueslati et al. 2017). Environmentally motivated taxes on energy products are often debated due to possible distributional effects. The financial burden of energy taxes disproportionately falls on low-income households. Low-income households spend larger share of their disposable income on goods and services (e.g., electricity), directly affected by environmentally motivated taxes. Also, these households are unable to claim tax benefits of energy-saving and renewable-energy residential installations (Charlier et al. 2018). Therefore, state/federal subsidies to partially support the financial adoption cost disproportionately favors the wealthy.

The role of insurance is largely unrecognized in public good games. Insurance deals with losses by providing financial protection following a damage. Insurance compensations are of considerably high value in comparison to the insurance premiums. Insurance is

[1] For details, please visit the website: https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php.

critical to risk management and determining contribution in threshold public goods games. However, there is only limited research on how buying insurance affects the contribution to provision of public goods under risk environments. We focus on the issue in this paper. Information has also been proven to play an important and significant role determining choices. A way to make people save energy is by informing them about the behavior of their comparable others. Comparative feedbacks are utilized as a motivational strategy or nudge, to increase energy savings (Allcott 2011). The comparisons act as normative conduct points guiding conservation behavior. Norms influence behavior by giving cues as to what is appropriate and desirable. For example, Allcott and Kessler (Allcott and Kessler 2019) discussed the importance of the social welfare evaluation of a home energy reports that compare a household's energy use to that of its neighbors and provide energy conservation tips.

Therefore, we applied a similarly framed information treatment in the decision experiment. This is a context rich laboratory experiment that addresses existing challenges in adoption of energy-saving and renewable-energy technologies. Firstly, the experiment considers a negative relation between energy saved and health hazard. Secondly, to address the non-monetary cost, the present values of energy-saving and renewable-energy technologies are cost ineffective in the absence of public benefit. Lastly, energy expenses are set to an insignificant amount in comparison to income and expenditure. The decisional framework has been enriched with suggestions from several experts in the field. Values of the characteristics variables in the experiment have been set around their median values collected from the 2010 census in Miami (Miami-Dade County). Under these circumstances we test value of group incentive mechanism not to subsidize wealthier households' renewable energy preferences at the cost of low-income families (Welton 2017).

Experiment Design

The experiment's software was written using the z-Tree (Fischbacher 2007). We recruited a unique group of eight subjects from the main campus of Florida International University (Miami, Florida) to participate in each of the sixteen experimental sessions. Email solicitations were sent to both undergraduate and graduate students. They were informed that they could earn \$10 to \$50 for making decisions in a decision experiment that last for 2 hours. Subjects were hired on a first come, first recruit basis and they could participate in one session only. Upon arrival, they were assigned to designated computers, and the instructions (see online Appendix A) were read and explained to them. Subjects were not allowed to communicate among themselves during the experiment. They took the Holt and Laury risk-aversion experiment (Holt and Laury 2012) before the main experiment began. They also completed a socio-demographic survey at the end of the experiment.

Experiment One

Experiment one was divided into 3 sections (baseline, treatment, and repeated baseline). In each section a subject had to make decisions for 30 rounds. In the beginning of each section (round 1), each subject was given an initial savings account balance of \$60,000. He/she then receives a payment \$50,000 as income in every round and a 3% interest on his/her savings account balance per round. All these earnings were deposited into their savings accounts. They also had expenses: \$30,000/round to meet basic consumption needs (e.g., food, education, housing, etc.), \$2000/round for their energy bill and an emission tax of \$300/round. Subjects could choose to reduce their energy bills with long-term and short-term energy-saving choices (ESC). Once installed, a long-term energy-saving choice (ESC^{LT}) was effective for all remaining rounds in that section. There were three long-term energy-saving choices (ESC^{LT}): (1) geothermal heat pump (GHP), (2) residential wind turbine (RWT) and (3) residential solar energy system (RSES). The respective installation costs were \$7000 for GHP, \$8000 for RWT and \$15,000 for RSES. The GHP saves 10% (\$200), the RWT saves 10% (\$200) and the RSES saves 20% (\$400) of the energy bill every round. There were two short-term energy-saving choices (ESC^{ST}): (1) energy efficient lighting (EEL) and (2) energy conservation behavior and the use of energy efficient appliances (ECB). The ESC^{ST} were effective for one round. The EEL costs \$100/round and saves 3% (\$60) of the energy cost. The ECB costs \$200/round and saves 7% (\$140) of the energy bill.

In the experimental design, subjects were exposed to emission related health risk with a 60% probability of getting sick. If a subject got sick, half of the time (50%) it was too trivial to incur any medical expenses. The rest of the time, it is either a minor or a major illness incident. A minor illness incident (47% of cases) led to medical expenses between \$1,000 and \$5,000 (uniformly distributed). A major illness event (3% cases) led to medical expenses between \$10,000 and \$60,000 (uniformly distributed). There was a positive association between energy consumption and health risk in the experimental design. The default energy bill was \$2000/round per subject. As a group of 8 subjects, the default group energy bill was \$16,000/round. The probability of health risk to each subject was reduced by 1% for every \$200 reduction in energy bill. For example, the emission related health risk is 40% (decreases by 20%) if the total energy bill is \$12,000 (\$4000 total savings in group energy bills).[2] The optimal strategy of each subject in the experiment was not to invest in ESC. However, it was in the advantage of the group to adopt all ESC from the very beginning.

While the first (Baseline) and the third sections (Repeated Baseline) of the experimental framework is as explained above, we applied either of the following two policy treatments in the second section (Treatment).

(A)*Increasing Emission Tax (IET)* During the IET treatment, the emission tax was increased from \$300/round to \$500/round following the 10th round if the total energy bill did not drop by a minimum of 30%.

Decreasing Emission Tax (DET) During the DET treatment, the emission tax was set equal to \$500/round for the first ten rounds. If the total energy bill dropped by minimum 30% by 10th round, the emission tax was reduced from \$500/round to \$300/round for the remaining period. The emission tax stayed at \$500/round after 10th round, provided the total energy bill did not go down by 30% at least.

If a subject did not have enough money in the savings account to pay for all the expenses, earnings for that section of the experiment were set equal to \$0. We conducted two experimental sessions that included IET treatment (16 subjects) and two experimental sessions that included DET treatment (16 subjects). For every subject, one of the three

[2] Subjects do not observe others' decisions. Based on how they experience emission induced sickness events, they can form expectations about energy-saving decisions of others. Therefore, within-session inter-subject collaboration concern is negligible.

Table 1 Average energy saving or average *CONSERVATION* ($) by treatment

Sessions		Baseline	Treatment	Repeated Baseline
Experiment One: ESC	IGT	762.38 (296.06)	807.08 (309.02)	853.33 (270.44)
	DGT	808.96 (277.49)	845.50 (234.50)	773.79 (317.29)
Experiment Two: ESC + HI	IGT	670.79 (334.96)	654.08 (324.63)	572.50 (387.96)
	DGT	812.83 (201.10)	755.08 (254.99)	680.58 (306.62)
Experiment Three: ESC + MDO	IGT	663.95 (277.44)	659.17 (281.05)	645.06 (317.52)
	DGT	815.29 (301.88)	857.54 (231.69)	782.42 (343.17)
Experiment Four: ESC + HI + MDO	IGT	712.92 (364.01)	847.29 (204.05)	680.88 (381.27)
	DGT	630.71 (244.38)	681.54 (235.08)	534.96 (305.31)

Average energy savings (*CONSERVATION*) in corresponding cells are in dollars and standard deviations are in the parenthesis

sections were randomly chosen to determine the payoff. 1 U.S. dollar was paid for every $30,000 in the savings account balance. Subjects were guaranteed and paid a minimum of $10 for their participation.

Experiment Two

In addition to the experiment one decisional framework, subjects were offered to purchase a health insurance (HI) policy in experiment two. There were two HI policies to choose from. Insurance one (Ins1) has a $1000 premium, with a 35% co-pay and $20,000 cap. Insurance two (Ins2) has $1300 premium with 10% co-pay and $5000 cap. Insurance policies last for one round only, and subjects must decide whether and which health insurance to purchase each round.

Experiment Three

In addition to the decisional framework of experiment one, subjects monitor aggregate long-term and short-term energy-saving choices of others (MOD) across the sections and at the end of every round during experiment three.

Experiment Four

Subjects received the option to purchase a health insurance policy (as described in experiment two) and could monitor aggregate ESC (as described in experiment three) during experiment four.

Estimation Result

Table 1 reports average energy savings across experiments, sections and treatments. IET treatment emerges more energy saving than the baseline during experiment one and four. However, the effect disappears in comparison to the repeated baseline in experiment one, as subjects save more energy on average per round in absence of the IET treatment. The average energy savings is higher under the impact of the DET treatment for experiment one, three and four both in comparison to the baseline and repeated baseline. Five indicator variables were created to quantity the energy saving efforts. They are *GEOTHERMAL*, *WIND, SOLAR, LIGHT* and *APPLIANCE*. *GEOTHERMAL*, *WIND* and *SOLAR* stand for the round in which the equivalent ESC^{LT} (respectively GHP, RWT and RSES) were installed. However, the indicator variable is set equal to 31 if a subject decides not to install an ESC^{LT}. That is, these indicator variables range from 1 to 31. Once chosen an ESC^{LT} is effective for a section. Hence, lower the value of these indicator variables, larger are resulting energy savings. Summarized in Table 2, RWT and RSES are installed relatively earlier during the treatment section. The average time to choose GHP in the treatment section is less than what it is in the repeated baseline section. ESC^{ST} last one round only. The indicator variables *LIGHT* and *APPLIANCE* represent how many rounds in one section EEL and ECB are chosen. Ranging from 0 to 30, larger values of *LIGHT* (and *APPLIANCE*) represent frequent choice of EEL (and ECB) and higher energy savings. The frequency of choosing ESC^{ST} are not largely different across sections. Using Wilcoxon Matched-Pairs Signed-Rank test, Wilcoxon Mann–Whitney Rank Sum test and the t-test effectiveness of the IET, DET, MDO and HI have been tested. In short, result suggest earlier installation of RWT during the IET treatment than the Baseline. RSES is installed significantly earlier during the treatment section (IET or DET) than the baseline and/or the repeated baseline section. Installation of GHP is significantly delayed, and choice of EEL and ECB are less frequent under the effect of the health insurance (HI).

The between-subjects and group-design in the experimental setup implies high correlation between the treatments and the groups. A group identity variable in the regression analysis for different session may obscure the treatment effect. Also, though the systematic nature of behavior is attached to individual characteristics, some unobservable effects may be lost. A generalized random effects panel estimation has therefore been applied. Each subject makes 30 choices (in 30 rounds) in each of 3 sections. That is, there are 90 observations of ESC for each of 128 subjects. Subject id has been set as the group variable ranging from 1 to 128, when the time variable for the panel estimation (*TIME*) is set from 1 to 90 (Davidson and MacKinnon 2004; Wooldridge 2010). The dependent variable of the regression analysis is the amount of energy-savings (*CONSERVATION*), the difference between the default ($2,000) and actual energy bill (due to ESCs). The summary statistics of the dependent and explanatory variables are listed in Tables 3 and 4. The estimation results of four different regression specifications are presented in Table 5.

In all four models, energy-saving in round one (*INI_CONSER*) is consistently significant at 1% level. Once installed, ESC^{LT} are effective for the complete section. It is rationally expected that several subjects would invest in ESC^{LT} in the very first round to take advantage of its' lifetime. Hence, energy saved the first round (*INICONSER*) is positively related to future energy savings. Over the rounds (*ROUND*), subjects save more energy at 1% level of significance. This represents the wealth effect to energy saved, as savings account balance increases over time. Average energy saved decreases significantly (at 1% level) over the consecutive sections (*SECTION*). This represents the negative knowledge effect to energy savings. That is, as the subjects learn the nature of the experiment, they choose to save less energy. We find significant and consistent evidence that both the IET (*INCREASE*) and DET treatment (*DECREASE*) increases energy-savings at 1% level of significance. The coefficient of *INSOPT* is negative and significant at 1% level. The estimation result shows that the participants, who choose either Ins1 (*INSONE*) or Ins2 (*INSTWO*), spend more on energy saving installations and choices at 1% or 5% level of

Table 2 Summary statistics of decision variables for non-parametric estimation

Variable	Definition	N	Baseline	Treatment	Repeated Baseline
GEOTHERMAL	Round when GHP is installed (1–30), 31 if never installed	384	5.81 (9.47)	6.40 (10.16)	8.11 (11.40)
WIND	Round when RWT is installed (1–30), 31 if never installed	384	9.20 (11.62)	8.45 (11.35)	9.90 (11.16)
SOLAR	Round when RSES is installed (1–30), 31 if never installed	384	7.05 (10.46)	4.97 (8.43)	8.71 (11.86)
LIGHT	Number of rounds EEL is selected (0–30)	384	17.14 (10.46)	17.04 (11.56)	16.45 (12.40)
APPLIANCE	Number of rounds EEL is selected (0–30)	384	18.97 (10.71)	18.75 (11.44)	18.13 (12.30)

The standard deviations are in the parenthesis. There is 1 observation for each of 128 subjects for every section (Baseline, Treatment, and Repeated Baseline). GHP, RWT, RSES, EEL, and ECB represents Geothermal Heat Pump, Residential Wind Turbine, Residential Solar Energy System, Energy Efficient Lighting, and Energy Conservation Behavior, respectively

Table 3 Summary statistics of the experimental data

Variable	Definition	N	M	SD
Conservation	Energy saving ($2000—Household energy bill)	11,520	729.53	309.35
Section	Section (Baseline = 1, Treatment = 2, Repeated Baseline = 3)	11,520	2	0.82
Round	Round index (1–30)	11,520	15.50	8.66
Time (t)	tth decision of subject (1–30 for Baseline, 31–60 for Treatment, and 61–90 for Repeated Baseline)	11,520	45.50	25.98
Iniconser	Energy saved in round 1	11,520	429.01	292.84
Increase	1 for IGT treatment, 0 otherwise	11,520	0.17	0.37
Decrease	1 for DGT treatment, 0 otherwise	11,520	0.17	0.37
Mdo	1 if participants monitor decision of others' (experiment three and four); 0 otherwise	11,520	0.50	0.50
Insopt	1 if HI is available (experiment two and four); 0 otherwise	11,520	0.50	0.50
Insone	1 if Ins1 is chosen; 0 otherwise	11,520	0.12	0.33
Instwo	1 if Ins2 is chosen; 0 otherwise	11,520	0.26	0.44

90 observations for each of 128 participants (11,520 = 90 × 128)

Table 4 Summary statistics of the sociodemographic characteristic variables

Variable	Description	N	M	SD
Aversion	Holt and Laury risk-aversion index (1–9)	128	6.70	2.13
Age	Age of the subject	128	25.82	4.34
Female	1 if Female; 0 otherwise	128	0.48	0.50
White	1 if White; 0 otherwise	128	0.19	0.39
Black	1 if African-American; 0 otherwise	128	0.08	0.27
Asian	1 if Asian, 0 otherwise	128	0.41	0.49
Ameind	1 if American Indian or Alaska Native; 0 otherwise	128	0.01	0.09
Liberal	Political orientation of respondent (0 = Extremely liberal, 1 = Liberal, 2 = Slightly Liberal, 3 = Middle of the road, 4 = Slightly conservative, 5 = Conservative, 6 = Very conservative)	128	2.41	1.49
Republican	1 if Republican; 0 otherwise	128	0.09	0.28
Independent	1 if Independent; 0 otherwise	128	0.55	0.50
Economics	1 if majoring in Economics; 0 otherwise	128	0.10	0.30
Social	1 if majoring in Social Science (other than Economics); 0 otherwise	128	0.09	0.29
Math	1 if majoring in Math, Statistics, Computer Science or Engineering; 0 otherwise	128	0.17	0.38
Natural	1 if majoring in Natural Science; 0 otherwise	128	0.30	0.46
Business	1 if majoring in Business; 0 otherwise	128	0.07	0.26
Other	1 if majoring in other subjects; 0 otherwise	128	0.23	0.42
School	School year (0 = Freshman, 1 = Sophomore, 2 = Junior, 3 = Senior, 4 = Graduate Student)	128	3.28	1.03
Health	How strongly the respondent believes that environmental pollution causes health issues			
(0–4; 0 = Really believe so, 4 = Do not believe so, at all)	128	0.22	0.50	
Energy	How strongly the respondent believes that conservation of energy saves the environment?			
(0–4; 0 = Really believe so, 4 = Do not believe so, at all)	128	0.43	0.77	
Environment	Environmental concern of respondent: (0 to 4; 0 = Very concerned, 4 = Not at all concerned)	128	0.57	0.76
Society	Concern for other people/society:			
(0–4; 0 = Very concerned, 4 = Not at all concerned)	128	0.55	0.86	

Male (*MALE*), Hispanic (*HISPANIC*), Democrat (*DEMOCRAT*), and major in arts, language (*ARTS*) are dropped to avoid multicollinearity problem. We drop American Indian (*AMEIND*) and Native Hawaiian or Other Pacific Islander (*PACISLAN*) since there were no observations

Table 5 Regression result (Dependent variable, *CONSERVATION*)

	Model 1	Model 2	Model 3	Model 4
Iniconser	0.36*** (0.01)	0.36*** (0.01)	0.36*** (0.01)	0.36*** (0.01)
Increase	0.02*** (4.53)	0.02*** (4.53)	0.02*** (4.53)	0.02*** (4.53)
Decrease	0.05*** (4.48)	0.05*** (4.48)	0.05*** (4.48)	0.05*** (4.48)
Insopt	−0.18*** (39.10)	−0.17*** (38.67)	−0.17*** (37.23)	−0.16*** (37.00)
Insone	0.04*** (7.62)	0.04*** (7.62)	0.04*** (7.62)	0.04*** (7.61)
Instwo	0.03** (7.81)	0.03** (7.81)	0.03** (7.81)	0.03** (7.81)
Information	−0.05 (36.81)	−0.04 (36.20)	−0.04 (35.51)	−0.04 (35.24)
Year	0.17*** (0.17)	0.17*** (0.17)	0.17*** (0.17)	0.17*** (0.17)
Section	−0.06*** (1.83)	−0.06*** (1.83)	−0.06*** (1.83)	−0.06*** (1.83)
Aversion	0.01 (8.79)	−0.001 (8.61)		
Age	0.04 (3.49)	0.01 (3.54)	0.03 (2.99)	0.03 (2.99)
Female	−0.01 (35.02)	−0.14** (33.29)	0.01 (32.81)	
White	0.01 (36.29)	0.02 (32.29)	0.001 (31.26)	−0.00 (31.15)
Black	0.04 (33.54)	0.07** (37.53)	0.05* (31.47)	0.05* (31.54)
Asian	−0.02 (38.92)	−0.10 (41.41)	−0.02 (37.59)	−0.03 (37.97)
Ameind	−0.10* (204.6)	−0.09 (201.4)	−0.10* (198.2)	−0.11* (198.4)
Political	0.02 (11.93)	0.03 (11.08)		
Republican	0.05 (74.41)	0.04 (72.43)		
Independent	0.02 (29.70)	−0.03 (29.95)		
School	0.01 (20.50)	0.02 (19.83)	0.01 (19.14)	0.01 (19.09)
Economics	−0.08 (111.80)	−0.02 (111.60)	−0.07 (104.40)	−0.03 (107.40)
Social	0.002 (117.10)	0.02 (115.50)	0.01 (112.20)	0.03 (112.30)
Math	−0.05 (111.60)	0.03 (110.50)	−0.04 (107.30)	−0.03 (106.70)
Natural	−0.004 (104.70)	0.08 (103.50)	0.01 (99.87)	0.01 (99.01)
Business	−0.08 (119.30)	−0.02 (118.20)	−0.07 (116.50)	−0.07 (115.50)
Other	−0.07 (106.30)	0.03 (106.20)	−0.07 (102.50)	−0.07 (101.60)
Health	−0.01 (27.45)		0.001 (22.08)	0.01 (17.85)
Environment	0.09* (19.25)		0.09** (18.32)	0.13*** (16.93)
Energy		0.05 (21.29)		−0.08 (25.95)
Society		−0.11** (17.75)		
Observations	11,520	11,520	11,520	11,520
R^2 (Overall)	0.37	0.36	0.37	0.37

***, **, * imply significance at 1, 5, and 10% levels respectively; numbers in the parenthesis are robust standard error

significance. Energy savings of the subjects significantly increase with rise in concerns for the environment (*ENVIRONMENT*) and/or for other people in the society (*SOCIETY*).

Figure 1 visually explains some of the regression result. The top two graphs show that the average energy savings are highest under the treatment section (IET or DET), compared to the baseline and the repeated baseline section. The middle two plots graph average energy savings across different rounds in effect of the health insurance (HI), and information (MDO). Average energy savings in response to information seem to less than what it is

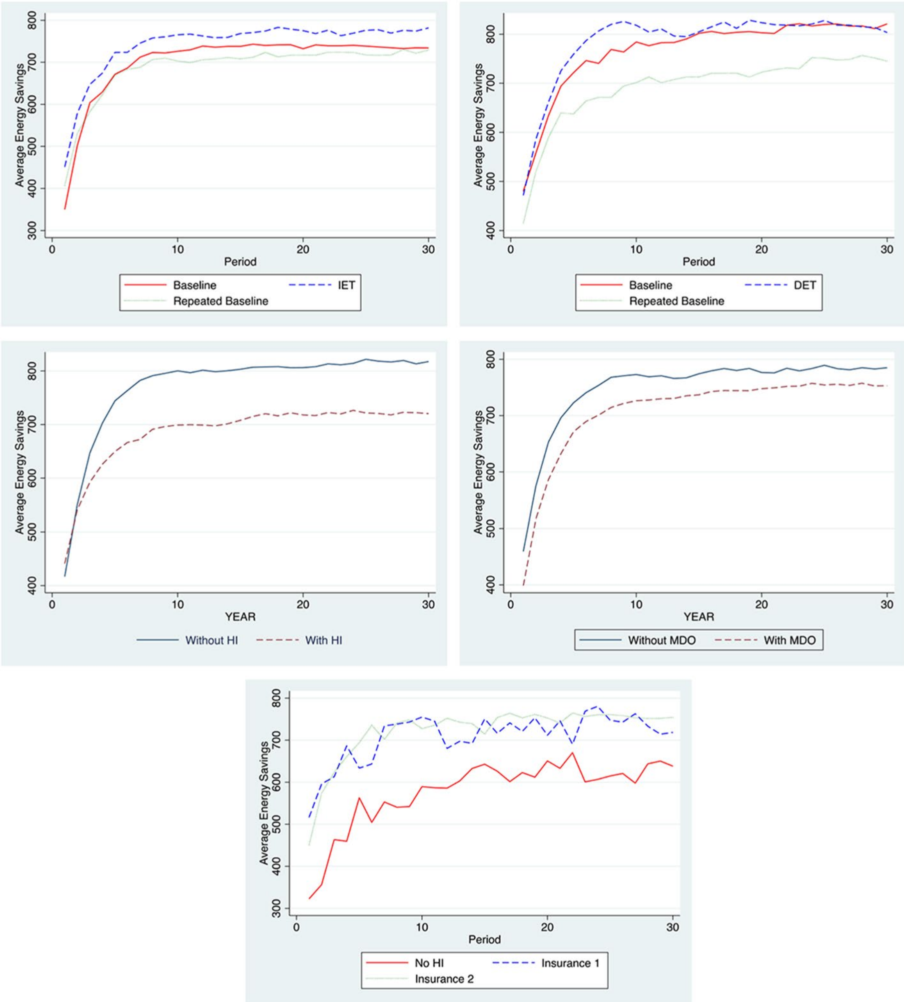

Fig. 1 Average energy savings across experiments and by treatments

without information. Also, average energy savings during experiment two and four (when subjects can buy a health insurance) is less than what it is during experiment one and three (when no health insurance choice is given). The bottom plot shows subjects who purchase insurance 1 or 2 save more energy than other surjects who purchase no insurance during experiment two and four.

Conclusion

The study addresses several major challenges to the adoption of energy-saving modern technologies. The energy bill is fifteenth part of consumption expenditure and twenty-fifth part of income in the experimental design. That is, household energy cost is set relatively insignificant to income and consumption. To account for the opportunity cost of adoption, private benefits to ESC are cost inefficient. Under this circumstance, both treatments (IET and DET) significantly increase energy savings. Based on the estimated coefficients, the DET treatment is relatively more effective. Expected financial gains are more effective than anticipated monetary loss to incentivize energy savings (Levitt et al. 2016; Szolnoki and Perc 2010). The result show no significant benefit to information (MDO). One's own contribution for a common benefit may substitute others' contributions (Kolm and Mercier Ythier 2006; Powell and Steinberg 2006). In contrast, self-contribution may well be complementary to others' contributions (Croson 2007). Therefore, on average, subjects may increase, decrease, or keep their energy-savings the same in response to information. Consequently, providing information may be advantageous, disadvantageous or of no significance, depending on the relative strength of crowding in versus crowding out effects (Zhou and Bukenya 2016; Büchs et al. 2018).

Results suggest average energy savings decrease with the option to buy HI. The literature has mostly predicted decrease in average contributions to public good in response to market insurance (Quaas and Baumgärtner 2008; Lohse et al. 2012). However, there is little to no evidence on how buying insurance affect the contributions to provision of public goods under risk environments (Du and Tang 2018). In the experiment we have translated environmental risks into expected medical losses, that is partly determined by the group energy savings. Given that medical damages can also be covered by HI (after the deductibles), energy-saving efforts and health insurance are substitutes in nature. It is therefore rational to find energy conservation behavior to be crowded out with the options to purchase HI (Ins1 or Ins2).

In comparison to those who participated in experiment one and three, average energy savings were relatively less for subjects in experiment two and four irrespective of their decision to purchase HI. However, based on experiment two and four only, subjects who purchase HI save more energy than those who prefer to stay uninsured. There are two explanations in the literature that can help interpret this result. Availability of HI makes environmental health risk private. Therefore, risk averse subjects actively choose to protect themselves with HI. Given the common benefit of energy savings, subjects who purchase HI feel more guilt than others' if they lack in efforts to reduce their energy bills. Therefore, although it is against their personal interest, subjects who buy HI save more energy than those who refuse to purchase one. Guilt has been proven to increase contributions to impure public good and we believe this is another example (Kesternich et al. 2019). However, there is a second line of explanation. Research have found that purchase of insurance does not necessarily decrease disaster preparation from moral hazard. Hudson et al., for example, have shown how insurance coverage does not result disaster risk reduction using survey data from Germany and the United States (Hudson et al. 2017). Cutler et al. have examined the relation between risky behaviors and insurance purchases in five different insurance markets (life insurance, acute health insurance, annuities, long-term care insurance, and Medicare supplemental insurance) in the United States (Cutler et al. 2008). They also found the absence of moral hazard in decision-making. That is, the lack of risk reduction behavior was systematically related to a decrease in the probability of insurance purchase. Botzen et al. have also found insurance and preventive behaviors are complements (Botzen et al. 2019). All the studies have recommended that the reasons for engaging in risk reduction come from the individual risk aversion nature. That is, risk averse subjects self-select themselves to buy insurance and take necessary measures to reduce their risk exposure. Hence, subject who purchase HI save more energy to reduce health risk than others who decides to stay uninsured.

Monetary incentives for sustainable energy practices are regularly under scrutiny for a possible connection to wealth distribution (Oueslati et al. 2017; Carattini et al. 2017). The adverse effects of climate change impact the economically challenged the most (Sedova et al. 2020). However, that that does not justify if the cost to fight climate change falls on them. The financial burden of energy taxes disproportionately falls on low-income individuals as they spend significant portion of their disposable income on goods and services directly affected by those taxes (e.g., electricity). Upfront costs are major bottlenecks to adoption of renewable energy technologies (Charlier et al. 2018). Monetary incentives, such as state subsidies to partially cover the cost, disproportionately favor wealthier homeowners at the cost of the tax-revenue from low-income families (Welton 2017). Incentivizing group conservation efforts address these limitations. Also, energy-saving goals can be tailored based on socioeconomic and demographic conditions. As group incentives are equally divided, the incentive scheme also reduces inequality.

Given these findings, we believe that the group incentive design can encourage energy efficient choices and renewable energy installations. However, confirming the result requires field tests with households. For reference, we can look into the field experiment on how feedbacks to households on their own and peers' home electricity usage in the electricity report nudge electricity conservation efforts (Costa and Kahn 2013). Field studies have also examined how extrinsic financial incentives interfere with the result of intrinsic incentives (Pellerano et al. 2016). We hope to design similar field experiment on energy saving decision making in the future to test our study result. Also, it would be interesting and important to compare the effectiveness of private and public benefit in follow-up studies.

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Data availability The data used in this manuscript will be made available upon reasonable request in compliance with the institutional review board (IRB) guideline.

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