Do wealth levels affect the contribution to negative externalities? *

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Abstract

This paper experimentally explores the link between poverty and decisions that lead environmental degradation. In the experiment, individuals with different wealth levels play a game that describes environmental degradation as a contribution to an activity that generates a negative externality. The experimental data show that wealth levels not related to the environment (exogenous poverty) play no significant role in environmental decisions. However, the variation in wealth as a consequence of the contribution to environmental degradation (endogenous poverty) affects the behavior of individuals, that enter a spiral of poverty and environmental degradation. These results suggest the existence of a poverty-environment trap.

Keywords: Environmental degradation; Exogenous poverty; Endogenous poverty; Negative externality; Experiment.

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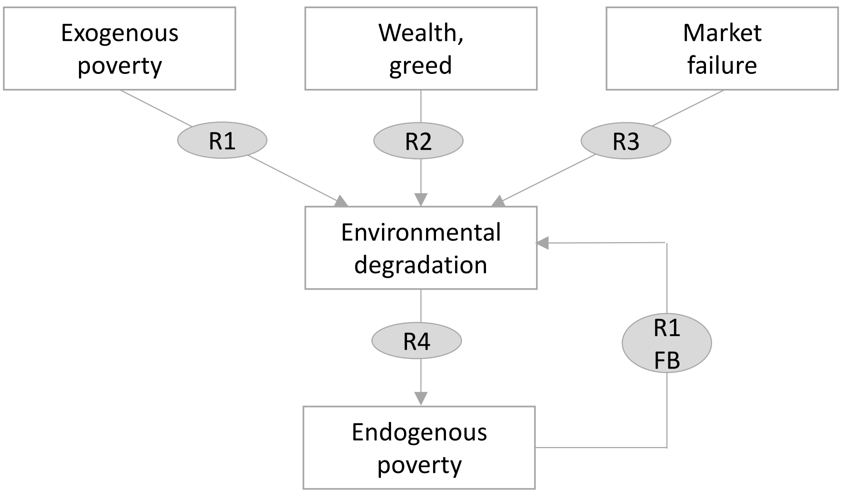
1 Introduction

"Many parts of the world are caught in a vicious downwards spiral: Poor people are forced to overuse environmental resources to survive from day to day, and their impoverishment of their environment further impoverishes them, making their survival even more difficult and uncertain". This is one of the main conclusions of the well-known Brundtland Report (WCED, 1987); a conclusion that puts the focus on the relationship between poverty and environmental degradation. This downward spiral is sometimes described as the *poverty-environment trap*, where poverty is a major cause of environmental degradation and environmental degradation causes poverty, forming a vicious circle (Durning, 1989).

Since this report, many authors have tried to shed light on the link between poverty and environmental degradation in order to prescribe policy options to mitigate both problems (see, for example, Durning (1989); Duraiappah (1998); Nadkarni (2000); (Barbier, 2010) for a general analysis or Dasgupta et al. (2005); Valkila (2009); Etongo et al. (2016); Peprah et al. (2017); among many others, for applied studies). These studies have shown that the relationship between poverty and environmental degradation is a multidimensional problem: demographic, cultural, economic, and institutional factors are important variables in the poverty-environmental degradation nexus. For example, the absence of local labor markets capable of absorbing all the poor and landless individuals looking for work, or the absence of well-functioning rural credit markets to lend needed capital, increases the pressure that poor put on the environment for their livelihood (Barbier (2010); Barrett and Carter (2013)). These studies have shown, however, that not all environmental degradation can be attributed to poverty and not all poverty can be attributed to environmental degradation (Nadkarni (2000); Haider et al. (2018)).

In this context, following Duraiappah (1998), we can distinguish between *exogenous poverty* and *endogenous poverty*. Exogenous poverty is poverty caused by factors other than environmental degradation, while endogenous poverty is poverty caused by environmental degradation. Given this distinction, and adding the market failure or institutional failure that characterize the economic interaction between humans and nature, Duraiappah (1998) proposes four possible relationships in the poverty-environmental degradation nexus (see Figure 1): (R1) Exogenous poverty causes environmental degradation; (R2) Power, wealth, and greed causes environmental degradation; (R3) Institutional/Market failure is the primary cause of environmental degradation; and (R4) Environmental degradation causes poverty. In addition, Duraiappah (1998) proposes the (R1) feedback relationship to capture the poverty-environmental trap: (R1FB) Endogenous poverty causes environmental degradation. These relationships are not mutually exclusive and can be presented simultaneously. He also shows how in real situations we encounter combinations of these relationships, each of which requires different and complex policy prescriptions.



Source: own elaboration based on Duraiappah (1998)

Figure 1: Possible relationships in the poverty-environmental degradation nexus

Against this background, this paper aims to investigate the connection between poverty and environmental degradation using the evidence provided by an experiment. At first, it may seem that a field experiment could be appropriate in the analysis of this link. However, we implement a lab experiment to properly isolate the effect of some wealth indicators. As Falk and Heckman (2009) state, resistance to laboratory evidence is often centered on an appeal to realism. This skepticism seems to have led to a lively debate in economics about field experiments versus laboratory experiments (see Roe and Just (2009) or Falk and Heckman (2009), among others). While some authors have argued in favor of laboratory experiments where controlled manipulations of conditions are performed in carefully documented populations (Smith (1994), Smith (2003), Plott (1986)), others have argued in favor of field experiments where conditions are more realistic, although with less controlled rigor (Levitt and List (2007) and Levitt and List (2009)). In this paper, our main objective is to isolate the effect of wealth inequality on the contribution to negative externalities controlling for other type of economic inequalities such as income inequality. Therefore, a laboratory approach seems to be more appropriate for such goal. A laboratory experiment allows us to create analogous, although stylized, scenarios that mimic real life situations in order to obtain data in a controlled way and test the relevance of the different factors that may affect the link between poverty and environmental degradation. To that end, and taking into account the different relationships displayed in Figure 1, we propose a game that describes a negative externality, a type of market failure showing the economic incentives in polluting activities or in natural resource extraction activities.

The effect of wealth and/or income inequality on individual and group behavior has been analyzed in different experimental settings. Isaac and Walker (1988), Buckley and Croson (2006), Sadrieh and Verbon (2006), Heap et al. (2016), Hauser, Kraft-Todd, Rand, Nowak and Norton (2019) or Hauser, Hilbe, Chatterjee and Nowak (2019) study public good provision when there is income inequality among individuals. All of them use different endowments in order to introduce income inequality in the game. Isaac and Walker (1988) report that groups with income inequality contribute less than groups with income equality. Buckley and Croson (2006) only consider groups with income inequality and compare the contributions of participants within the group. They show that endowment inequality does not affect absolute contributions reveling that, subjects with higher income contribute a smaller proportion of their income. The results in Hauser, Kraft-Todd, Rand, Nowak and Norton (2019) are different at the absolute level, as they observe higher absolute contributions of richer participants, but similar at the relative level, as poorer participants contribute a larger amount of their endowment. Heap et al. (2016) also consider the effect of income inequality but controlling for individual income and they find that inequality decreases the contribution of the rich but not that of the poor. Sadrieh and Verbon (2006) consider dynamic contribution to public goods and they find no significant differences due to income inequality. Buckley and Croson (2006) also consider wealth inequality but it is highly correlated to income levels and, therefore, the aforementioned results are maintained, high wealth subjects contribute a smaller proportion of their income but there are no differences in absolute terms. Hauser, Hilbe, Chatterjee and Nowak (2019) add differences in productivity to differences in endowment, finding that cooperation increases when more productive individuals receive higher endowments.

Economic inequality has also been studied in the appropriation of common property resources (CPR). Hackett et al. (1994) introduce income inequality based on endowment heterogeneity in a CPR with and without communication, showing that communication increases cooperation even in an environment with inequality. In Cardenas et al. (2002) economic inequality is introduced through unequal market wages among the participants in a field experiment. At the aggregate level, the groups with unequal market wages put on average less pressure on local environmental quality than the groups with symmetric market returns, thus suggesting that economic inequality reduces environmental degradation. At the individual level, the high-wage players spent less time harvesting firewood than the poorer ones, but the restraint needed to achieve outcomes better than those of the Nash equilibrium came largely from low-wage subjects. On the other hand, in Cardenas (2003) and Cardenas (2007) market wages are equal among the participants and economic inequality is measured using data about participants' real wealth. The results show that, in this case, social efficiency in the appropriation of the commons decreases as the variance of wealth among participants in a group increases, that is, economic inequality increases resource degradation.

Nishi et al. (2015) use laboratory experiments to study cooperative interactions in social networks and they observe that, among other things, poorer subjects are more likely to cooperate, making them worse off relative to their neighbors and allowing the rich to get richer. Endowment inequality is again the way to introduce economic inequality in the experiment. These authors also explore the effects of visibility or knowledge about economic inequality in cooperative behavior, as it happens in Hauser, Kraft-Todd, Rand, Nowak and Norton (2019).

In the experiment reported in this paper, instead of introducing economic inequality through endowment inequality, it is introduced through exogenous wealth levels. In order to isolate the effect of wealth inequality on cooperative behavior, endowments are equal among the participants. Moreover, the investment opportunities are the same for all the participants. Accordingly, the capacity to harm the environment contributing to negative externalities is independent of the wealth levels.[1]

In the game, the participants are randomly assigned a wealth level, which is used to differentiate between poor and rich individuals. With the same endowment, each participant can invest in a project that generates a negative externality or in a project with-

[1]We focus on wealth inequality rather than on income inequality because wealth is an important feature of socioeconomic position and, in comparison with income, provides greater financial security in addition to status, political power, and autonomy (Keister and Moller, 2000).

out externalities. Investment in the activity that generates a negative externality is a contribution to environmental degradation (R3). According to the experimental design, high contributions to environmental degradation can reduce participants' wealth, that is, environmental degradation can cause poverty (R4). The contribution to environmental degradation of poor participants shows whether exogenous poverty causes environmental degradation (R1), while the contribution to environmental degradation of rich participants shows whether wealth causes environmental degradation (R2). Finally, participants play the game for several rounds and they observe the evolution of their wealth and their position in the group. Decreasing wealth reveals situations of endogenous poverty that can affect subsequent investment decisions, and hence environmental degradation (R1FB).

The experimental results show a high contribution to environmental degradation both by individuals that can be considered (exogenously) poor and by individuals that can be considered (exogenously) rich. However, the experimental evidence does not show significant differences in the contribution to environmental degradation among these individuals. Poverty and wealth lead to high levels of environmental degradation without any of them prevailing over the other. These results point to market failure (externalities) as the main reason for observing high levels of environmental degradation; a result that is reinforced by what is observed in the control treatment in which the wealth is evenly distributed. Finally, we find experimental evidence showing that the variation in wealth as a consequence of the contribution to environmental degradation affects the behavior of individuals. Those that experience a decrease in their wealth tend to increase the contribution to environmental degradation, which leads to new decreases in wealth and then to a greater contribution to environmental degradation, entering a spiral of poverty and environmental degradation.

The paper is organized as follows. Section 2 introduces the experimental game and how it captures wealth distribution and externalities. Section 3 contains the experimental design and procedure and section 4 shows the main results of the experiment. Finally, section 5 concludes.

2 The game

2.1 Wealth distribution and the poverty line

Consider a society formed by n agents, $i = 1, \ldots, n$, each of which has at time t an absolute wealth W_{it}, while her relative wealth is $\frac{W_{it}}{\overline{W}_t}$, where $\overline{W}_t = \frac{\sum_{i=1}^{n} W_{it}}{n}$. $\overline{W}_t$ is average wealth and the absolute and the relative wealth levels may differ among the agents.

An agent is poor if her absolute wealth is below 60% of the average wealth of the society. We refer to this 60% of the average wealth, $0.6\overline{W}_t$, as the *poverty line*.[2] Therefore, the relative wealth of a poor agent falls bellow 0.6. Similarly, we consider that an agent whose absolute wealth is above 120% of the average wealth of the society is a rich agent. The relative wealth of rich agents is above 1.2. Agents with a relative wealth greater than 0.6 but lower than 1.2 are, therefore, middle-class agents. The classification of agents is summarized in Table 1.

Table 1: Agents classification

Relative wealth	Social group
$\frac{W_{it}}{\overline{W}_t} \leq 0.6$	Poor agent
$0.6 < \frac{W_{it}}{\overline{W}_t} < 1.2$	Middle agent
$\frac{W_{it}}{\overline{W}_t} \geq 1.2$	Rich agent

2.2 Investment possibilities and the environment

Assume that each agent has an initial *exogenous wealth* W_{i0}. The society plays the following game over T rounds. At the beginning of each round, $t = 1, \ldots, T$, each participant

[2]EUROSTAT recommends that poverty risk be defined as 60% of the median income. Persons falling below the threshold of 60% of the median income are referred to as being at risk of (income) poverty (EUROSTAT, 2002). In our experiment, we take 60 percent of average wealth as a reference for poverty.

(individual) receives an endowment e, the individual labor, which is equal for all the participants. Each participant can invest her endowment in two different projects or economic activities: (i) a production/consumption activity that causes environmental degradation (non-eco friendly project) or (ii) an out-environment alternative (eco-friendly project).

We characterize the activity that causes environmental degradation as a project that generates negative externalities. This non-eco-friendly project yields a marginal benefit α_A. In addition, investment in the project by participant i has a marginal cost β for every group member (including subject i making the investment), that is, the environmental degradation negatively affects the whole society. In economic terms, the marginal private cost of the non-eco friendly project is β, the marginal external cost of this project is $(n-1)\beta$, and the marginal social cost of the project is $n\beta$. Therefore, for the non-eco-friendly project the marginal private net benefit is greater than the marginal social net benefit, $(\alpha_A - \beta) > (\alpha_A - n\beta)$, due to the negative externality. The eco-friendly project yields a marginal benefit α_B for the participant making the investment and has no cost. As a consequence, for the eco-friendly project the marginal private net benefit is equivalent to the marginal social net benefit, α_B. Table 2 summarizes the main features of the two projects.

Let $x_{it} \in [0, e]$ be the *contribution to environmental degradation* (i.e., investment in the non-eco friendly project) of participant i in round t. Assuming that the whole endowment must be invested, investment in the eco-friendly project of participant i in round t is $(e - x_{it}) \in [0, e]$. The wealth of participant i in round t, is therefore

$$W_{it} = W_{it-1} + \alpha_A x_{it} + \alpha_B (e - x_{it}) - \beta \sum_{i=1}^{n} x_{it} \qquad (1)$$

From the individual point of view, we assume that, in any round t, investment in the non-eco-friendly project is more profitable than investment in the eco-friendly project, which means that the marginal private net benefit from the non-eco-friendly project is greater than the marginal private net benefit from the eco-friendly project, $(\alpha_A - \beta) > \alpha_B$. From the social point of view, we assume that the eco-friendly project is better than the non-eco-friendly project, that is, the marginal social net benefit from the non-eco-friendly project is smaller than the marginal social net benefit from the eco-friendly project, $(\alpha_A - n\beta) < \alpha_B$. All participants, regardless of their wealth position, face a social dilemma/market failure: individual behavior, driven by the maximization of individual payoffs, leads to actions that are socially suboptimal.

Table 2: Characteristics of the investment projects. A social dilemma.

	Non-eco-friendly project	Eco-friendly project	Social dilemma
Marginal benefit	α_A	α_B	
Marginal private cost	β	-	
Marginal external cost	$(n-1)\beta$	-	
Marginal social cost	$n\beta$	-	
Marginal private net benefit	$\alpha_A - \beta$	α_B	$\alpha_A - \beta > \alpha_B$
Marginal social net benefit	$\alpha_A - n\beta$	α_B	$\alpha_A - n\beta < \alpha_B$

Observe that the variation in wealth in round t for agent i is

$$\Delta W_{it} = \alpha_B e + (\alpha_A - \beta - \alpha_B)x_{it} - \beta X_{-it} \tag{2}$$

where $X_{-it} = \sum_{j \neq i} x_{jt}$. Wealth variation depends on the contribution of agent i to environmental degradation and on the contribution of the other members of her group to environmental degradation. This wealth variation can be used to measure *endogenous wealth* and *endogenous poverty.*

2.3 The benchmarks

Nash solution We have already pointed out that the marginal private net benefit from the non-eco-friendly project is greater than the marginal private net benefit from the eco-friendly project, $(\alpha_A - \beta) > \alpha_B$. Accordingly, by backward induction, the investment strategy that maximizes individual wealth, that is, the best response solution or the *Nash solution*, is full investment in the non-eco-friendly project ($x_{it} = e, \forall i, \forall t$). Notice that the Nash solution does not depend on absolute or relative wealth.

As endowments are equal among participants, each agent gets the same change in absolute wealth from this strategy. In the Nash solution, the variation in wealth for each participant in each period is $\Delta W^N = (\alpha_A - n\beta)e$. We assume a negative wealth variation from the Nash solution, that is, $(\alpha_A - n\beta) < 0$, in order to emphasize the negative effects that a widespread individual behavior degrading the environment can have on well-being (World Bank, 2007). Therefore, the Nash solution decreases absolute wealth. The effect on relative wealth depends on the wealth position of the individuals: for those below the average, $\frac{W_{i0}}{\overline{W}_0} < 0$, relative wealth decreases, but for those above the average, $\frac{W_{i0}}{\overline{W}_0} > 0$, relative wealth increases.[3] Notice that the Nash solution describes the highest possible environmental degradation in the game. This extreme situation of the environment negatively affects the poor in both absolute and relative terms.

Social solution As mentioned above, the marginal social net benefit from the non-eco-friendly project is smaller than the marginal social net benefit from the eco-friendly project,

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[3] Assume a variation y in individual wealth for all i, $W_{it+1} = W_{it} + y, \forall i$. Average wealth in $(t+1)$ is $\overline{W}_{t+1} = \overline{W}_t + y$. The variation in average wealth of subject i is:

$$\Delta \frac{W_i}{\overline{W}} = \frac{W_{it+1}}{\overline{W}_{t+1}} - \frac{W_{it}}{\overline{W}_t} = \frac{W_{it} + y}{\overline{W}_t + y} - \frac{W_{it}}{\overline{W}_t} = \frac{y\left(\overline{W}_t - W_{it}\right)}{\left(\overline{W}_t + y\right)\overline{W}_t}$$

Observe that in the Nash solution $y < 0$. Then, if individual wealth is below the average wealth, $W_{it} < \overline{W}_t$, the Nash solution decreases relative wealth (we assume $\overline{W}_t > 0, \forall t$, that is, $\overline{W}_{t+1} = \overline{W}_t + y > 0$). On the contrary, if individual wealth is above the average wealth, $W_{it} < \overline{W}_t$, the Nash solution increases relative wealth.

$(\alpha_A - n\beta) < \alpha_B$. Therefore, using backward induction, the solution that maximizes aggregate wealth, that is, the *social solution* or efficient solution, is full investment in project B ($x_{it} = 0, \forall i, \forall t$). As in the previous benchmark, this strategy does not depend on absolute or relative wealth.

The variation in individual wealth in any round is positive and equal for every participant, $\Delta W^S = \alpha_B e$. As in the previous benchmark, the social solution affects wealth. It increases absolute wealth, but the effect on relative wealth depends on the wealth position of the individuals: for those below the average, $\frac{W_{i0}}{\overline{W}_0} < 0$, relative wealth increases, but for those above the average, $\frac{W_{i0}}{\overline{W}_0} > 0$, relative wealth decreases.[4] The efficient solution describes the best situation for the environment in the game and a situation that improves the wealth of the poor in both absolute and relative terms.

3 Experimental design and procedure

3.1 Parametrization

We implement three different treatments, all with the same parametrization except for initial wealth distribution (see Table 3). The game is played in groups of 4 individuals over 10 rounds. Initial average wealth is equal in all the treatments, $\overline{W}_0 = 1000$ experimental points. Therefore, the initial poverty line is set at 600 points in every treatment. In treatment T1, two subjects have an initial wealth below the poverty line, $W_{i0} = 500$, and two subjects have an initial wealth above the poverty line, $W_{i0} = 1500$. Consequently, according to the classification in Table 1, two subjects are poor and two subjects are rich. In treatment T2, three subjects are initially below the poverty line, $W_{i0} = 500$, and one is above the poverty line, $W_{i0} = 2500$. Therefore, three are poor and one is rich. Treatment

[4]Following the explanation in the previous footnote, in the social solution $y > 0$. Therefore, if individual wealth is below the average wealth, $W_{it} < \overline{W}_t$, the social solution increases relative wealth. However, when individual wealth is above the average wealth, $W_{it} > \overline{W}_t$, the social solution decreases relative wealth.

T0 is the control treatment: all the subjects have an initial wealth equal to the average, $W_{i0} = 1000\ \forall i$. During the experiment, we refer to the wealth of the subjects as the *bag of points*.

Table 3: Treatments

Treatment	T0	T1	T2
Wealth agent 1	1000	1500	2500
Wealth agent 2	1000	1500	500
Wealth agent 3	1000	500	500
Wealth agent 4	1000	500	500
Average wealth ($\overline{W}_0$)	1000	1000	1000
Poverty line ($0.6\overline{W}_0$)	600	600	600
Number of groups	8	8	8

The rest of the parameters are equal in the three treatments. Table 4 summarizes this parametrization. The marginal private benefit from the non-eco-friendly project is $\alpha_A = 3$, the marginal benefit from the eco-friendly project is $\alpha_B = 1$, and the marginal private cost of the non-eco-friendly project is $\beta = 1$. The endowment in each round is 20 experimental points and participants decide simultaneously and individually how many points they want to invest in the non-eco-friendly project. The rest of the endowment points are automatically invested in the eco-friendly project.

Table 4: Parametrization of the investment projects

	Project A (non-eco-friendly)	Project B (eco-friendly)	Social dilemma
Marginal benefit	3	1	
Marginal private cost	1	-	
Marginal external cost	3	-	
Marginal social cost	4	-	
Marginal private net benefit	2	1	$2 > 1$
Marginal social net benefit	-1	1	$-1 < 1$

3.2 Endogenous wealth and the poverty trap

With this parametrization, the variation in wealth in round t for agent i ranges from -40 to +40 depending on her contribution and on the contribution of the rest of her group to environmental degradation, $\Delta W_{it} \in [-40, 40]$. Wealth variation is represented in Figure 2. Observe that half of the possible situations (X_{-it}, x_{it}) lead to a negative variation in wealth and the other half lead to a positive variation in wealth for agent i. In addition, notice that the variation in wealth is -20 in the Nash solution $(X_{-it}, x_{it}) = (60, 20)$ and 20 in the social solution $(X_{-it}, x_{it}) = (0, 0)$.

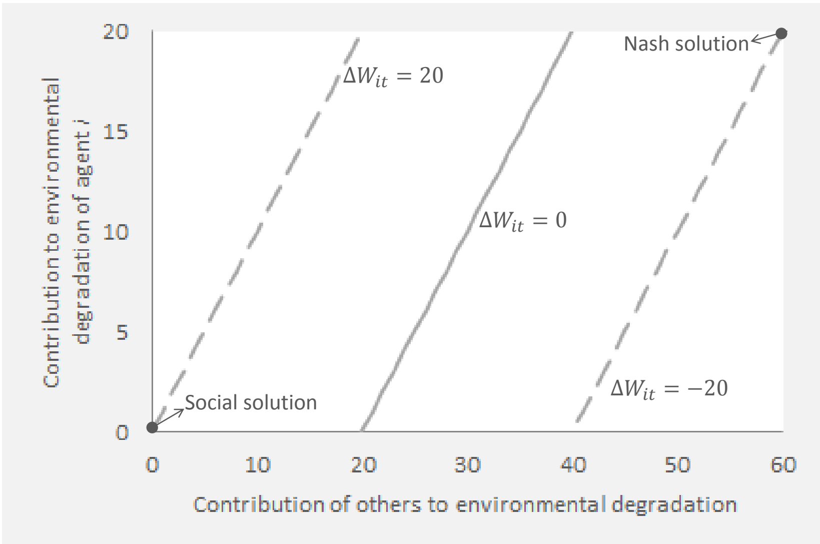

Figure 2: Endogenous poverty: positive and negative wealth variation

The poverty trap has been defined as a spiraling mechanism which forces people to remain poor (Durning, 1989). According to the previous parametrization, for poor agents, that is, those below the poverty line, the investment possibilities prevent them from climbing out. In fact, at the efficient solution those in the poverty trap (T1 and T2) can reach

58.3% of average wealth. The evolution of relative wealth in the social and Nash strategies is depicted in Figure 3. The social solution increases relative wealth for those below the poverty line without reaching it. The Nash solution decreases relative wealth for those below the poverty line. Given the investment possibilities, it is not possible to fall below the poverty line in the control treatment.

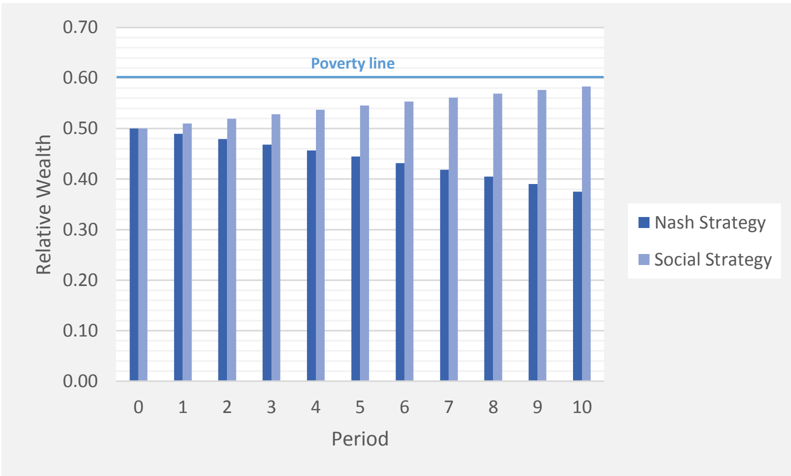

Figure 3: The poverty trap in T1 and T2: relative wealth for those below the poverty line.

3.3 Procedure

The exogenous wealth of the agents was assigned randomly. During the experiment, the non-eco-friendly project and the eco-friendly project were called project A and project B, respectively. We ran three different sessions, one per treatment, that were conducted using the z-tree program (Fischbacher, 2007) at Lineex, an experimental lab located in Valencia. There were 32 participants (8 groups) per treatment, which made for a total of 96 participants. 61.5% of the participants were female and 38.5% males. The average age of the participants was 25 years, with the youngest participant being 17 and the oldest participant 50 years old. They came from different academic backgrounds (economics, psychology, engineering, political science, among others), without any particular background standing among the others.

At the end of each round, the participants received summary information about investment decisions and consequences in that round: own investment in the non-eco-friendly project, average investment of the group in the non-eco-friendly project, and individual wealth variation from that round. In addition, they had data about the absolute wealth of each participant (including own absolute wealth) and the average wealth of the group.

In the instructions we included examples of possible investment situations in order to make the structure of the game clear to the participants. Subjects were told that the points would be exchanged for cash at a prespecified exchange rate at the end of the experiment. Each session lasted around one hour and the average earnings per subject amounted to about 18.54 euros with a standard deviation of 11.82 euros. The highest earnings were 51.66 euros, while the lowest were 5.46 euros, thus reflecting the different wealth positions of the agents involved in the experiment. Table 5 shows these data per treatment.

Table 5: Earnings (in euros)

Earnings	T0	T1	T2
Average	18.50	18.68	18.44
Standard deviation	1.57	10.50	17.77
Minimum	15.14	6.24	5.46
Maximum	21.02	31.8	51.66

4 Results

4.1 Relationships in the poverty-environmental degradation nexus

Using the experiment described above, we look for evidence that confirms or refutes the various relationships in Figure 1. Specifically, we examine the following hypothesis.

R1 Exogenous poverty causes environmental degradation.

Let i be a subject such that $W_{i0} < 0.6\overline{W}_0$ *and let j be a subject such that* $W_{j0} > 1.2\overline{W}_0$. *If R1 applies,* $x_{it} > x_{jt}$.

That is, if exogenous poverty causes environmental degradation, we expect poor agents to contribute more to environmental degradation than rich agents.

R2 Wealth and greed cause environmental degradation.

Let i be a subject such that $W_{i0} < 0.6\overline{W}_0$ *and let j be a subject such that* $W_{j0} > 1.2\overline{W}_0$. *If R2 applies,* $x_{it} < x_{jt}$.

That is, if wealth and greed cause environmental degradation, we expect rich agents to contribute more to environmental degradation than poor agents.

R3 Market failure is the primary cause of environmental degradation.

If R3 applies, $x_{it} \approx x_{jt} > 0$ *for any* W_{it}, W_{jt}.

That is, if market failure is the primary cause of environmental degradation, we expect to find positive contributions to environmental degradation with no differences between poor, rich, or middle-class agents.

R4 Environmental degradation causes poverty.

If R4 applies, $\sum_{i=1}^{n} x_{it}$ *is such that* $\Delta W_{it} < 0$ *for any* i, t.

That is, if environmental degradation causes poverty, we expect the aggregate contribution to environmental degradation to reach levels that lead to a negative variation in wealth levels.

R1 FB Endogenous poverty causes environmental degradation.

Let $\Delta W_{it} < 0$ *and* $\Delta W_{jt} > 0$. *If R1FB applies,* $x_{it+1} > x_{jt+1}$.

That is, if endogenous poverty causes environmental degradation, we expect those observing a decrease in wealth to contribute more to environmental degradation than those observing an increase in wealth.

4.2 Exogenous poverty, wealth and greed, or/and market failure?

In treatments T1 and T2, agents are (i) poor and their wealth is below the poverty line $W_{it} < 0.6\overline{W}$, or they are (ii) rich and their wealth is at least twice the poverty line $W_{it} > 1.2\overline{W}$. In order to test whether exogenous poverty or wealth and greed are the main causes of environmental degradation, we compare the average contribution to environmental degradation of poor agents and rich agents in both treatments. These contributions are shown in Figure 4a for treatment T1 and in Figure 4b for treatment T2. In both treatments, poor agents contributed slightly less than rich agents in seven of the ten rounds, although the differences are not statistically significant the 5% level (see Table 6). Therefore, our experimental data suggest that neither exogenous poverty nor wealth and greed make a difference in the contribution to environmental degradation.

Figure 4: Contributions to environmental degradation of poor and rich agents

Observe that the poor agents in treatments T1 and T2 have the same exogenous wealth in absolute and relative terms. However, poor agents account for half of the group in treatment T1, while they account for two-thirds of the group in treatment T2. Comparing the average contribution to environmental degradation of poor agents in these treatments, we found that there is no difference between poor agents in treatment T1 and poor agents in treatment T2 (see Figure 4c and Table 6). Therefore, the proportion of agents below the poverty line has no effect on the contribution of poor agents to environmental degradation. On the other hand, the rich agents in treatment T2 are wealthier than the rich agents in treatment T1 in both absolute and relative terms. However, there is no difference in the average contribution to environmental degradation between the rich agents in treatments T1 and T2 (see Figure 4d and Table 6), showing again that wealth is not relevant for the contribution to environmental degradation in this setting.

Table 6: Contributions of poor and rich agents: Statistical tests.

	Statistic	p-value
Poor vs. Rich agents: T1$^{(a)}$	-1.784	0.084
Poor vs. Rich agents: T2$^{(a)}$	-1.021	0.348
Poor agents: T1 vs. T2$^{(b)}$	-1.059	0.306
Rich agents: T1 vs. T2$^{(b)}$	-0.378	0.739

Notes: $^{(a)}$ Wilcoxon matched-pairs signed-rank test. $^{(b)}$ Two-sample Wilcoxon rank-sum (Mann-Whitney) test.

Therefore, we find similar investment decisions for poor and rich agents. Both contribute a high proportion of their endowment to environmental degradation; a proportion that increases with repetition. Overall, these results are not consistent with relationships R1 and R2. On the contrary, the information provided by Figure 4 and Table 6 points to the possibility that market failure is a primary cause of environmental degradation (relationship R3). For a deeper analysis of this issue, we compare the investment decisions of treatments T1 and T2 with the investment decisions of agents in the control treatment where all the agents have a wealth level equal to the average wealth and, according to the definition in Table 1, are middle-class agents. To that end, we examine the density functions of the contribution to environmental degradation in the three treatments. We address this issue by means of non-parametric techniques, thus avoiding the lack of generality and flexibility associated with parametric methods. The non-parametric approach does not require specifying any particular functional form beforehand, though a method to smooth the data must be selected. An immediate option is to use histograms, the oldest and best-known non-parametric density function estimator (Stangor, 2011). Histograms are useful to describe certain data characteristics, but they have several limitations.[5] For this reason, in our analysis we complement the information provided by histograms with a kernel density estimator, which has the advantage of being independent of the choice of origin (corresponding to the location of the bins in a histogram) (Wand and Jones, 1995).[6]

Figure 5 shows the results obtained when these non-parametric methods are used to estimate the density functions of the distribution of the contribution to environmental degradation in the three treatments. As can be seen, the external shape of the distribution is similar in the three cases, particularly in the last period. In order to confirm this visual impression, we performed several two-sample Kolmogorov-Smirnov tests of equality of distributions.[7] Table 7 reveals that the results of these tests do not allow us to reject the null hypothesis of equality of distributions, either between T0 and T1, or between T0 and T2 or between T1 and T2, thus confirming that there are no statistically significant

[5]For example, the problem of how to define the origin and length of each interval, and the possibility of improving the accuracy and efficiency of the estimates (Silverman, 1986).

[6]Specifically, the Epanechnikov kernel function was used, while the smoothing parameter was determined according to Silverman (1986, p. 48)

[7]Given the relatively small sample size, the p-values of the Kolmogorov-Smirnov test were obtained by modifying the asymptotic p-value using a numerical approximation technique.

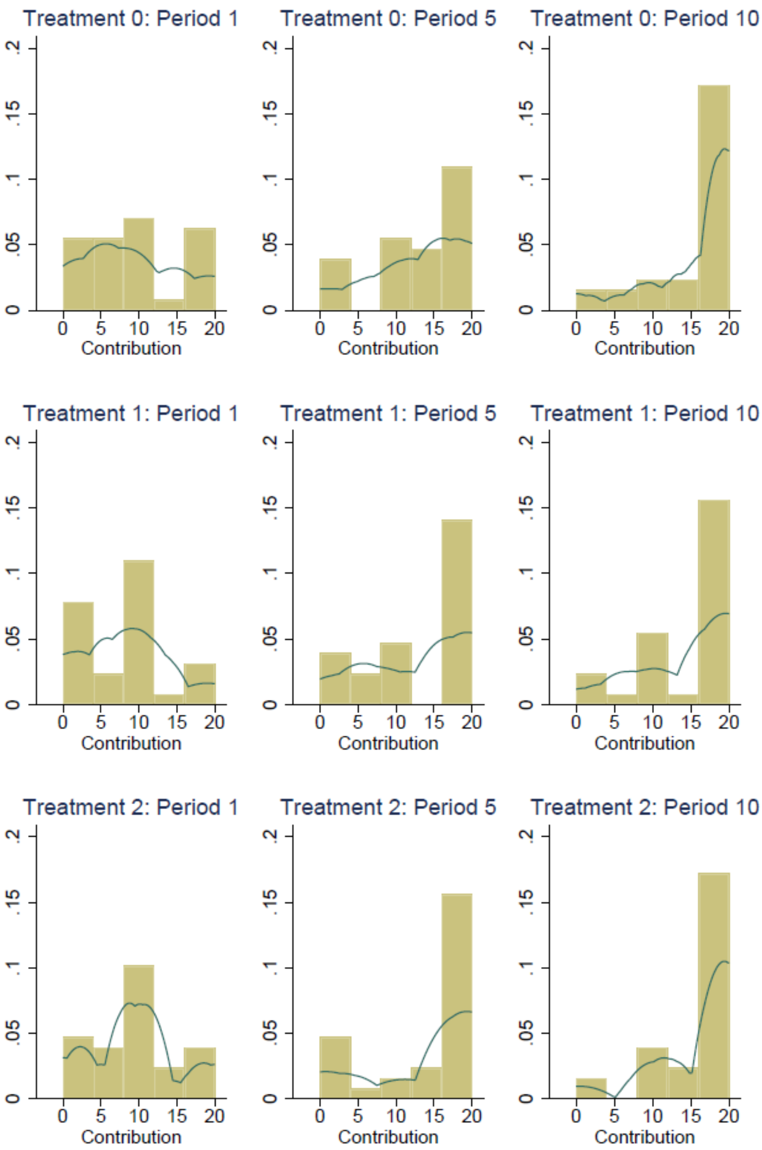

Figure 5: Histograms and kernel density estimates

differences in contributions to environmental degradation among these treatments. This result suggests that the existence of different wealth levels among the groups does not significantly affect the contributions to environmental degradation, which reinforces the importance of market failure as a primary cause of environmental degradation.

Table 7: Kolmogorov-Smirnov tests

	Period 1		Period 5		Period 10	
	Statistic	p-value	Statistic	p-value	Statistic	p-value
T0 vs. T1	0.125	0.968	0.125	0.968	0.156	0.838
T0 vs. T2	0.094	0.999	0.219	0.434	0.094	0.999
T1 vs. T2	0.125	0.968	0.219	0.434	0.125	0.968

Figure 5 also shows that contributions to environmental degradation are, on average, below the Nash prediction but above the efficient level in all treatments and periods. Nevertheless, this does not imply that the initial situation remains stable over time. In particular, regardless of the treatment considered, our estimates reveal that the density located at the upper end of the distribution increased throughout the various periods, thus indicating that the contributions to environmental degradation tend to rise over time. This pattern is clearly illustrated in the average contributions shown in Figure 6, which suggests that the involvement of agents in non-eco-friendly activities increases over the ten periods, thus amplifying their adverse consequences on environmental quality. This is not an unexpected result. It is well-know in the experimental literature that cooperation decays with repetition as many participants are conditional cooperators (see the reviews of Leyard (1995) or Chaudhuri (2011)). The interesting result here is that there is no difference among the three treatments, showing that the exogenous wealth levels and its distribution among the participants does not affect the contribution patterns. Therefore, the mere existence of poor agents does not raise the contribution to environmental degradation. In fact, the *vicious downward spiral* described in the Brundtland Report is also found in the control treatment where there are no poor agents. In any case, a Kruskal-Wallis test shows that we cannot reject the hypothesis that the three treatments have the same underlying distribution ($\chi^2 = 0.343$, p-value $= 0.842$), which is in line with the information provided by Figure 5 and Table 7.[8] Market failure, which is the same in the three treatments, seems to be behind the relatively high contributions to environmental degradation.

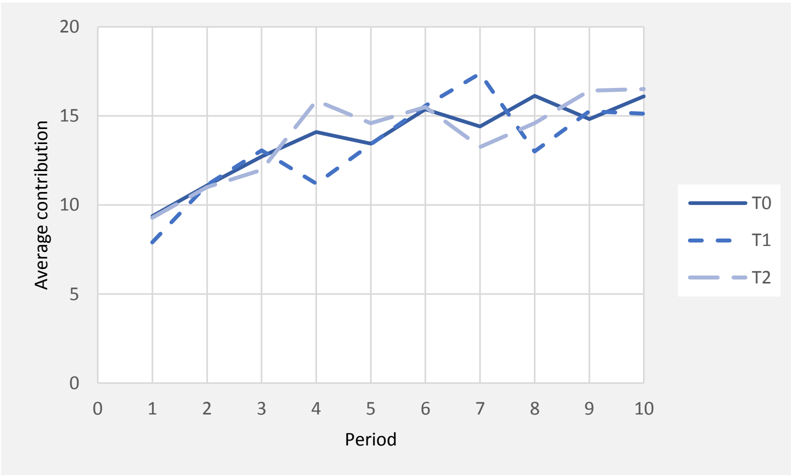

Figure 6: Contribution to environmental degradation.

4.3 The role of endogenous poverty

The increasing trend in environmental degradation shown so far may be an indication of a negative variation in wealth for some participants, that is, of endogenous poverty. In order to shed light on this issue, Figure 2 has been replicated in Figure 7, including the observations in the different treatments. In the first period and in all of the treatments, half of the participants show a positive wealth variation and the other half a negative wealth variation. In the last period, however, most of the participants show a negative

[8]This conclusion is confirmed if we resort to the Mann-Whitney-U test to perform a comparison by pairs among the three treatments.

wealth variation. These variations are endogenous changes in wealth: a positive variation indicates endogenous wealth, while a negative variation indicates endogenous poverty. The open question is whether this variation in endogenous wealth affects the contributions to environmental degradation.

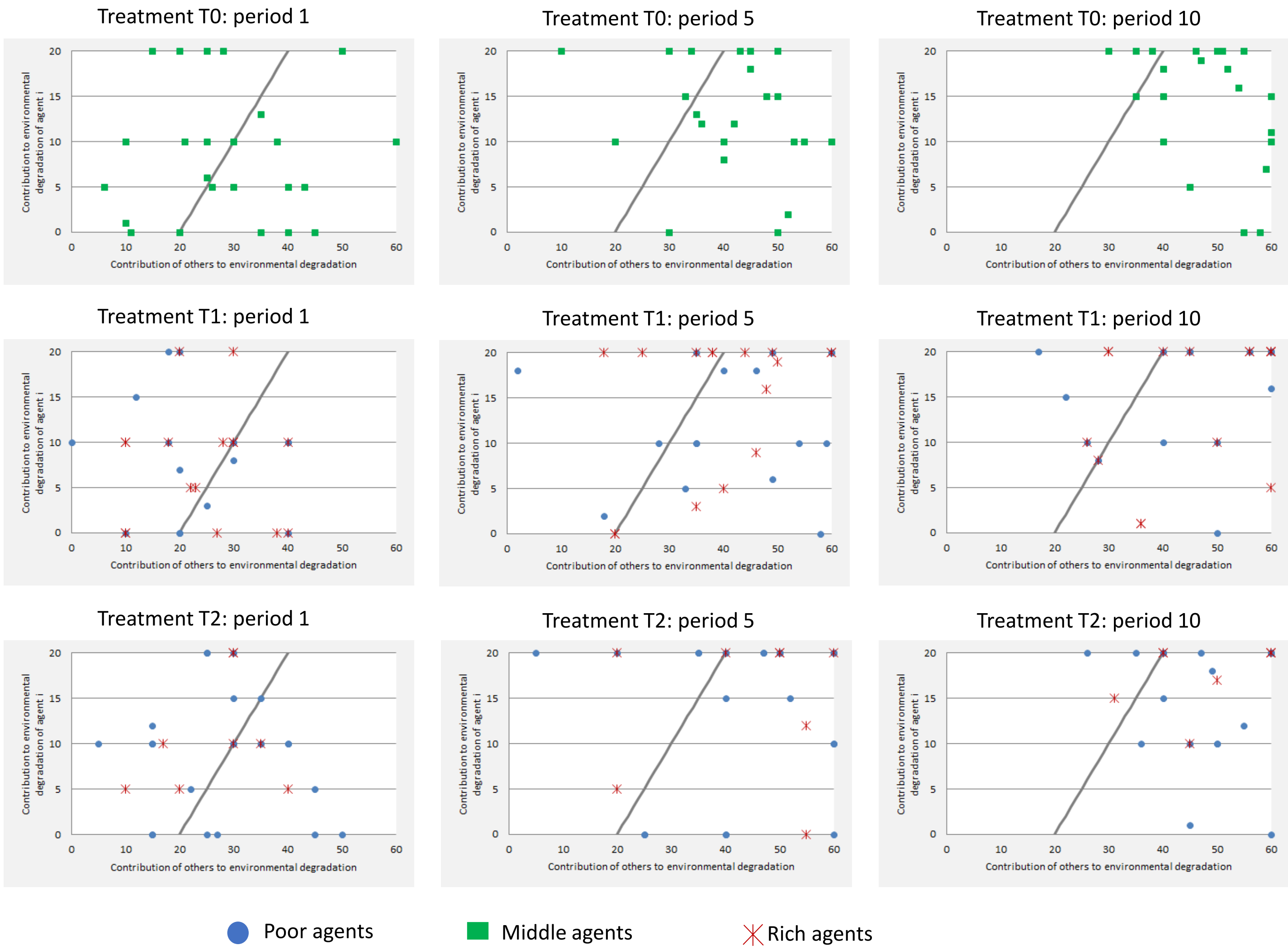

Figure 7: Positive and negative wealth variation

In order to explore this point, we now examine the determinants of contributions to environmental degradation at the individual level through a regression analysis. We focus our attention on the relationship between the endogenous wealth variation of individuals and their contributions to environmental degradation. To investigate this issue, we calculate the endogenous poverty, EnP_{it}, and the endogenous wealth, EnW_{it}. The variable endogenous poverty is the absolute value of wealth variation in the case where it is negative and zero in the case where it is positive. Mathematically, $EnP_{it} = |min\{\Delta W_{it}, 0\}|$. In turn, the variable endogenous wealth is constructed analogously and is the value of wealth variation if it is positive and zero if the agent's wealth variation is negative. That is, $EnW_{it} = max\{\Delta W_{it}, 0\}$.

In addition to the role played by absolute wealth in this context, we are also interested in the effect of the relative wealth of the subjects on environmental degradation. For this reason, we calculate for each individual the relative deprivation index proposed by Yitzhaki (1979) to measure relative wealth. This index is based on individual wealth and measures the cumulative difference between an individual's wealth and those with greater wealth within the group divided by the group size. Furthermore, the group average of Yitzhaki's relative deprivation index is equal to the Gini index, a widely used measure in the literature on inequality (Yitzhaki (1979); Hey and Lambert (1980)).

Additionally, following the analysis in different experiments with positive (Fehr and Gächter (2000)) and negative (Osés-Eraso and Viladrich-Grau (2011), Benito-Ostolaza et al. (2014)) externalities, we investigate whether being below or above the group average contribution to the externality may influence subsequent decisions. The variable below average contribution is $BAC_{it} = max\{\overline{x}_t - x_{it}, 0\}$ and the variable above average contribution is $AAC_{it} = max\{x_{it} - \overline{x}_t, 0\}$. The model also incorporates a time trend to examine whether contributions to environmental degradation are affected by the evolution over time, as well as different dummies to distinguish between the various treatments.

Finally, we include as control variables two characteristics of the participants that have been extensively studied in the experimental literature that analyzes the cooperative behavior of agents in different contexts. On the one hand, we control by gender, distinguishing whether there is a difference in the behavior of males and females (Andreoni and Vesterlund, 2001). We include a dummy variable that identifies females. On the other hand, we control whether previous training in economics influences the decisions of the participants (Marwell and Ames, 1981). For that purpose, we identify those participants that declare having an academic background in economics or business administration using a dummy variable.

Given that our data set includes time-varying and time-invariant variables, we begin by estimating a random effects model, which allows us to take into account the panel structure of the data. In order to avoid any potential simultaneity bias, the time-varying covariates described above are lagged one period. In turn, all the estimations are performed using robust standard errors adjusted for intra-group correlation and heteroskedasticity of unknown form. Furthermore, given the characteristics of the dependent variable, we also repeat the analysis employing a random effects tobit model that explicitly considers the lower and upper bounds of x_{it}. The results are in Table 8 and Table 9, respectively.

Table 8: Determinants of individual contributions to environmental degradation: OLS regression analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
Absolute wealth (lagged)	-0.001	0.000		-0.000	0.000	
	(0.001)	(0.000)		(0.001)	(0.000)	
Relative deprivation index (lagged)	-3.651		-1.514	-1.745		-1.209
	(3.385)		(1.087)	(3.475)		(1.106)
Below Average (lagged)	-0.329***	-0.331***	-0.330***	-0.349**	-0.348**	-0.349**
	(0.091)	(0.091)	(0.091)	(0.108)	(0.108)	(0.108)
Above Average (lagged)	0.809***	0.819***	0.814***	0.791***	0.796***	0.792***
	(0.132)	(0.131)	(0.131)	(0.164)	(0.164)	(0.164)
Endogenous poverty (lagged)	0.146***	0.144***	0.145***	0.185***	0.184***	0.185***
	(0.038)	(0.038)	(0.038)	(0.045)	(0.045)	(0.045)
Endogenous wealth (lagged)	-0.209***	-0.212***	-0.211***	-0.164*	-0.166***	-0.165*
	(0.058)	(0.058)	(0.058)	(0.072)	(0.072)	(0.072)
Period	0.310**	0.306**	0.308**	0.286*	0.284*	0.286*
	(0.096)	(0.095)	(0.095)	(0.118)	(0.118)	(0.118)
Treatment 1	0.573	-0.335	0.041			
	(1.001)	(0.541)	(0.604)			
Treatment 2	1.567	0.189	0.761	0.862	0.638	0.794
	(1.384)	(0.534)	(0.673)	(0.708)	(0.549)	(0.567)
Female	-0.805***	-0.854***	-0.835***	-1.751**	-1.783**	-1.761**
	(0.461)	(0.459)	(0.458)	(0.582)	(0.578)	(0.578)
Major in economics	2.410***	2.365***	2.379***	2.955***	2.926***	2.944***
	(0.574)	(0.572)	(0.572)	(0.728)	(0.725)	(0.725)
Constant	11.338***	10.184***	10.583***	10.927***	9.948***	10.607***
	(1.386)	(0.881)	(0.798)	(2.192)	(1.001)	(0.964)
R-squared	0.140	0.139	0.139	0.163	0.163	0.163
Treatment	All	All	All	T1T2	T1T2	T1T2
Groups	24	24	24	16	16	16
Observations	864	864	864	576	576	576

Notes: Random effects model. Robust standard errors clustered at the group level in parentheses. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Column 1 of both tables show the results obtained when the model is estimated for the whole sample. As can be observed, the coefficient of the variable endogenous poverty is positive and statistically significant, thus showing that the greater the decrease in wealth as a result of environmental degradation, the greater the investment in the non-eco-friendly project in the following period. Furthermore, the coefficient for endogenous wealth is negative and statistically significant, that is, the greater the increase in wealth after the investments, the lower the investment in the non-eco-friendly project in the following period.

Table 9: Determinants of individual contributions to environmental degradation:Tobit regressions.

	(1)	(2)	(3)	(4)	(5)	(6)
Absolute wealth (lagged)	-0.002	0.001		-0.001	0.001	
	(0.002)	(0.001)		(0.002)	(0.001)	
Relative deprivation index (lagged)	-10.664		-4.365	-6.809*		-3.872
	(7.317)		(2.360)	(7.905)		(2.529)
Below Average (lagged)	-.640***	-0.646***	-0.643***	-0.741***	-0.740***	-0.740***
	(0.196)	(0.196)	(0.196)	(0.248)	(0.248)	(0.248)
Above Average (lagged)	1.680***	1.707***	1.695***	1.639***	1.659***	1.647***
	(0.284)	(0.283)	(0.283)	(0.373)	(0.373)	(0.373)
Endogenous poverty (lagged)	0.263***	0.259***	0.262***	0.368***	0.365***	0.367***
	(0.080)	(0.080)	(0.080)	(0.102)	(0.102)	(0.102)
Endogenous wealth (lagged)	-0.419***	-0.429***	-0.425***	-0.316***	-0.323***	-0.319***
	(0.125)	(0.125)	(0.125)	(0.162)	(0.162)	(0.162)
Period	0.687***	0.670***	0.678***	0.725**	0.713***	0.721***
	(0.205)	(0.205)	(0.205)	(0.268)	(0.267)	(0.267)
Treatment 1	2.751	0.065	1.169			
	(2.176)	(1.149)	(1.303)			
Treatment 2	4.799	0.802	2.440*	1.772	0.935	1.410
	(2.973)	(1.139)	(0.449)	(1.578)	(1.243)	(1.279)
Female	-2.493**	-2.624***	-2.573***	-4.501***	-4.613***	-4.551***
	(0.999)	(0.997)	(0.996)	(1.347)	(1.341)	(1.341)
Major in economics	5.336***	5.200***	5.241***	6.382***	6.261***	6.319***
	(1.295)	(1.291)	(1.290)	(1.723)	(1.723)	(1.722)
Constant	13.235***	9.856***	10.997***	13.752**	9.907***	11.986***
	(2.974)	(1.869)	(1.675)	(4.995)	(2.245)	(2.165)
Pseudo R-squared	0.034	0.034	0.034	0.040	0.040	0.040
Treatment	All	All	All	T1T2	T1T2	T1T2
Groups	24	24	24	16	16	16
Observations	864	864	864	576	576	576

Notes: Random effects Tobit regressions. Standard errors in parentheses. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

This implies that endogenous poverty leads to higher levels of environmental degradation, consistently with relationship R1FB. Moreover, the coefficients of the absolute wealth and the relative deprivation index are not statistically significant at conventional levels, which reveals that the absolute and relative situations of individuals in terms of wealth do not affect their contributions to environmental degradation. As shown in columns 2 and 3, this result is not driven by the relatively high correlation between both variables ($\rho = 0.745$).

On the other hand, the difference between own contribution to environmental degradation and average contribution to environmental degradation is significant, therefore explaining the dependent variable. In particular, our estimates indicate that BAC and AAC exert a negative and positive effect, respectively, on individual contribution to environmental degradation. That is, the higher the difference with the average from below (the higher BAC), the lower the subsequent individual contribution to environmental degradation. Likewise, the higher the difference with the average from above (the higher AAC), the greater the subsequent individual contribution to environmental degradation. This seems to show a lack of a convergence process toward the average in this context.

Furthermore,the results for the time trend are consistent with the increasing tendency in the contributions to non-eco-friendly activities observed in Figures 5 and 6. Finally, the coefficients of the dummy variables used to distinguish between the various treatments are not statistically significant either. This is in line with the information provided by Figures 5 and 6, thus confirming that there are no significant differences in the contribution to environmental degradation among the three treatments. It is also worth mentioning that the coefficient of the dummy variable used for economic background is statistically significant, those with economic training contribute more to negative externalites. The coefficient of the dummy variable used for gender is positive and statistically significant, females contribute less to negative externalities.

In order to complement these results, we now repeat the analysis considering only those treatments in which there is a poverty trap (treatments T1 and T2). As can be checked in columns 4-6 of Table 8 and Table 9, in all cases the results are very similar to those obtained for the whole sample, thus reinforcing the robustness of our findings.[9]

[9]A potential concern about these findings is that the number of clusters in Table 8 is relatively small, raising the possibility that asymptotic approximations for inference may not be valid. In order to overcome this potential problem, we re-estimate the model by ordinary least squares (OLS) using the wild bootstrap procedure proposed by Cameron et al. (2008) to calculate the standard errors. The results are very similar to those obtained in Table 8.

5 Conclusions

We design an experiment to isolate the effect of wealth inequality on the contribution to negative externalities. For this purpose, subjects have the same income and the same investment possibilities but different exogenous wealth level. As environmental problems are described in the economic literature as situations that involve negative externalities, we also link the experiment with the poverty-environmental nexus described in (Duraiappah, 1998).

The results show that wealth inequality have no significant effect on the contribution to negative externalities, agents with different wealth levels contribute in a similar way to negative externalities. When we analyze the details of the poverty-environmental nexus, we observe that endogenous changes in wealth levels have a significant effect on the contribution to negative externalities. Endogenous poverty, a decrease in the wealth level, increases the contribution to negative externalities but endogenous wealth, an increase in the wealth level, decreases the contribution to negative externalities.

Figure 8 summarizes the main relationships in the poverty-environmental nexus examined in this paper. Relationships R1 and R2, that is, exogenous poverty and wealth, respectively, as causes for environmental degradation are not backed by the reported experimental results. The experimental data support relationship R3, market failure is a primary cause of environmental degradation; relationship R4, environmental degradation causes poverty; and relationship R1FB, endogenous poverty causes environmental degradation. Therefore, there exists a downward spiral or a poverty-environmental trap as described by the Brundtland Report. But addressing poverty is not a solution for the environmental problem because the type of poverty in the downward spiral is endogenous poverty. According to our results, addressing the incentives, that is, the market failure, can achieve better results.

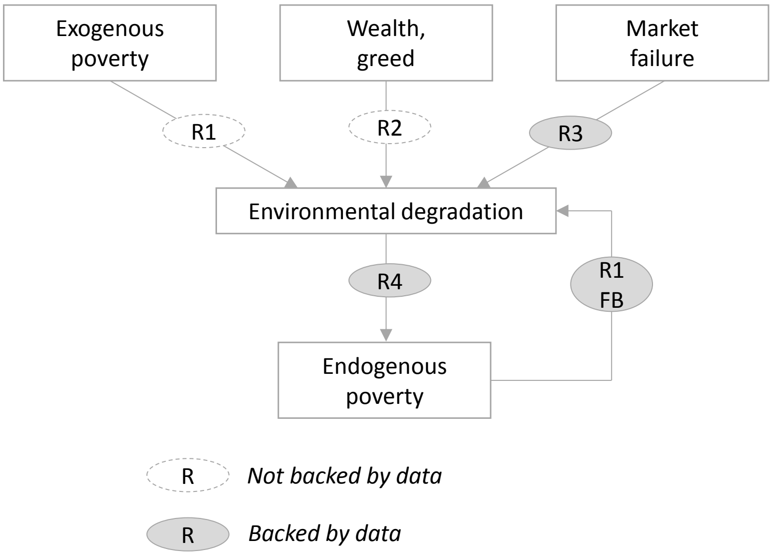

Figure 8: Possible relationships in the poverty-environmental degradation nexus. Experimental results.

The experimental results presented in this paper have certain limitations. In the game, we control for income or endowment inequality, which means that the capacity to contribute to environmental degradation is the same for poor and rich agents. In many situations, however, the capacity to contribute to environmental degradation may be linked to wealth. For example, in the forest sector, poor individuals do not have the resources to adopt unsustainable deforestation activities that are available for the rich (Duraiappah, 1998). Moreover, the experiment also control for the return of investment, which implies that the out-environment alternative is the same for poor and rich agents. In field settings, the out-environment alternative is usually different for rich and poor individuals. For example, the range of choices and trade-offs available to the poor is affected by their access to key markets (labor, credit, goods, and services) (Barbier (2010), Barrett and Carter (2013)). Further experimental analyses should be done to address these issues.

References

Andreoni, J. and Vesterlund, L. (2001). Which is the fair sex? gender differences in altruism, *Quarterly Journal of Economics* **116**(1): 293–312.

Barbier, E. (2010). Poverty, development, and the environment, *Environmental and Development Economics* **15**: 635–660.

Barrett, C. and Carter, M. (2013). The economics of poverty traps and persistent poverty: Empirical and policy implications, *The Journal of Development Studies* **49**: 976–990.

Benito-Ostolaza, J., Ezcurra, R. and Osés-Eraso, N. (2014). Negative externalities in cropping decisions: Private versus common land, *Ecological Economics* **105**: 185–192.

Buckley, E. and Croson, R. (2006). Income and wealth heterogeneity in the voluntary provision of linear public goods, *Journal of Public Economics* **90**: 935–955.

Cameron, A., Gelbach, J. and Miller, D. (2008). Bootstrap-based improvements for inference with clustered errors, *Review of Economics and Statistics* **90**(3): 414–427.

Cardenas, J. (2003). Real wealth and experimental cooperation: experiments in the field lab, *Journal of Development Economics* **70**: 263–289.

Cardenas, J. (2007). Wealth inequality and overexploitation of the commons: field experiments in colombia, *Inequality, Cooperation, and Environmental Sustainability* **Baland, Bardhan, Bowles Eds.**(Chapter 8).

Cardenas, J., J., S. and Willis, C. (2002). Economic inequality and burden-sharing in the provision of local environmental quality, *Ecological Economics* **40**: 379–395.

Chaudhuri, A. (2011). Sustaining cooperation in laboratory public goods experiments: a selective survey of the literature, *Experimental Economics* **14**: 47–83.

Dasgupta, S., Deichmann, U., Meisner, C. and Wheeler, D. (2005). Where is the poverty–environment nexus? evidence from cambodia, lao pdr, and vietnam, *World Development* **33**: 617–628.

Duraiappah, A. (1998). Poverty and environmental degradation: A review and analysis of the nexus, *World Development* **26**: 2169–2179.

Durning, A. (1989). Poverty and the environment: reversing the downward spiral, *Worldwatch Paper* **92**.

Etongo, D., Djenontin, I. and Kanninen, M. (2016). Poverty and environmental degradation in southern burkina faso: An assessment based on participatory methods, *Land* **5**.

Falk, A. and Heckman, J. (2009). Lab experiments are a major source of knowledge in the social sciences, *Science* **326**(5952): 535–538.

Fehr, E. and Gächter, S. (2000). Cooperation and punishment in public goods experiments, *American Economic Review,* **90**: 980–994.

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

Hackett, S., Schlager, E. and Walker, J. (1994). The role of communication in resolving commons dilemmas: experimental evidence with heterogeneous appropriators, *Journal of Environmental Economics and Management* **27**: 99–126.

Haider, L., Boonstra, W., Peterson, G. and Schluter, M. (2018). Traps and sustainable development in rural areas: A review, *World Development* **101**: 311–321.

Hauser, O., Hilbe, C., Chatterjee, K. and Nowak, M. (2019). Social dilemmas among unequals, *Nature* **572**: 524–543.

Hauser, O., Kraft-Todd, G., Rand, D., Nowak, M. and Norton, M. (2019). Invisible inequality leads to punishing the poor and rewarding the rich, *Behavioural Public Policy* pp. 1–21.

Heap, S., Ramalingam, A. and Stoddard, B. (2016). Endowment inequality in public goods games: A re-examination, *Economics Letters* **146**(4-7).

Hey, J. and Lambert, P. (1980). Relative deprivation and the gini coeffcient: Comment, *Quarterly Journal of Economics* **95**: 567–573.

Isaac, R. and Walker, J. (1988). Communication and free-riding behavior: The voluntary contribution mechanism, *Economic inquiry* **26**(4): 585–608.

Keister, L. and Moller, S. (2000). Wealth inequality in the united states, *Annual Review of Sociology* **26**: 63–81.

Levitt, S. and List, J. A. (2007). Viewpoint: On the generalizability of lab behaviour to the field, *Canadian Journal of Economics / Revue canadienne d'Economique* **40**(2): 347–367.

Levitt, S. and List, J. A. (2009). Field experiments in economics: The past, the present, and the future, *European Economic Review* **53**: 1–18.

Leyard, J. (1995). Public goods: a survey of experimental research, *In Kagel, J.H. and Roth, A.E. (Eds) Handbook of Experimental Economics* (Princeton University Press. Princeton): 111–194.

Marwell, G. and Ames, R. (1981). Economist free ride, does anyone else?, *Journal of Public Economics* **15**: 295–310.

Nadkarni, M. (2000). Poverty, environment, development. a many-patterned nexus, *Economic and Political Weekly* pp. 1184–1190.

Nishi, A., Shirado, H., Rand, D. and Christakis, N. (2015). Inequality and visibility of wealth in experimental social networks, *Nature* **526**: 426–439.

Osés-Eraso, N. and Viladrich-Grau, M. (2011). The sustainability of the commons: giving and receiving, *Experimental Economics* **14**: 458–481.

Peprah, P., Abalo, E., Amoako, J., Nyonyo, J., Duah, W. and Adomako, I. (2017). The reality from the myth: The poor as main agents of forest degradation: Lessons from ashanti region, ghana, *Environmental and Socio-economic Studies* **5**: 1–11.

Plott, C. (1986). Laboratory experiments in economics: The implications of posted-price institutions, *Science* **232**: 732–738.

Roe, B. and Just, D. (2009). Internal and external validity in economics research: tradeoffs between experiments, field experiments, natural experiments and field data, *American Journal of Agricultural Economics* **5**: 1266–1271.

Sadrieh, A. and Verbon, H. (2006). Inequality, cooperation, and growth: An experimental study, *European Economic Review* **50**: 1197–1222.

Silverman, B. W. (1986). *Density Estimation for Statistics and Data Analysis*, Monographs on Statistics and Applied Probability 26.Chapman and Hall, London.

Smith, V. (1994). Economics in the laboratory, *The Journal of Economic Perspectives* **8**(1): 113–131.

Smith, V. (2003). Constructivist and ecological rationality in economics, *American Economic Review* **93**(3): 465–508.

Stangor, C. (2011). *Research Methods For The Behavioral Sciences*, Cengage Learning, Wadsworth.

Valkila, J. (2009). Fair trade organic coffee production in nicaragua — sustainable development or a poverty trap?, *Ecological Economics* **68**: 3018–3025.

Wand, M. and Jones, M. (1995). *Kernel Smoothing*, Chapman-Hall, London.

WCED (1987). *Our Common Future*, World Commission on Environment and Development, Oxford University Press.

Yitzhaki, S. (1979). Relative deprivation and the gini coefficient, *Quarterly Journal of Economics* **93**: 321–324.