How beliefs influence prevention expenditure

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Abstract

We study how beliefs affect individuals' willingness to undertake prevention expenditure through a two-type, N-person public good game and test several results empirically. We show analytically that pessimistic agents will invest more in prevention expenditure than optimists. We should how pessimistic beliefs lead to a 'double deprivation' and discuss potential issues and remedies. The more optimistic the society the lower will be its total green expenditure. We also demonstrate how small differences in beliefs may induce substantial differences in type-related prevention expenditure. The more atomistic agents are the less they will contribute to the public good.

We then use a large international survey to study determinants of prevention expenditure. We proxy beliefs through three variables, namely science optimism, eco optimism and feelings of atomism. For each variable we find, as predicted by the theoretical model, a significant relationship with the willingness to undertake prevention expenditure. However, environmental education shapes these relationships. While environmental education does not affect the relationship between eco optimism and prevention expenditure, it leads to a stronger relationship between both science optimists, and those who feel atomistic, and prevention expenditure.

Finally, we develop a dynamic game with endogenous beliefs based on the static model and discuss the main differences in the optimal choices of the agents. We find that pessimistic agents have a higher prevention expenditure compared to the static case since they take the endogenous feedback of the prevention expenditure on their beliefs into account.

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Keywords: beliefs, environment, public good, Nash game, logit estimation, dynamic game.

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1 Introduction

Different beliefs are an important aspect to study when one is concerned with decision-taking under uncertainty, policy effects, the effect of information and contributions to public goods. The objective of this article is to show how different beliefs lead to different willingnesses to contribute to the environment. The theoretical contribution consists of analyzing the effects of beliefs on prevention expenditure in a general N-player public good game. Our model is related to the literature on precautionary savings and consumption, e.g. Dreze and Modigliani [9], and to the works on optimal prevention (e.g. Ehrlich and Becker [12]). Here we extend these articles to an N-player game with different beliefs. In particular, we suggest that there are two types of agents, where those that are pessimistic believe that shocks have a stronger impact on their net income than those that are optimistic. Within this setting we study how the beliefs affect the willingness to undertake prevention expenditure. Then we examine whether the predictions of the model carry forward to the data and study the importance of the beliefs for explaining differences in the willingness to undertake prevention expenditure. For this we use the International Social Survey Programme 2000 Environment II survey, in which a large number of individuals from 22 countries are interviewed about personal views and characteristics.

While there exists a growing number of articles that explain why a certain belief evolves through society[1], these articles do not study how the beliefs impact decision-taking. Hence, in this article we assume that individuals already hold certain beliefs and study how these affect investments in a public good (prevention expenditure). With our model, a two-type, N-person public good game, we show analytically that agents who are pessimistic and believe that environmental degradation is likely to be a serious threat to their welfare will invest more in prevention expenditure than optimists. This ultimately leads to what

[1] This is mostly studied through non-Bayesian updating of beliefs, see e.g. Ehrbeck and Waldmann [11], Carroll [7], Rabin and Schrag [22] and Lord et al [18]. Other approaches are learning or social dynamics.

we call a ‘double deprivation’: pessimistic agents are worse of, i.e. have a lower indirect utility, because they hold pessimistic beliefs and spend more on prevention expenditure. We discuss potential policy issues and remedies that may arise from this double deprivation. Furthermore, the more optimistic the society the lower will be its total green expenditure. We also demonstrate how even small differences in beliefs may induce substantial differences in type-related prevention expenditure.

We then use a large international survey that covers 22 countries to study determinants of prevention expenditure. Based on the analytical model we proxy beliefs through three variables, namely science optimism, eco optimism and feelings of atomism. For each variable we find a significant relationship with the willingness to undertake prevention expenditure. However, environmental education shapes these relationships. While environmental education does not affect the relationship between eco optimism and prevention expenditure, it leads to a stronger relationship between both science optimists, as well as those who feel atomistic, and prevention expenditure. We find these results to be robust to additional controls that have been found to bear significant effects on individuals’ attitudes towards prevention expenditure.

There already exists a larger literature on the determinants of individuals’ attitudes towards prevention expenditure. However, the main variables that have been focused on are socio-demographic ones like age and sex (e.g. Whitehead [28], Carlsson and Johansson-Stenman [6], Howell and Laska [15], Nord et al. [19]), marital status (e.g. Dupont [10]), in addition to education (e.g. Blomquist and Whitehead [4], Engel and Pötschke [13], Danielson et al [8]), wealth (e.g. Stevens et al [23], Popp [21], Isael and Levinson [16]), geographic locality (Veisten et al [27], Bulte et al [5]) and political interests (Torgler and Garcia-Valiñas [25]) or social capital (Ostrom [20]). An excellent overview of much of the literature can be found in Torgler and Garcia-Valiñas [25]. Given the focus on these variables, one obviously wonders why there has been little emphasis until now on the importance of information, beliefs and knowledge when it comes to determining the individuals' attitudes towards prevention expenditure. Indeed, one could imagine that the environmental beliefs that individuals hold are among the crucial drivers of environmental attitude and behavior. As we shall show in this article, they are significant contributors to an individual's willingness to undertake prevention expenditure.

In a final step we develop a dynamic game with endogenous beliefs based on the static version and then discuss the main differences in the optimal choices of the agents. In this case the pessimistic agents are likely to have a higher prevention expenditure since they take the endogenous feedback of the prevention expenditure on their beliefs into account. The difference in the optimal choices of the agents between the dynamic model and the static one is given by the endogenous feedback effect on the beliefs of the agents. Thus, if one expects beliefs to be endogenous, the dynamic model presented in this section would be a better approach than the previous static one. However, we also show how this result depends on how strong the degree of endogeneity is and the weight agents attach to future periods.

We proceed as follows. In section 2 we study how beliefs affects contributions to safety or environmental maintenance in a simple public good game. Section 3 is an empirical investigation of the effect of beliefs on the willingness to pay for the environment. We study whether the intuitions from the model carry forward into the real world. In section 4 we develop the dynamic model with endogenous feedbacks. Section 5 concludes.

2 The Model

The model that we propose here is a two-type, N-player game, where each player takes the optimal decisions of the other players as given when choosing the own strategy. The players may choose to invest an amount $x_i \geq 0$, where $i = 1, ..., N$, of their wealth $w > 0$

into prevention expenditure. This reduces the impact of an expected shock on net wealth $w - x_i$, where the shock comes as a percent $1 - F$ of net wealth. Prevention expenditures of the players are perfect substitutes and reduce the impact of the shock. The two types differ only in their belief of the extent to which they are impacted by the shock. Pessimists, denoted by subscript p, believe that the shock has a stronger impact on their final wealth than optimists, denoted by subscript o. There are N_o optimists and consequently $N - N_o$ pessimists. We write the shock as $S = 1 - F(\sum_{i=1}^{N} x_i, k) \in (0, 1)$, where $k \geq 1$ denotes the types' beliefs on the shock. Optimists are assumed to believe that $k = 1$, while pessimists believe that $k > 1$. The shape of function $F(\sum_{i=1}^{N} x_i, k) \in (0, 1)$ follows $F(0, k) > 0$, $F(\infty, k) = 1$, $F_x > 0$, $F_x(0, k) = \infty$, $F_k < 0$, $F_{xk} > 0$ and $F_{xx} < 0$.

The utility functions are assumed to be linear[2] in final wealth and thus take the form

$$V_i = (w - x_i)F\left(\sum_{i=1}^{N} x_i, k\right). \tag{1}$$

In this N-person game each player i has a strategy set S_i, with $x_i \in S_i$, and a pure strategy payoff function V_i that gives utility $V_i(\mathbf{x}) = V(x_i, x_{-i})$ for each strategy profile $\mathbf{x} = (x_1, ..., x_n) \in S = S_1 \times \cdots \times S_n$. The strategy set S_i consists of $S_i \in [0, w]$. We write the game in normal form as $\Gamma = [N, S_i, V_i(\cdot)]$.

Definition 1 *A strategy profile* $\boldsymbol{x} = (x_1, ...x_n)$ *is a Nash-equilibrium of game* $\Gamma = [N, S_i, V_i(\cdot)]$ *if, for all* $i = 1, ..., n$, $V_i(x_i, x_{-i}) \geq V_i(x_i', x_{-i})$, *for all* $x_i' \in S_i$.

Assume that agents choose according to the Nash game as defined above. Then the first-order condition of player i is

$$w - x_i \leq \frac{F(\sum_{i=1}^{N} x_i, k)}{F_x(\sum_{i=1}^{N} x_i, k)}, \tag{2}$$

[2] Within this setup, any monotonic transformation to the utility function would not change the results.

which holds with equality if $x_i > 0$. There are N of these first-order conditions. The second-order condition is given by

$$-2F_x(\sum_{i=1}^{N} x_i, k) + (w - x_i)F_{xx}(\sum_{i=1}^{N} x_i, k) < 0. \tag{3}$$

Proposition 1 *The game $\Gamma = [N, S_i, V_i(\boldsymbol{x})]$ has a unique Nash equilibrium.*

Proof 1 *By assumption, the strategy space is $S_i = [0, w]$. Thus, it is non-empty, closed, bounded and convex. We define*

$$\psi_i(x_i, x_{-i}) = \arg\max_{x_i \in S_i} V_i(x_i, x_{-i}).$$

where $\psi_i(x_i, x_{-i})$ solves the first-order condition (2). Existence and uniqueness follows from the second-order condition (3), continuity by the Implicit Function Theorem. We now define $\omega(\boldsymbol{x}) = (\psi_1(x_1, x_{-1}), ..., \psi_n(x_n, x_{-n}))$. Thus, by Brouwer's Fixed Point Theorem, $\exists(\boldsymbol{x}^*) \in S$, such that $\boldsymbol{x}^* = \omega(\boldsymbol{x}^*)$.

Having defined the Nash game and having shown that a unique Nash equilibrium exists, we now proceed to derive the main properties of this setup. At the Nash equilibrium, all optimists will choose the same x_o and all pessimists the same x_p. Consequently, we obtain the two type-dependent first-order conditions

$$w - x_p \leq \frac{F(N_o x_o + (N - N_o)x_p, k)}{F_x(N_o x_o + (N - N_o)x_p, k)}, \tag{4}$$

$$w - x_o \leq \frac{F(N_o x_o + (N - N_o)x_p, 1)}{F_x(N_o x_o + (N - N_o)x_p, 1)}, \tag{5}$$

where equation (4) holds with equality if $x_p > 0$, and (5) holds with equality for $x_o > 0$. Prevention expenditure x_i reduces initial wealth w, while it increases final wealth through diminishing the damage that a shock S causes. Clearly, the higher the damage the larger will be the optimal prevention expenditure. Furthermore, the higher the marginal contribution of x_i towards damage reduction the larger should be the optimal prevention expenditure. We now summarize the results in the following proposition.

Proposition 2 *Given the game Γ, we find that, at the Nash equilibrium as defined in Definition 1, the following results hold:*

1. *either $x_p > 0$ and $x_o = 0$, or $x_p > 0$ and $x_o > 0$,*
2. $x_p > x_o$,
3. $\frac{dx_p(x_o)}{dx_o} < 0$,
4. $\frac{dx_p}{dk} > 0$.

Proof 2 *Proof of Part 1)*

Assume that $x_p > 0$ and $x_o = 0$. From equations (4) and (5) this implies that

$$w = \frac{F((N - N_o)x_p, k)}{F_x((N - N_o)x_p, k)} + x_p$$

and

$$w \leq \frac{F((N - N_o)x_p, 1)}{F_x((N - N_o)x_p, 1)}.$$

Combining the two conditions yields

$$\frac{F((N - N_o)x_p, k)}{F_x((N - N_o)x_p, k)} + x_p \leq \frac{F((N - N_o)x_p, 1)}{F_x((N - N_o)x_p, 1)}.$$

Since $d(F/F_x)/dk < 0$, then there exists an $x_p > 0$ such that this inequality is satisfied.

Assume now that $x_p = 0$ and $x_o > 0$. Proceeding like above we get

$$w = \frac{F(N_o x_o, 1)}{F_x(N_o x_o, 1)} + x_o$$

and

$$w \leq \frac{F(N_o x_o, k)}{F_x(N_o x_o, k)}.$$

Combining the two conditions we obtain

$$\frac{F(N_o x_o, 1)}{F_x(N_o x_o, 1)} + x_o \leq \frac{F(N_o x_o, k)}{F_x(N_o x_o, k)},$$

which is a contradiction since $d(F/F_x)/dk < 0$.

Assume now that $x_p > 0$ *and* $x_o > 0$. *Then we obtain*

$$w - x_p = \frac{F(N_o x_o + (N - N_o)x_p, k)}{F_x(N_o x_o + (N - N_o)x_p, k)},$$

together with

$$w - x_o = \frac{F(N_o x_o + (N - N_o)x_p, 1)}{F_x(N_o x_o + (N - N_o)x_p, 1)}.$$

Using the Implicit Function Theorem we can write $x_o(x_p)$. *Thus, at Nash equilibrium we obtain*

$$w - x_p = \frac{F(N_o x_o(x_p) + (N - N_o)x_p, k)}{F_x(N_o x_o(x_p) + (N - N_o)x_p, k)}.$$

That there exists an $x_p > 0$ *that solves this equation has been shown in Proof 1.*

Proof of Part 2)

Since $d(F/F_x)/dk < 0$ *the result follows immediately.*

Proof of Part 3)

We study equation (4). *Taking the total derivative with respect to* x_o *and* x_p *we obtain*

$$\frac{dx_p}{dx_o} = -\frac{F_x^2 - F F_{xx}}{F_x^2(1 + N - N_o) - F_{xx}(N - N_o)} < 0.$$

Proof of Part 4)

To show that $\frac{dx_p}{dk} > 0$ *we use equation (4) again and derive*

$$\frac{dx_p}{dk} = -\frac{F_x F_k - F F_{xk}}{F_x^2(1 + N_o \frac{\partial x_o}{\partial x_p} - N + N_o) - F F_{xx}(N_o \frac{\partial x_o}{\partial x_p} - N + N_o)} > 0,$$

since

$$\frac{dx_o}{dx_p} = -\frac{F_x^2 - F F_{xx}}{F_x^2(1 + N_o) - F F_{xx} N_o}(N - N_o) < 0,$$

and it can easily be shown that $N_o \frac{dx_o}{dx_p} + N - N_o > 0$. ■

Part 1 of Proposition 2 implies that pessimists are always willing to have a positive amount of prevention expenditure, while optimists either have a corner solution or an interior one. Part 2 holds that, ceteris paribus, optimists would be willing to contribute lower amounts towards the public good prevention expenditure than pessimists.

Part 3 suggests that the prevention expenditure of the two types are optimal substitutes. Thus, if optimists reduce their prevention expenditure then pessimists increase theirs. This is a result of the Nash game setting and the fact that prevention expenditure of both types is assumed to be a linear combination in the loss function. It means that there is no difference in who provides the public good - for the public good a dollar from a pessimist is the same as the dollar from an optimists. However, this also implies that when pessimists were to become more pessimistic (e.g. due to new information on climate change), then while they will increase their prevention expenditure, the optimists will reduce theirs. Thus, there is clearly an issue of some degree of free-riding on the pessimism of the others. While this free-riding is the result of optimal decisions at Nash Equilibrium and not due to moral hazard, it would, for example, pose an issue if beliefs can be subjectively chosen.[3]

The last part of Proposition 2 states that pessimists will increase their prevention expenditure if they believe that a shock has a stronger impact. Combining this with the

[3]Though an important and relevant question per se, we are not going to develop upon this in the current article.

result of part 3 we know that an increase in the differences of beliefs will lead to a lower optimal amount of prevention expenditure of the optimists.

2.1 Numerical example

In this section we now provide a numerical example of the analytical model above. We denote function F by $F(N_o x_o + (N - N_o)x_p, k) = \frac{1+N_o x_o+(N-N_o)x_p}{kA+N_o x_o+(N-N_o)x_p}$, with $A > 1$, where optimists believe that $k = 1$ and pessimists that $k > 1$. As a consequence, inaction of both types would imply that the optimists assume that $(A-1)/A$ percent of their net wealth is destroyed, while pessimists believe that $(kA-1)/(kA)$ percent vanishes. Clearly, the larger is the prevention expenditure of either type, the smaller will be the effect of the shock in equilibrium. In this numerical example we choose $A = 500$, $w = 100$, $N = 51$, and assume a range of $k \in [1, 1.2]$ and $N_o = \{1, 11, 21, 31, 41\}$. Table 1 gives the sensitivity results of our numerical example. We notice that even minor differences in beliefs may lead to

Table 1: Numerical example

	$N_0 = 1$			$N_0 = 11$			$N_0 = 21$			$N_0 = 31$			$N_0 = 41$		
k	x_0	x_p	$\sum_i x_i$	x_0	x_p	$\sum_i x_i$	x_0	x_p	$\sum_i x_i$	x_0	x_p	$\sum_i x_i$	x_0	x_p	$\sum_i x_i$
1.00	1.63	1.63	83.17	1.63	1.63	83.17	1.63	1.63	83.17	1.63	1.63	83.17	1.63	1.63	83.17
1.02	1.36	1.64	83.37	1.41	1.69	83.33	1.47	1.75	83.29	1.52	1.80	83.25	1.58	1.86	83.21
1.04	1.10	1.65	83.57	1.20	1.76	83.49	1.31	1.86	83.41	0.00	4.09	81.73	0.00	7.88	78.84
1.06	0.84	1.66	83.76	1.00	1.82	83.64	0.00	2.76	82.92	0.00	4.10	81.91	0.00	7.90	79.00
1.08	0.59	1.67	83.95	0.80	1.87	83.79	0.00	2.77	83.11	0.00	4.10	82.09	0.00	7.92	79.16
1.10	0.35	1.68	84.13	0.00	2.10	83.80	0.00	2.78	83.28	0.00	4.11	82.26	0.00	7.93	79.32
1.12	0.12	1.68	84.30	0.00	2.10	83.98	0.00	2.78	83.46	0.00	4.12	82.43	0.00	7.95	79.47
1.14	0.00	1.69	84.47	0.00	2.10	84.15	0.00	2.79	83.63	0.00	4.13	82.59	0.00	7.96	79.62
1.16	0.00	1.69	84.64	0.00	2.11	84.32	0.00	2.79	83.79	0.00	4.14	82.75	0.00	7.98	79.76
1.18	0.00	1.70	84.80	0.00	2.11	84.48	0.00	2.80	83.95	0.00	4.15	82.90	0.00	7.99	79.90
1.20	0.00	1.70	84.96	0.00	2.12	84.64	0.00	2.80	84.10	0.00	4.15	83.05	0.00	8.00	80.03

Remark: In this numerical example we choose $A = 500$, $w = 100$, $N = 51$ and assume a range of $k \in [1, 1.2]$ and $N_0 = \{1, 11, 21, 31, 41\}$.

significant differences in the optimal green expenditure at Nash equilibrium. For example, moving from the symmetric case with $k = 1$ to one where pessimists believe that k is only 0.06 points larger leads to a Nash equilibrium where pessimists pay double as much prevention expenditure compared to optimists. A small increase of additional 0.08 points leads to a corner solution in the optimal prevention expenditure of the optimists while pessimists further increase theirs. Minor differences in beliefs, therefore, lead to crucial differences in the optimal prevention expenditure.

Another result from this numerical example is that the more optimistic a society the lower will be its total prevention expenditure. This result gets aggravated the larger the differences in beliefs. For example, moving from a society where the difference in beliefs is very small ($k = 1.02$) with a minority of optimists ($N_o = 1$), to a society with a majority of optimists ($N_o = 41$), leads to a reduction in total prevention expenditure of only 0.2%. In contrast, if the differences in beliefs is relatively large $k = 2$, then the same change in the number of optimists leads to a reduction of nearly 6%. This also implies that corner solutions for optimists are more likely to occur for larger differences in beliefs. While a corner solution does not always need to imply a reduction in total prevention expenditure, it does so for a society with a sufficiently large share of optimists.

2.2 On the 'double deprivation'

What we learn from this is, essentially, that environmental pessimists are subject to a 'double deprivation'. Firstly, their indirect utility is lower than the one from optimists since they believe that a shock will destroy more of their net wealth. Secondly, their indirect utility will be reduced further because they are willing to undertake more prevention expenditure. Furthermore, the more optimistic the other agents, the larger will be the prevention expenditure of the pessimists. This is clearly the case in the climate change debate, where several countries hold the position of climate pessimists and strongly contribute to emission reductions, while other countries have optimistic beliefs and free-ride on the beliefs of the pessimists. Here we discuss some policy-relevant points that arise from the double deprivation.

Assuming that beliefs fall like mana from heaven and agents get randomly assigned a pessimistic or optimistic belief, then this leads to an efficient allocation of prevention expenditure. However, fairness falls short since those with pessimistic beliefs are subject to the double deprivation, while optimists may even free-ride on the beliefs of the pessimists. Consequently, should those that hold pessimistic beliefs also be required to pay for these beliefs? This would require a policy intervention from a fairness perspective, where pessimists do not get penalized for their beliefs. Thus, fairness would demand, in this setting, that the policy maker equalizes indirect utilities.

Let us assume that a policy maker can tax agents and then use these taxes for prevention expenditure. Equalizing indirect utilities would require that optimists contribute more to prevention expenditure than pessimists. However, how can a policy maker really elicit who holds which kind of belief? This is clearly a problem of asymmetric information which, essentially, gives rise to moral hazard from optimists. The optimists will try to pose as pessimists, since then they face lower taxes and consequently end up with a higher indirect utility. Whether the pessimists will announce to the policy maker that they are pessimists or optimists depends on the whether the higher costs of the additional prevention expenditure that the pessimists would need to bear if they pose as optimists exceed those from the higher expected damage due to the lower total contribution if the pessimists announce that they are pessimists. As one can see, the attempt to elicit who holds which kind of belief will face substantial difficulties due to strategic behavior. Indeed, the policy maker will have to design a good mechanism that would prevent this kind of strategic behavior that feeds on the asymmetric information.

Clearly, the fairness problem arises from the asymmetric beliefs. These tend to arise through non-Bayesian updating of beliefs (see e.g. Bikhchandani et al. [3], Ehrbeck and Waldmann [11], Carroll [7], Rabin and Schrag [22], Lord et al [18]), or simply asymmetric information. In both cases can the policy maker follow the strategy to influence those beliefs via information provision, advertisement or education, in order to bring beliefs closer to the correct beliefs. Here, moral hazard or asymmetric information will be of secondary importance, especially if the agents' belief strongly adjust to information. In the empirical section we show the importance of education for asymmetric beliefs.

3 Econometric evidence

In this section we study whether different beliefs have consequences for the willingness to undertake prevention expenditures and whether some of the analytical results from the economic model carry forward to the data. We utilize the International Social Survey Programme 2000 Environment II survey. In this survey approximately 20,000 individuals from 22 countries are interviewed about personal views and characteristics. Most variables which are relevant for us are categorical ones and range from one to five. We recode all categorical variables as dummy variables and drop (without significant changes to the results) those observations where individuals answer *don't know*. The complete variable description is given in Table 2.

For our dependent variable we ideally would like to have a variable that describes how much prevention expenditure an individual would be willing to undertake. Since this variable does not exist in our survey we resort to three proxies. The first one, which we call *status*, asks individuals "would you be willing to accept cuts in your standard of living in order to protect the environment?" This question attempts to extract information on whether an individual would accept changes to his status quo to protect the environment. Those individuals that would not be willing to see a change in their status quo would score a zero, while the others score a one. Our second proxy is *prices*, and the question asked is "How willing would you be to pay much higher prices in order to protect the environment?"

Our third proxy is *taxes*, and it derives from the question "How willing would you be to pay much higher taxes in order to protect the environment?" We recoded both questions such that someone who would not want to face higher prices or taxes would score a zero, while all others would score a one. Hence, all three dependent variables have in common that an an individual scoring a zero would not want to give something up in order to protect the environment, while the others would be willing to contribute to prevention expenditure.

Based on these three dependent variables we assess whether the predictions of the theoretical model hold true in our data. We now summarize the hypotheses that come from the theoretical model which we test here.

Hypothesis 1: *People who are pessimistic about the future state of the environment are willing to pay more for the environment than optimists.*

This hypothesis derives from Proposition 2 of the theoretical part. We basically showed above that individuals who believe that a shock will affect them strongly are willing to resort to a higher prevention expenditure than those that believe that the shock has a lesser impact.

To analyze this hypothesis, one needs data on the individuals' beliefs about the environment. One would, of course, like to have a survey question directly on the beliefs of individuals. However, since this data is not available, we resort to two proxies. The first proxy we use is a question from the questionnaire that asks whether individuals agree with the statement that "modern science will solve our environmental problems with little change to our way of life". Those individuals scoring a zero do not believe that science solves environmental problems, while those who believe score a one. We interpret those individuals who agree with that statement as science optimists, and those who disagree as science pessimists. We dub the variable *science*. Given the predictions of the model we expect science optimists to be less willing to accept cuts in their standards of living than science pessimists. As the second proxy we use a question that asks individuals whether they believe that "many of the claims about environment threats are exaggerated". This variable we dub *exagg*, where an individual scoring a zero believes that the claims are exaggerated, while those scoring a one do not. An individual who agrees with that statement believes that climate change or environmental degradation is an insignificant problem. In this case, the model predicts a negative relationship between the belief that claims about environmental threats are exaggerated and the willingness to pay for the environment. We dub those who believe that claims are exaggerated as eco optimists and the others as eco pessimists.

Hypothesis 2: *The more atomistic an agent feels the less he will be willing to contribute to the environment.*

This hypothesis suggests that individuals who believe that their actions have little to no impact on the environment will not resort to the same level of prevention expenditure as those individuals who believe that they may actually have an influence. Based on our model above we can derive this result mathematically as follows. Define the number of optimists as $N_o + m$, where $m > 0$, while we keep the number of pessimists constant. Then function F can be re-written as $F = F((N_o + m)x_o + (N + m - N_o - m)x_p, 1)$. The comparative statics at Nash equilibrium then lead to

$$\frac{dx_o}{dm} = -\frac{F_x^2 - FF_{xx}}{F_x^2 + (N_o + m + (N - N_o)\frac{\partial x_p}{\partial x_o})(F_x^2 - FF_{xx})} x_o < 0, \tag{6}$$

with an equivalent result for dx_p/dm. As a consequence, the theoretical model predicts that individuals that feel atomistic have a lower prevention expenditure. To analyze this hypothesis we use a question which asks individuals whether "there is no point in doing what I can for the environment unless others do the same". This is a proxy for how marginal the individual views his or her own contribution to prevention expenditure. We label this variable *atomism*. An individual scoring a zero is a person that does not agree with the statement, while an individual who agrees scores a one. The model predicts that an individual who agrees with that statement is likely to have a lower prevention expenditure. We therefore expect a negative sign.

One aspect that we ignored so far but that should clearly play a role in determining the beliefs of individuals is their knowledge of environmental problems, in other words their environmental education. Education has already been found to be an explanatory variable for the willingness to undertake prevention expenditure in survey studies, for example in Blomquist and Whitehead [4], Engel and Pötschke [13], Danielson et al [8]. We take a proxy for an individual's knowledge about the environmental impact of human activity in order to integrate the level of environmental education into the statistical model. From the survey we use a question where individuals are asked whether "every time we use coal or oil or gas we contribute to the greenhouse effect". An individual scoring a zero implies someone disagrees with that statement, while those that score a one agree. We dub this variable *informed*. We hypothesize that someone who is informed about environmental issues is also willing to pay more for the environment.

An additional aspect that we emphasize here is that environmental education should interact with individuals' beliefs. For example, someone who is unaware of the fact that our consumption of fossil fuels adds to the greenhouse gases should also be unaware that technical progress may actually reduce our consumption of fossil fuels and, consequently, our impact on the environment. Thus, we would expect a potentially important interaction between environmental education and science optimism. We expect those individuals with a higher environmental education to be more pessimistic about the potential of science to solve the environmental problems. Thus, we expect environmentally educated individuals to have a weaker impact from science optimism to the willingness to undertake prevention expenditure. In addition, individuals that hold more knowledge about the environment might also be more pessimistic about its evolution. Hence, we expect a potentially stronger impact of eco pessimism on the willingness to undertake prevention expenditure for those individuals that are better informed about the environment. Finally, we suggest that individuals that have a higher environmental education could also be feeling less powerless when it comes to actually improving the environment. Thus, we expect that those individuals that have a better environmental education to have a weaker impact from atomism to their willingness to undertake prevention expenditure.

Table 3 provides summary statistics. Our final sample size is 17,374 individuals. Within this sample we find that respondents are on average somewhat less willing to undertake prevention expenditure. Our variable *status* has a mean of 0.37, our variable *taxes* one of 0.283, and *prices* has one of 0.407. Around half of all respondents feel that they are atomistic (0.468), that news about the environment are exxagerated (0.488) and that science will alleviate environmental problems (0.518).

3.1 Regression analysis

Our basic specification is

$$x_i = \mathrm{F}(\mathrm{science}_i, \mathrm{exagg}_i, \mathrm{atomism}_i, \mathrm{informed}_i, C_i, \epsilon_i),$$

where x_i is either status, taxes or prices. We run nine regressions, three for each dependent variable. Our baseline regressions include only the variables that proxy for beliefs ($\mathrm{science}_i$, exagg_i, $\mathrm{atomism}_i$), the variable $\mathrm{informed}_i$ and the country dummies. In our second step regression we control for the interaction between the environmental education via the variable $\mathrm{informed}_i$ and the belief variables, while the final regressions include all controls. As controls we use sex, marital status, age, subjective social class and religious association. We use country dummies to control for possible country-specific effects and robust standard errors (the Huber/White/sandwich estimator of variance) that are clustered at the country level.

For the basic regressions of both status and prices we find that the Hosmer-Lemeshow test (HL test) suggests some model misspecification, while for the full models and for the regressions with taxes the test always rejects model misspecification. However, while the HL test in the basic regressions for status and prices hints at model misspecification, the results are nevertheless robust and the exclusion of the controls does not lead to qualitatively different results. In addition, the Lagrange multiplier test of generalized logit always rejects that a generalized h-family logit model would provide a better fit than the logit models that we employ here. Our main result in Table 4 is that the hypotheses are supported for all dependent variables and across all models. As a consequence, our empirical results support the predictions of the model. The detailed results are as follows.

We find considerable support for Hypothesis 1, as the statistically significant coefficients on the variable exagg throughout all regressions show. We observe that eco optimists are less willing to pay higher taxes for the environment than eco pessimists. This finding is robust across all specifications and models and in line with the predictions from the theoretical model. Conclusively, different beliefs have a substantial effect on the willingness to undertake prevention expenditure. Judging purely by the size of the coefficients (between -.59 and -.731), we can conclude that eco optimism bears the strongest influence of all variables on the willingness to undertake prevention expenditure within our sample. As regressions (2), (5) and (8) show, e*i, the interaction between exagg and informed, has the expected positive sign, but it is not statistically significantly different from zero. These results also hold in the regressions with controls, namely (3), (6) and (9). Thus, whether or not a person is knowledgeable about how mankind influences the environment does not significantly impact how his eco optimism or pessimism influences his willingness to undertake prevention expenditure. Though a simple Pearson Chi2 test is able to show that more informed individuals are also less likely to be eco optimists (Pearson chi2(1) =

153.8, Pr = 0.00), in terms of overall frequency the difference is not large. While 44.7% of the individuals that have less knowledge on how mankind influences the environment are eco optimists, 39.3% of the informed individuals are eco optimists. This difference might not be large enough to induce statistically significantly different results. Conclusively, although we find a statistically significant correlation between eco optimism and environmental education, this does not significantly impact an individual's willingness to undertake prevention expenditure.

Beliefs, as proxied through science optimism or pessimism, turns out statistically significantly different from zero only in the baseline regression (1). The impact is negative, suggesting that a science optimist is less likely to accept cuts in the standard of living in order to improve the environment. However, there is a statistically significant interaction with whether or not the individual is informed about mankind's effects on the environment. Regressions (2), (5) and (8) show that interacting science with informed, given by s*i, suggests that only those individuals that know about mankind's impact on the environment are also those for which science optimism or pessimism affects their willingness to undertake prevention expenditure. As a consequence, we find that a prerequisite for whether or not science optimism plays a significant role for the willingness to undertake prevention expenditure is that the individual is informed about the fact that science may alter how mankind impacts the environment. This result is especially significant in the status regression (coeff. -.247, p-val 0.000), marginally significant in the prices regression (coeff. -.106, p-val 0.057) and marginally insignificant for taxes (coeff. -.104, p-val 0.118).

The variable atomism is highly statistically significant and has the expected sign, thus we find support for Hypothesis 2. We observe that someone has a lower willingness to pay for the environment if he believes actions are only useful given that others act, too. This has some analogy to empirical evidence on cultural aspects and segregated societies. For example, a good social network and strong norms are important ingredients for a successful management of a local environment (Ostrom [20]). Alesina and La Ferrara [2] show that living in a racially mixed community and living in a community with a high degree of income disparity leads to lower trust. Furthermore, both Alesina and La Ferrara [1] and Habyarimana et al. [14] show that more homogeneous ethnic communities lead to a higher public good provision. Therefore, societies with a higher degree of trust manage commons better than societies with lower trust. If an individual trusts other individuals then he will be more inclined to contribute to public goods. Interacting variable atomism with an individual's environment education, a*i, shows that environmental education shapes the relationship between an individual's willingness to undertake prevention expenditure and his belief on whether actions are only useful given others act, too. Apart from the regression with prices as the dependent variable, in all other specifications we find a statistically significant catalytic effect of environmental education.

In regressions (3), (6) and (9) we also add controls in order to know whether our results are robust to the inclusion of additional determinants of prevention expenditure. Overall, we find no qualitatively different results between the regressions that exclude these controls and those that include them. In terms of controls we find that age and marital status turn out to be statistically insignificant[4]. Sex is statistically not different from zero in the status regression, while it is significant in the prices and taxes ones. This is in contrast to the results by e.g. Johnson et al. [17] and Torgler and García-Valiñas [26], who find that gender and age explain both environmental concern and behavior. We also find that more educated people are willing to pay more for the environment, a result similar to that one in Tjernström and Tietenberg [24]. As expected, more religious individuals tend to be more willing to accept cuts in the standard of living or face higher price, while this variable turns out marginally insignificant in the taxes equation. Finally, an individual's wealth, proxied by his subjective social class, is highly statistically significant across all equations and has

[4] Age is only marginally significant in regression (9).

a positive sign.

These regression results show that our variables that proxy for beliefs are not fully robust across the different specifications. While eco optimism, atomism and environmental education tend to be robust determinants of an individual's willingness to undertake prevention expenditure, this is not the case for science optimism. We only obtain a highly statistically significant result for science optimism in the status regressions. A priori, one would, however, not necessarily expect different results between status, prices or taxes. Nevertheless, science optimism may not give fully robust results across all specifications since there could be a potential relationship between science optimism and the dependent variables. For example, an individual could believe that an increase in taxes would then be used to finance research and development and this thereby also positively affects his belief that science may solve the environmental problems. Thus, an individual might view higher taxes, prices or a reduction in status as a prerequisite for a successful scientific green revolution. Whether this is the case is not possible to assess with the data here. However, the questions were not asked in a such a way that an individual might have been induced to expect a relationship between prices, taxes, status and the use of the money (e.g. for scientific green research). Nevertheless, from all three dependent variables, the dependent variable status is the least precise one and not necessarily related to governmental interventions but potentially more to a personal or societal choice. Thus, individuals could view the reduction in status more in terms of a growth-environment trade-off. In contrast, an increase in prices or in taxes could be understood as an increase in governmental revenue that then in turn would be used for green scientific research. This could, potentially, explain why science optimism turns out statistically significant in the status regressions but not in the prices or taxes one. In order to be certain that this potential endogeneity did not drive our results we re-ran the regressions excluding both science and its interaction with informed. There were no important changes to the results.

4 Extension to endogenous beliefs

In this section we provide an extension to endogenous beliefs in a dynamic setting. Our approach is to stick to the original model as far as possible but allow the beliefs to be influenced by the choices of the agents. For this we re-define k, the belief variable, as a dynamic variable. This variable then represents the extent to which the current state of the world affects the shock. For example, one would believe that shocks to one's income are increasing with the level of pollution. For simplicity, we write the belief of the agent to be directly proportional to the level of pollution. Let us, thus, define k_t as the current level of pollution, with a law of motion given by

$$\dot{k}_t = Nw - \sum_i x_{it} - \beta \sum_i x_{it} - \alpha k_t, \tag{7}$$

where $k_0 > 1$ and $k_t \geq 1$. The state $k_t = 1$ should thus be interpreted as the belief where the environment is in the natural state, or the best possible state. Consequently, total consumption $Nw - \sum_i x_{it}$ increases pollution, while total prevention expenditure, $\beta \sum_i x_{it}$, with $\beta > 0$, decreases pollution and thus both directly influence the beliefs of the pessimistic agents. Pollution also is assumed to have a self-regeneration rate of $\alpha > 0$.

We then assume that agents have a utility functional given by $U_i = \int_0^\infty (w - x_{it}) F(\sum_i x_{it}, k_t) e^{-\rho t} dt$, where pessimistic agents are again assumed to believe that $k_t \geq 1$ while optimistic agents believe that $k_t = 1$. To conform with the standard literature we assume that agents discount the future at rate $\rho > 0$. This assumption is also sufficient to insure the convergence of the utility functional. Essentially, the main differences to the static model are, thus, the assumption of an endogenous k_t and the dynamic setting with agents discounting the future. Our intention here is not to fully solve this dynamic model but to discuss what drives potential differences in the optimal choices of the agents between the dynamic and static model.

Each agent i solves

$$\max_{x_{it}} \int_0^{\infty} (w - x_{it}) F(\sum_i x_{it}, k_t) e^{-\rho t} dt, \tag{8}$$

subject to the law of motion $\dot{k}_t = Nw - (1+\beta)\sum_i x_{it} - \alpha k_t$, $k_0 > 1$, $x_{it} \geq 0$ and $w > x_{it}$.

We denote the Hamiltonian by

$$\mathcal{H}(x_{it}, k_t, \lambda_t, t) = (w - x_{it}) F(\sum_i x_{it}, k_t) e^{-\rho t} + \lambda_t \big(Nw - (1+\beta) \sum_i x_{it} - \alpha k_t \big), \tag{9}$$

with λ_t being the shadow value associated with k_t. To incorporate corner solutions we write the Langrangian as

$$\mathcal{L}(x_{it}, k_t, \lambda_t, \phi_i, t) = \mathcal{H}_t + \sum_i \phi_i x_i. \tag{10}$$

From now on we shall ignore time subscripts unless it leads to confusion. First-order conditions then give

$$Fe^{-\rho t} - (w - x_i) F_x e^{-\rho t} = -(1+\beta)\lambda + \phi_i, \text{ for } i = 1, ..., N, \tag{11}$$

$$(w - x_i) F_k e^{-\rho t} - \alpha \lambda = -\dot{\lambda}, \tag{12}$$

where the complementary slackness constraints give $\phi_i x_i = 0$, $\forall i$. Here we obtain the first-order conditions of the dynamic model, which we can compare to those given in equation (2) of its static counterpart. To facilitate comparison we re-write the dynamic version of the first-order conditions and get

$$w - x_i \leq \frac{(1+\beta)\lambda e^{\rho t} + F}{F_x}, \ \forall i. \tag{13}$$

As the reader can see, there is a crucial difference between the two sets of first-order conditions, which is the occurrence of $(1+\beta)\lambda e^{\rho t}$ in the dynamic conditions. Clearly, k_t is a cost to utility, so the shadow value λ_t attached to k_t is negative. Consequently, if agents take the endogenous evolution of beliefs into account, then for a given w and k_t, the optimal choice of x_i in the dynamic model exceeds the one in the static case. This endogenous feedback would then, in our language from above, lead to a triple deprivation for pessimists. Indeed, for $(1+\beta)\lambda e^{\rho t} \leq -F$, there is even the possibility of corner solutions such that $w = x_i$.

Let us then, as in the static model, assume the existence of two types, with N_o optimistic agents and $N - N_p$ pessimistic ones. The optimistic agents still believe that $k = 1$, while this time the pessimistic ones take the endogenous feedback of consumption and prevention expenditure on their beliefs into account, such that k is endogenously determined, may change over time and $k_t \geq 1$. At Nash equilibrium, we then have, similar to equations (11) and (12), two type-dependent optimality conditions given by

$$w - x_p \leq \frac{(1+\beta)\lambda e^{\rho t} + F(N_o x_o + (N - N_o)x_p, k)}{F_x(N_o x_o + (N - N_o)x_p, k)}, \tag{14}$$

$$w - x_o \leq \frac{F(N_o x_o + (N - N_o)x_p, 1)}{F_x(N_o x_o + (N - N_o)x_p, 1)}, \tag{15}$$

where equation (14) holds with equality if $x_p > 0$, and equation (15) holds with equality if $x_o > 0$.

For interior solutions such that $x_i \in (0, w)$ and $k_t > 1$ we obtain a dynamic system characterized by

$$\begin{aligned}
\dot{x}_o &= \frac{(\alpha+\rho)(F-(w-x_o)F_x)}{(1+N_o)F_x-(w-x_o)F_{xx}N_o} \\
&\quad -\frac{(N-N_o)F_x-(w-x_o)F_{xx}(N-N_o)}{(1+N_o)F_x-(w-x_o)F_{xx}N_o}\dot{x}_p, && (16) \\
\dot{x}_p &= \frac{(\alpha+\rho)(F-(w-x_p)F_x)+(w-x_p)((1+\beta)F_k+F_{xk}\dot{k})-F_k\dot{k}}{(1+N-N_o)F_x-(w-x_p)F_{xx}(N-N_o)} \\
&\quad -\frac{N_oF_x-(w-x_p)F_{xx}N_o}{(1+N-N_o)F_x-(w-x_p)F_{xx}(N-N_o)}\dot{x}_o, && (17) \\
\dot{k}_t &= Nw-N_ox_o-\beta(N-N_o)x_p-\alpha k. && (18)
\end{aligned}$$

At steady state the following conditions obey

$$\begin{aligned}
w-x_o &= \frac{F}{F_x}, && (19) \\
w-x_p &= \frac{(\alpha+\rho)F}{(\alpha+\rho)F_x-(1+\beta)F_k}, && (20) \\
k &= \frac{1}{\alpha}\big(Nw-(1+\beta)(N_ox_o-(N-N_o)w_p)\big). && (21)
\end{aligned}$$

These equations clearly show the role of the endogenous feedback on the beliefs. For example, if the agents discount the future highly, such that ρ is large, then the dynamic model at steady state gives equivalent result to the static one. On the other hand, pessimistic agents now take the endogenous feedback of their decisions and the decisions of the optimistic agents on their beliefs into account. The effect corresponding to this is given by the term $(1+\beta)F_k$ in the denominator of the steady state equation (20). For example, for F_k very large, or a large impact of prevention expenditure on beliefs, such that β is large, we obtain the result that, even at steady state, the prevention expenditure of the pessimistic agents tends to their income. If pollution quickly returns to its natural level $k=1$, such that α is very high, then the beliefs of the pessimistic agents converge to those of the optimistic agents.

As one might have expected, the difference between the dynamic model and the static one is given by the endogenous feedback effect on the beliefs of the agents. Thus, if one expects beliefs to be endogenous, the dynamic model presented in this section would be a better approach than the previous static one. However, this also depends on how strong the degree of endogeneity and the weight agents attach to future periods.

5 Conclusion

In this article we analyzed how beliefs affect agents' investments in prevention expenditure through a two-type , N-person public good game. We show analytically that agents who are pessimistic and believe that environmental degradation is likely to bear a significant impact on their wealth will invest more in prevention expenditure than optimists. This consequently leads to a double deprivation, which raises relevant policy questions. Furthermore, the more optimistic the society the lower will be its total green expenditure. We show that even marginal differences in beliefs may result in significant changes to the contributions of agents in the Nash equilibrium.

In the second part of this article we investigate empirically whether beliefs significantly affect the willingness to undertake prevention expenditure. For this we use a questionnaire from the Eurobarometer where 17,374 individuals state their preferences and basic characteristics. We proxy beliefs by three variables, namely science optimism, eco optimism and atomism. Science optimists believe that science will come to the rescue and prevent further environmental degradation, while eco optimists believe that the claims about the environment are exaggerated. Atomistic individuals believe that they cannot impact the environment unless others act the same. We find that science optimism, eco optimism and atomism in general lead to a reduced willingness to undertake prevention expenditure. While eco optimists are less willing to undertake prevention expenditure than eco pessimists, this relationship only holds for science optimists if they are also well environmentally educated. Similarly, the relationship between atomism and prevention expenditure becomes much stronger if the respondents have a good environmental education. Consequently, environmental education seems to shape the relationship between beliefs and the willingness to undertake prevention expenditure.

In a final step we develop a dynamic game with endogenous beliefs based on the static version and then discuss the main differences in the optimal choices of the agents. In this case the pessimistic agents are likely to have a higher prevention expenditure since they take the endogenous feedback of the prevention expenditure on their beliefs into account. The difference in the optimal choices of the agents between the dynamic model and the static one is given by the endogenous feedback effect on the beliefs of the agents. Thus, if one expects beliefs to be endogenous, the dynamic model presented in this section would be a better approach than the previous static one. However, we also show how this depends on how strong the degree of endogeneity is and the weight agents attach to future periods.

The results presented in this article give rise to at least two further research questions. One question concerns beliefs themselves. While this article concentrated on understanding how different beliefs lead to different prevention expenditures, an extension of this work should look into the question of how beliefs themselves are formed. We already partly treated this by assuming that beliefs are proportional to a variable that is endogenously determined and expected to affect the strength of shocks. However, further questions would treat in how far environmental education shapes beliefs, whether the actual state of the environment is more important, or even the political position. The second question, related to the first, would look into the evolution of beliefs through society. For example, if my neighbor is an eco optimist, would this influence my own belief or not? While the first question is a more empirical one, the second one would be more of an analytical kind and could, for example, be approached through a model based on evolutionary dynamics.

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Table 2: Variable description

Variable	Description
status	How willing would you be to accept cuts in your standard of living in order to protect the environment? (1 - very willing, 5 - very unwilling), recoded as (1,2 and 3=1) and (4 and 5=0)
prices	How willing would you be to pay much higher prices in order to protect the environment? (1 - very willing, 5 - very unwilling), recoded as (1,2 and 3=1) and (4 and 5=0)
taxes	How willing would you be to pay much higher taxes in order to protect the environment? (1 - very willing, 5 - very unwilling), recoded as (1,2 and 3=1) and (4 and 5=0)
science	Modern science will solve our environmental problems with little change to our way of life. (1 - strongly agree, 5 - strongly disagree), recoded as (1,2 and 3=1) and (4 and 5=0)
exagg	Many of the claims about environment threats are exaggerated. (1 - strongly agree, 5 - strongly disagree), recoded as (1,2 and 3=1) and (4 and 5=0)
atomism	There is no point in doing what I can for the environment unless others do the same. (1 - strongly agree, 5 - strongly disagree), recoded as (1,2 and 3=1) and (4 and 5=0)
informed	Every time we use coal or oil or gas, we contribute to the greenhouse effect. (1 - strongly agree, 4 - strongly disagree), recoded as (1 and 2=1) and (3 and 4=0)
s*i	interaction of science*informed
e*i	interaction of exagg*informed
a*i	interaction of atomism*informed
age	corresponds to actual age of respondent
sex	0 = male, 1 = female
married	0 = single, 1 = married
education	What is your highest achieved level of education? (1 - none; 7 - university completed), recoded as (1,2,3, and 4 = 0) and (5,6 and 7 = 1)
religious	How often do you attend religious services? (1- once a week or more; 6- never), recoded as (1,2 and 3=1) and (4,5 and 6=0)
class	Which social class do you attribute yourself to? (1-lower class; 6- upper class), recoded as (1,2 and 3=0) and (4,5 and 6= 1)

Table 3: Summary statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
dependent variables					
prices	0.407	0.491	0	1	17,374
taxes	0.283	0.451	0	1	17,374
status	0.37	0.483	0	1	17,374
independent variables					
science	0.518	0.5	0	1	17,374
exagg	0.488	0.5	0	1	17,374
atomism	0.468	0.499	0	1	17,374
informed	0.84	0.367	0	1	17,374
s*i	0.429	0.495	0	1	17,374
e*i	0.392	0.488	0	1	17,374
a*i	0.387	0.487	0	1	17,374
control variables					
sex	0.513	0.5	0	1	17,374
age	44.665	16.22	15	96	17,374
married	0.626	0.484	0	1	17,374
religious	0.274	0.446	0	1	17,374
class	0.561	0.496	0	1	17,374
education	0.554	0.497	0	1	17,374

Table 4: Regression results

	(1) status Coef./S.e.	(2) status Coef./S.e.	(3) status Coef./S.e.	(4) prices Coef./S.e.	(5) prices Coef./S.e.	(6) prices Coef./S.e.	(7) taxes Coef./S.e.	(8) taxes Coef./S.e.	(9) taxes Coef./S.e.
science	-.213**	-.007	.021	-.100	-.059	-.025	-.081	.070	.100
	(.0709)	(.1211)	(.1187)	(.0561)	(.1106)	(.1091)	(.0667)	(.0976)	(.1000)
exagg	-.647***	-.721***	-.731***	-.606***	-.704***	-.726***	-.605***	-.613***	-.640***
	(.0692)	(.1028)	(.1089)	(.0682)	(.1016)	(.1078)	(.0739)	(.1192)	(.1226)
atomism	-.459***	-.241*	-.193*	-.437***	-.273*	-.197	-.416***	-.185	-.108
	(.0515)	(.1022)	(.0962)	(.0540)	(.1330)	(.1277)	(.0627)	(.1512)	(.1452)
informed	.341***	.535***	.543***	.332***	.385***	.398***	.366***	.578***	.587***
	(.0518)	(.0833)	(.0827)	(.0581)	(.1086)	(.1087)	(.0593)	(.0743)	(.0755)
s*i		-.240**	-.257**		-.046	-.071		-.174*	-.199*
		(.0906)	(.0903)		(.1018)	(.1010)		(.0771)	(.0848)
e*i		.085	.097		.114	.132		.008	.024
		(.0906)	(.0912)		(.1086)	(.1099)		(.1091)	(.1081)
a*i		-.254**	-.270**		-.191	-.221		-.267*	-.298*
		(.0931)	(.0916)		(.1272)	(.1252)		(.1364)	(.1353)
sex			-.050			-.155***			-.233***
			(.0442)			(.0360)			(.0404)
age			.001			.003			.005*
			(.0019)			(.0022)			(.0022)
married			-.013			-.060			-.068
			(.0414)			(.0337)			(.0440)
education			.254***			.355***			.377***
			(.0524)			(.0603)			(.0685)
religious			.202**			.188***			.087
			(.0651)			(.0523)			(.0459)
class			.187***			.344***			.336***
			(.0483)			(.0468)			(.0458)
Constant	.462***	.302**	-.083	-.267**	-.310*	-.792***	-.196**	-.374***	-.820***
	(.0800)	(.1160)	(.1124)	(.0812)	(.1225)	(.1501)	(.0728)	(.0965)	(.1285)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	.069	.070	.074	.060	.060	.072	.053	.054	.066
Obs.	17374	17374	17374	17374	17374	17374	17374	17374	17374
LM test (Chi-sq.)	.430	.211	.047	.958	.906	.198	.000	.007	.030
LM test (p-val.)	.51	.65	.83	.33	.34	.66	.99	.93	.86
HL test (Chi-sq.)	13.313	15.923	8.585	10.490	8.465	7.108	16.999	10.600	13.739
HL test (p-val.)	.10	.04	.38	.23	.39	.52	.03	.23	.09
interactions									
science+s*i		-.247***	-.236***		-.106*	-.095*		-.104	-.098
		(.000)	(.000)		(.057)	(.075)		(.118)	(.128)
exagg+e*i		-.636***	-.635***		-.590***	-.595***		-.605***	-.616***
		(.000)	(.000)		(.000)	(.000)		(.000)	(.000)
atomism+a*i		-.495***	-.463***		-.464***	-.418***		-.452***	-.406***
		(.000)	(.000)		(.000)	(.000)		(.000)	(.000)

Remark: P-values are in parentheses. LM test is the Langrange multiplier test of generalized logit (see Stukel 1988). A significant test statistic suggests that a generalized h-family logit model would provide a better fit than a logit model. The HL test is the Hosmer-Lemeshow test for model misspecification. It compares the sample frequency of the dependent variable with the fitted probability within subgroups of observations (see e.g. Cameron and Trivedi, 2009). We use 10 groups, which is the commonly used number of subgroups.