Climate change awareness: Empirical evidence for the European Union

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Introduction

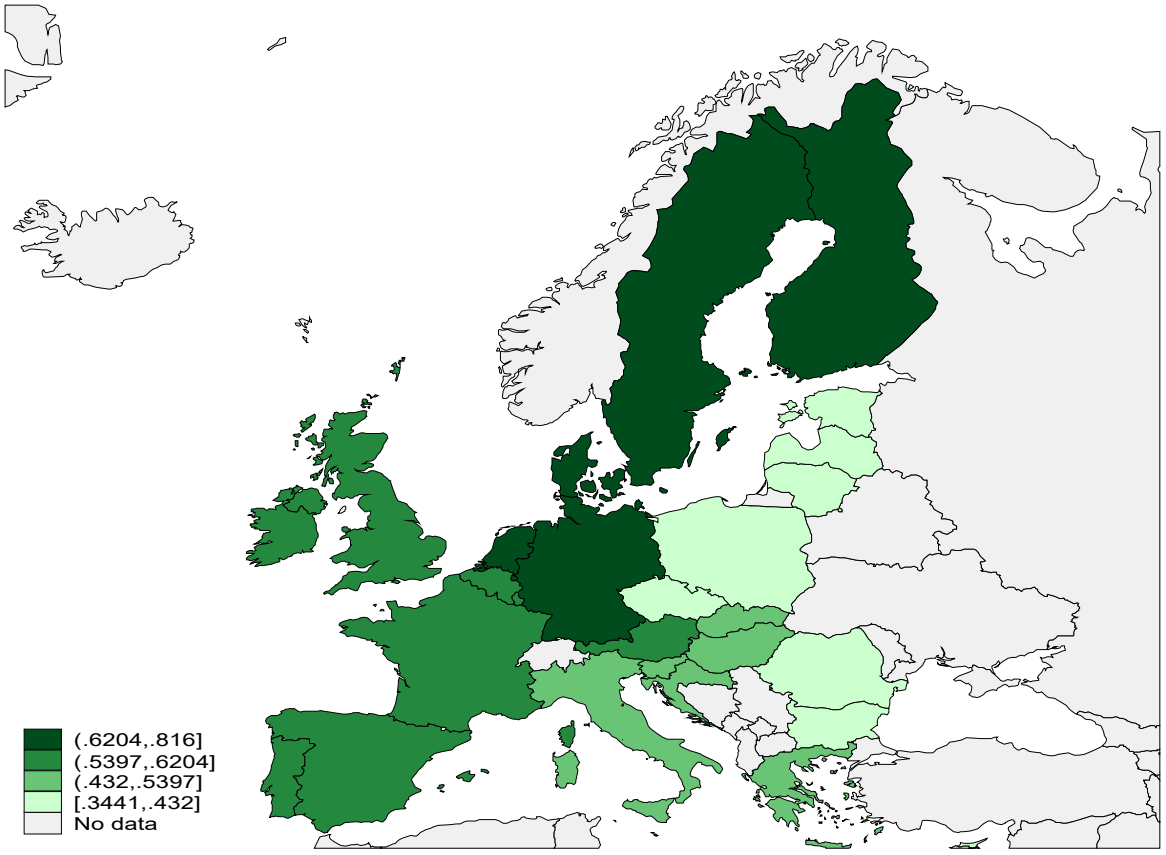
What explains climate change concern in the EU?
The recent Special Eurobarometer on Climate Change Survey April 2019 release (Eurobarometer, 2019) shows that **climate change is increasingly seen as one of the major threats** to the world as a whole by EU citizens.

In particular, **58%** of the interviewed EU citizens in 2019 retain **climate change as one of the first four major challenges** currently faced by humanity, and **22%** of them rank it as **the most important challenge.**

Moreover, **concerning the gravity of the threat**, **16%** of the respondents see it as a **serious issue**, and **77%** of them as a **very serious threat**.

Introduction

- However, there is heterogenity across European states:



The plot shows an estimate for the **%** of respondents in the *Special Eurobarometer Survey on Climate Change* who rank climate change as **one of the four most important challenges and at least of serious gravity** for year 2019.

- **What are the determinants of this heterogeneity in climate change concerns?**

Introduction

- **Understanding the drivers of climate change attitudes is an important and urgent task, since in democratic systems the legitimacy of political decisions on climate change mitigation actions relies on the support of public opinion.**

- This will be in favour only where there is sufficient concern for the economic, human and social implications of climate change.

- And in the light of recent evidence, showing that, at current levels of greenhouse gas emissions, **the carbon budget for meeting the Paris Agreement target of 2°C will be exhausted in less than three decades**, while less than a decade is left to limit the increase in global temperature to 1.5°C, **urgent mitigation actions are required**

Previous results

In this paper we focus on **the evolution in climate change concern in Europe over the last decade**. The period investigated is interesting, as it allows us to assess how European climate change attitudes have been affected by the "Paris Agreement", the election of Trump as U.S. President and his denial campaigns, and the environmentalists' response led by Greta Thunberg and the "Fridays for future" movement

To the authors' knowledge, there are **no studies in the literature focusing on data more recent than 2014.** Moreover, our assessment is based on the **Special Eurobarometer surveys on Climate Change**, which are in-depth thematic studies integrated into Standard Eurobarometer's polling waves and published every two years since 2009.

Although the Special Eurobarometer surveys provide an accurate view of climate change attitudes, they have been neglected in the literature so far. Finally, unlike previous studies, **our analysis focuses on aggregate survey results over different countries.** This paper thus fills some important gaps in the literature.

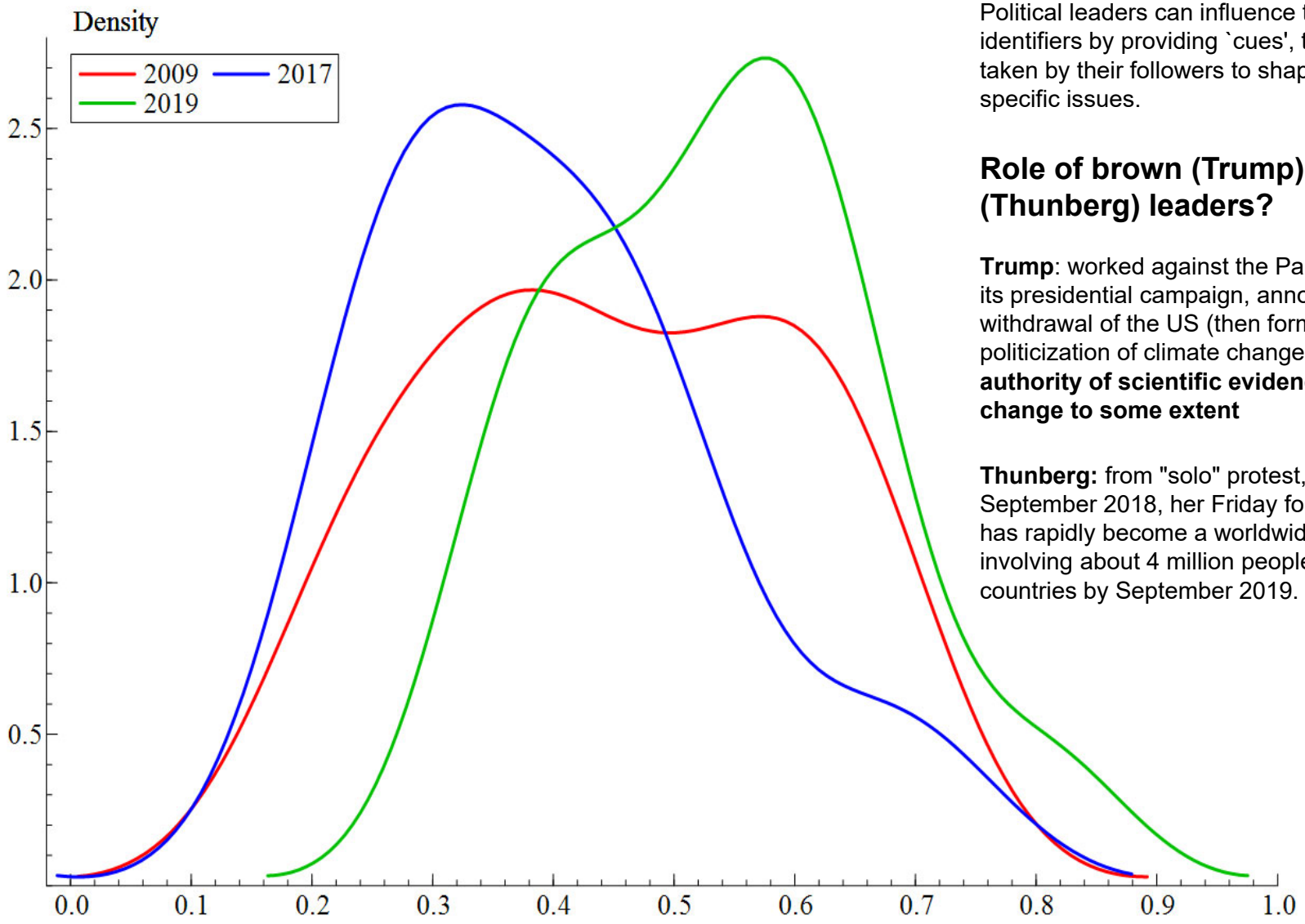
Descriptive statistics

Climate change is one of the first four most important challenges faced by humanity and it is at least a serious problem							
Q1*Q2	Min	Mean	Median	Max	Std. Dev.	Skewn	Ex-Kurt
2009	0.200	0.450	0.430	0.670	0.148	-0.061	-1.279
2011	0.240	0.451	0.450	0.650	0.109	-0.189	-0.807
2013	0.210	0.440	0.430	0.750	0.123	0.536	-0.039
2015	0.170	0.435	0.420	0.730	0.142	0.072	-0.763
2017	0.200	**0.397**	**0.390**	0.730	0.138	0.736	-0.167
2019	0.340	**0.535**	**0.540**	0.820	0.127	0.292	-0.496

Comparisons with earlier Eurobarometer results, show that the raise in **climate change concern does not appear to have followed a linear pattern over time**.

In fact, already 45% of respondents regard climate change as one of the first four most important problems and of at least of serious gravity already in 2009. Apart from the sudden drop in 2017, the cross-sectional mean does not sizably alter until 2019, when it sizably increases relative to previous figures (+9 (+14) percentage points relative to 2009 (2017)).

Figure 1: Kernel estimates of survey answer cross-sectional distributions



Effect of leadership cues on public polarization?

Political leaders can influence their respective party identifiers by providing `cues', that are in general taken by their followers to shape their beliefs on specific issues.

Role of brown (Trump) vs. green (Thunberg) leaders?

Trump: worked against the Paris agreement since its presidential campaign, announcing the withdrawal of the US (then formalized in 2017); his politicization of climate change **jeopardized the authority of scientific evidence on climate change to some extent**

Thunberg: from "solo" protest, which started in September 2018, her Friday for Future movements has rapidly become a worldwide phenomenon, involving about 4 million people across 169 countries by September 2019.

Conditional analysis

Yet what the above unconditional analysis is unable to establish a causal linkage between changes in climate change concern and political leaderships or to pin down what are the underlying forces of the observed patterns over time.

This calls for a conditional assessment of climate change concern, aiming to uncover drivers and mechanics of climate change concern.

In the light of the nonlinear pace of growth in climate change concern and the potential role of political leaders, the theoretical framework of our analysis is grounded on the well-known **model of information diffusion**.

This model predicts that **an "innovation", when the decision to adopt is voluntary, spreads across the members of a social system according to a sigmoid pattern of adoption** (the S-shaped curve).

Conditional analysis: theoretical framework

- In our framework the "S" shape describes the diffusion of climate change concern, conditional to socio-economic and climatological factors which might impact as well on the appreciation of the phenomenon.

- Hence:

$$y_t = \frac{1}{1 + \exp(-\mathbf{x}_t'\boldsymbol{\beta})}$$

where y_t is a given proxy for CC concern and $\mathbf{x}_t$ is a $k \times 1$ vector of socio-economic and climatological control variables.

"*The truth is always destined to have only one brief victory parade between two long time spans in which it's first being condemned as paradoxical and then belittled as trivial*" (Arthur Schopenauer (1788-1860) - The World as Will and Representation (1818))

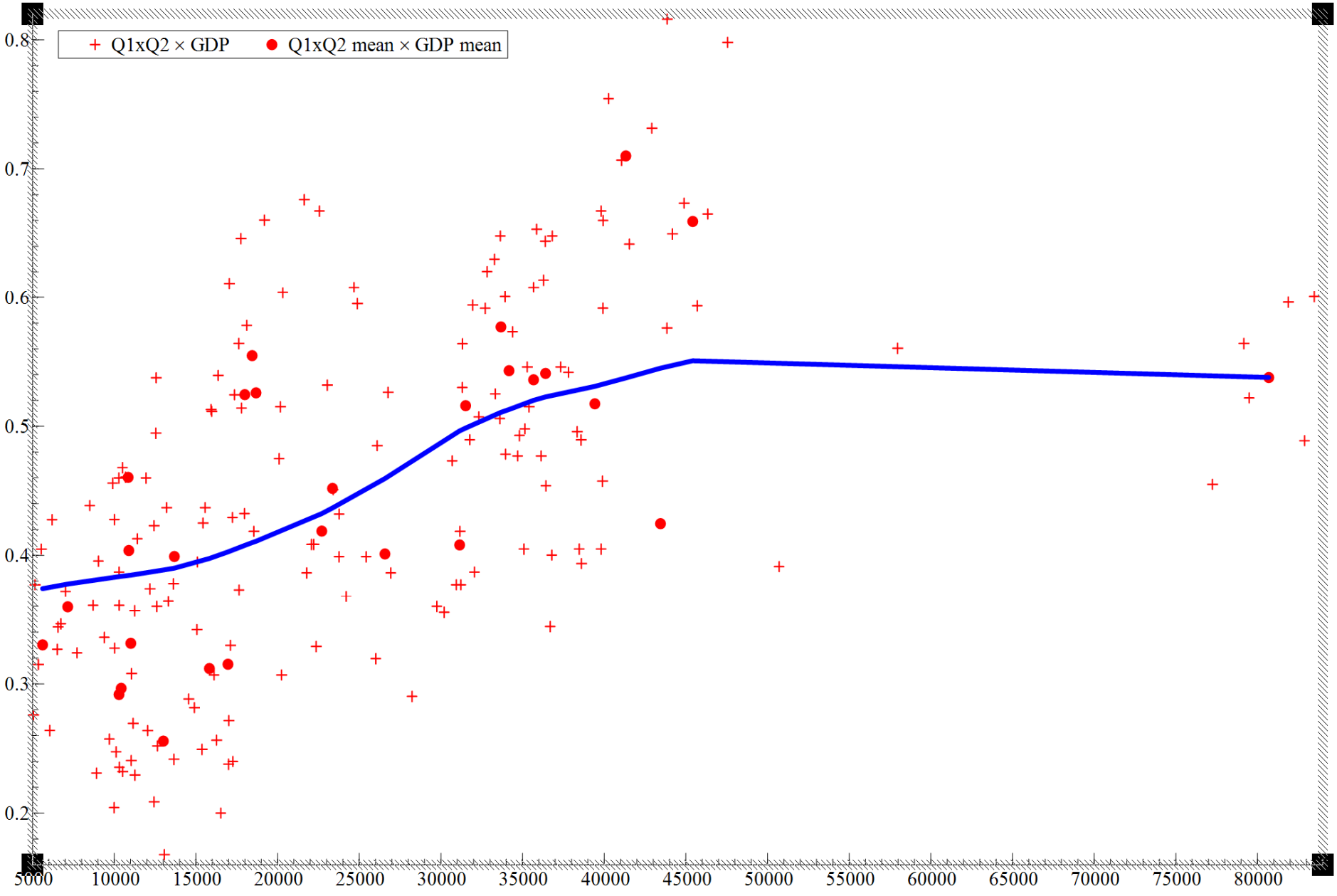
Conditional analysis: model specification

- Concerning the drivers of the process of awareness diffusion, we consider a very large set of variables, which characterise the socio, economic and political framework:

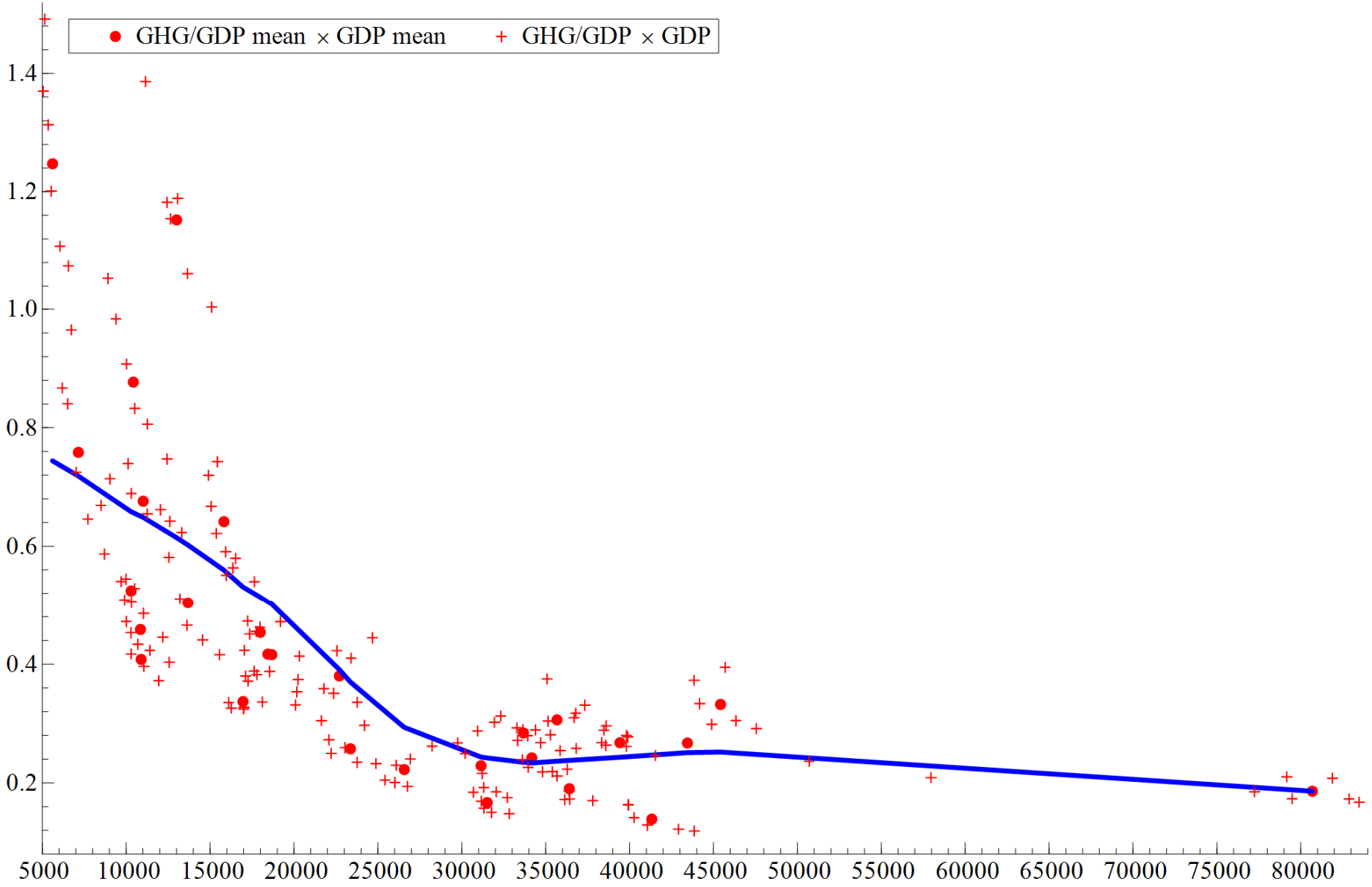
- REAL GDP PER CAPITA (+) : STANDARD OF LIVING EFFECTS (income increases above threshold level are also associated with an increase in the demand for environmental protection, i.e. with an improvement in environmental attitudes. We name this linkage the "climate change awareness curve").

This curve is naturally related to the environmental Kuznets curve, i.e. the inverse-U shaped relationship between greenhouse gas emissions and per capita GDP: in short, the existence of **a threshold income level beyond which greenhouse gas emissions decrease and economic development becomes sustainable** is posited. Moreover, **as citizens enjoy a higher standard of living, they value more postmaterialistic values and public goods, such as the quality of life in general and of the environment too.** Hence, ***income increases above threshold level are also associated with an increase in the demand for environmental protection and environmental concern.***

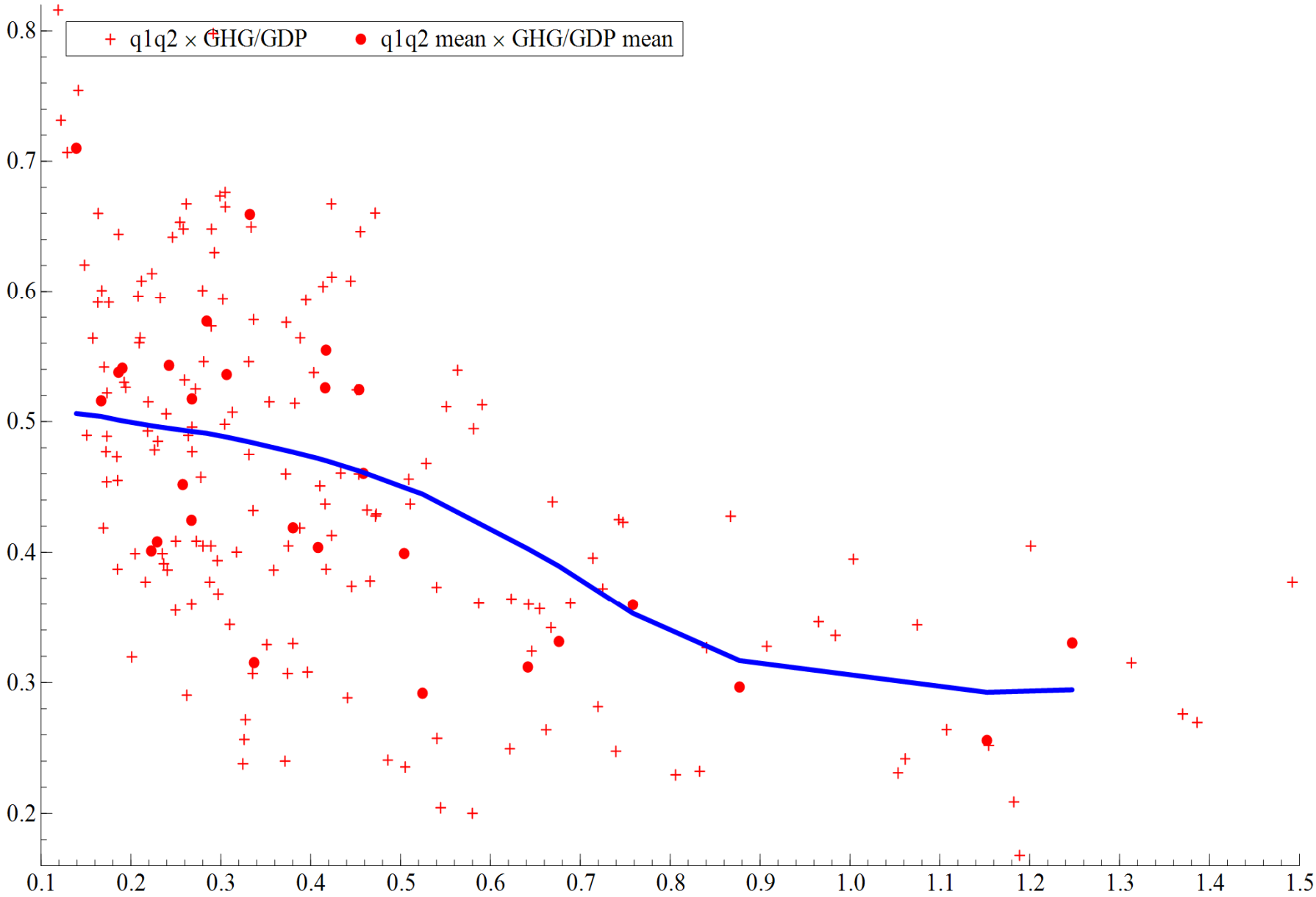
The climate change awareness curve



The environmental Kuznets curve



The climate change awareness curve II



Conditional analysis: model specification

- **POLITICAL LEADERS**: GREEN (+; DV 2019), BROWN (-; DV 2017)

- **ENVINRONMENTALLY FRIENDLY CULTURAL CONTEXT**:
  - VEGETARIAN ATTITUDES (+; TIME INV 2014; STOCH COUNTRY EFFECTS)
  - CO2 EMISSIONS/KM FROM NEW CARS (-)
  - ENERGY PRODUCTIVITY GDP/ENERGY (+)
  - ENVIRONMENTAL PERFORMANCE INDEX (EPI, +)
  - ***RELATIVE POWER OF RIGHT-WING PARTIES (% cabinet posts; -)***
  - ***YOUNG PEOPLE OVER TOTAL POPULATION (+)***
  - FEMALE EMPOWERMENT INDEX (+)
  - NOTRE-DAME GLOBAL ADAPTATION INDEX (-)
  - ***TRUST IN INSTUTIONS (+; TIME INV 2013; STOCH COUNTRY EFFECTS)***
  - ***PER CAPITA GHG EMISSIONS*** AND ENVIRONMENTAL TAXES/ GDP (+)

Conditional analysis: model specification

- **ACQUISITION AND PROCESSING ABILITY OF THEORETICAL INFORMATION ABOUT CLIMATE CHANGE** :
  - ***SECONDARY EDUCATION LEVEL (% OF POPULATION)*** **+**
  - ***TERTIARY EDUCATION LEVEL (?)***
  - ***CLIMATE CHANGE MEDIA COVERAGE (UNOFFICIAL JRC INDEX)*** +
  - LEVEL OF INTERNET ACCESS (+)
  - ACCUMULATED CYCLONE ENERGY INDEX (+; COUNTRY INV; STOCH TIME EFFECTS)

- **PRACTICAL KNOWLEDGE OF CLIMATE CHANGE**
  - CUMULATIVE FATALITIES CAUSED BY EXTREME WEATHER (+; TIME INV)
  - ***LOSSES GENERATED BY CLIMATOLOCICAL EVENTS (EU; +,COUNTRY INV)***
  - ***CUMULATIVE LOSSESS GENERATED BY CLIMATOLOCICAL EVENTS (+; COUNTRY INV)***
  - ***NUMBER OF COOLING (+)*** AND HEATING (-) ***DEGREE DAYS***
  - EUROPEAN TEMPERATURE ANOMALY (+; TEMP; COUNTRY INV)
  - El Niño (warm) EPISODES. (-; COUNTRY INV)

- **DETERMINISTIC TIME AND COUNTRY EFFECTS**

Conditional analysis: econometric model

The econometric model is then

$$y_{i,t} = \frac{1}{1+\exp(-\mathbf{x}'_{i,t-1}\boldsymbol{\beta} + \varepsilon_{i,t})}$$

where *i* is the country index, which refers to each the 27 current EU member countries plus the UK and *t* is the temporal index, which refers to a set of six biannual observations for the years 2009, 2011, 2013, 2015, 2017 and 2019, apart from Croatia, for which we have data only since 2013. Hence, the available panel counts 166 observations in total. Moreover, $\varepsilon_{i,t}$ is a zero mean i.i.d. stochastic disturbance term.

The reduced form model is a natural setting for the investigation of the data at hand, since survey results are collected in March/April and therefore much earlier than the contemporaneous control variables.

Conditional analysis: econometric model

The model can be easily linearized, yielding the OLS estimable regression function (reduced form model)

$$\ln\left((1/y_{i,t})-1\right)=\mathbf{x}'_{i,t-1}\boldsymbol{\gamma}+\varepsilon_{i,t} \qquad \boldsymbol{\gamma}=-\boldsymbol{\beta}$$

In our analysis, the panel nature of the data is properly taken into account by the inclusion of **some conditioning variables that are either time-invariant (stochastic country-effects) or country-invariant (stochastic time-effects). Deterministic time and country effects are also allowed for**, and selected, as for the other conditioning variables, through a **general to specific reduction strategy, also exploiting impulse saturation analysis** (Hendry et al., 2008; Johansen and Nielsen, 2009).

OLS estimation is then expected to provide consistent and asymptotically normal estimates.

We also consider stochastic effects modelling for robustness.

Conditional analysis: econometric results

Q1xQ2	Coefficient	Std.Error	t-value	t-prob
GDP	2.0486	0.6939	2.95	0.0037
GDP^2	-1.1566	0.6696	-1.73	0.0864
Du17	-0.2145	0.0589	-3.64	0.0004
Du19	0.40469	0.0599	6.75	0.0000
GHG*GDP	-1.3944	0.5560	-2.51	0.0133
TRUST*GDP	3.7081	0.4947	7.5	0.0000
EdTer	-0.6660	0.1354	-4.92	0.0000
EdSec	0.7303	0.1796	4.07	0.0001
Cool	0.5960	0.1536	3.88	0.0002
LOSS	0.8326	0.2326	3.58	0.0005
LOSS*GDP	-2.5236	0.7687	-3.28	0.0013

R^2	0.845129	F(27,138) =	27.89 [0.000]**
Adj.R^2	**0.814829**	log-likelihood	6.09038
no. of observations	166	no. of parameters	28
AIC	-2.57391	SC	**-2.04899**

Normality test: Chi^2(2) = 0.7791 [0.6773]
Hetero test: F(29,130) = 1.1784 [0.2629]
Hetero-X test: F(63,96) = 1.0779 [0.3659]
RESET23 test: F(2,136) = 1.1163 [0.3305]

Conditional analysis: econometric results

Q1xQ2	Coefficient	Std.Error	t-value	t-prob
I:7(BE)	0.6013	0.2819	2.13	0.0347
I:19(CY)	0.9500	0.2802	3.39	0.0009
I:49(EL)	0.7470	0.2836	2.63	0.0094
I:104(LV)	0.6692	0.2621	2.55	0.0118
I:119(NL)	1.0010	0.2707	3.7	0.0003
I:145(SI)	0.5292	0.2817	1.88	0.0624
d_BE	0.5244	0.127	4.13	0.0001
d_EL	0.4618	0.1301	3.55	0.0005
d_ES	0.5511	0.1322	4.17	0.0001
d_FR	0.6227	0.1334	4.67	0.0000
d_SE	0.5971	0.1601	3.73	0.0003
d_SI	0.5870	0.1566	3.75	0.0003
d_DE	0.4274	0.1216	3.51	0.0006
d_MT	0.4889	0.1731	2.82	0.0054
d_PL	-0.2215	0.1156	-1.92	0.0574
d_HU	0.2524	0.123	2.05	0.0421

Conditional analysis: econometric results

We then construct the composite country fixed effect variable:

D_set = I:7 + I:104 + I: 49 + I:145 + 2*I:19 + 2*I:119 + d_BE + d_EL + d_ES + d_FR + d_SE + d_SI + d_MT + d_DE + 0.5*d_HU - d_PL

and test the implied restriction validating its construction, obtaining

Chi^2(15) = 3.3303 [0.9992]

The composite variable is then entered in the final specification of the econometric model

Conditional analysis: econometric results

Q1xQ2	Coefficient	Std.Error	t-value	t-prob
D_set	0.5310	0.0407	13.1	0.0000
Constant	1.5890	0.1420	11.2	0.0000
GDP	2.0159	0.4749	4.25	0.0000
GDP^2	-0.9817	0.4639	-2.12	0.0360
Du17	-0.2265	0.0547	-4.14	0.0001
Du19	0.3939	0.0565	6.97	0.0000
GHG*GDP	-1.5955	0.3895	-4.1	0.0001
TRUST*GDP	3.7025	0.3437	10.8	0.0000
EdTer	-0.6330	0.1174	-5.39	0.0000
EdSec	0.7124	0.1349	5.28	0.0000
Cool	0.5396	0.1095	4.93	0.0000
LOSS	0.8442	0.1533	5.51	0.0000
LOSS*GDP	-2.5389	0.5765	-4.4	0.0000

R^2 0.841392 F(12,153) = 67.64 [0.000]**
Adj.R^2 **0.828952** log-likelihood 4.11119
no. of observations 166 no. of parameters 13
AIC -2.73078 SC **-2.48707**

Normality test: Chi^2(2) = 0.61773 [0.7343]
Hetero test: F(21,144) = 0.89843 [0.5933]
Hetero-X test: F(64,101) = 0.70975 [0.9297]
RESET23 test: F(2,151) = 1.1576 [0.3170]

Conditional analysis: non-saturated model

Q1 xQ2	Coefficient	HCSE	t-HCSE
Constant	1.6848	0.2506	6.7222
GDP	3.9347	0.6668	5.9009
GDP^2	-1.9437	0.6062	-3.206
Du17	-0.2276	0.0724	3.1406
Du19	0.3431	0.0701	4.8936
GHGxGDP	-2.1996	0.6008	-3.661
TRUSTxGDP	3.0565	0.4726	6.4669
EdTer	-0.7302	0.1623	-4.4992
EdSec	0.6963	0.2361	2.9488
Cool	0.7461	0.1883	3.9606
LOSS	1.0243	0.2202	4.6511
LOSSxGDP	-2.5209	0.8629	-2.9215

R^2	0.66481	F(11,154) =	27.77 [0.000]**
Adj.R^2	**0.640868**	log-likelihood	-57.9945
no. of observations	166	no. of parameters	12
AIC	-1.99457	SC	**-1.76961**

Normality test: Chi^2(2) = 2.7814 [0.2489]
Hetero test: F(19,146) = 1.5392 [0.0803]
Hetero-X test: F(53,112) = 2.0105 [0.0010]**
RESET23 test: F(2,152) = 0.17586 [0.8389]

Conclusions

In this paper we investigate climate change attitudes in the European Union over the last decade.

We find that climate change concern has increased with the level of per capita income. We name this relationship "climate change/environmental awareness curve".

This curve is theoretically motivated by the public good nature of environmental quality, for which demand increases with the level of income. This curve is also related to the "environmental Kuznets curve", which describes an inverse-U shaped relationship between greenhouse gas emissions and the level of per capita income.

Once threshold income level is crossed, economic development becomes sustainable, i.e. higher income levels are associated with lower emissions, and, in our framework, also with higher climate change concern.

Conclusions

Other variables influence the CC awareness curve (in the income-awareness space):

- positively: secondary education, media coverage, effects of global warming (monetary losses and changing weather), share of the young in the population (level), social trust (slope);
- negatively: tertiary education, relative power position of right-wing parties in government (level), greenhouse gases emissions (slope).

- We also find a potential role role for political (Trump; negative) and environmental (Thunberg; positive) leaders.

These variables affect the slope of the environmental awareness equation, amplifying or dampening the effects of income, or affect its position (in the income-awareness space).

Policy conclusions

Two main policy implications follows from our study.

Firstly, in the light of the key role played by living standard in the determination of environmental concern, it appears that **income levels should be preserved during any transition to a carbon neutral economy.**

This is even more urgent in the light of the sizable worldwide economic contraction caused by the COVID-19 pandemics, since, as also learned during the Great Recession, **public's concern about climate change is negatively affected by economic insecurity** (Scruggs and Benegal, 2012).

Policy conclusions

Secondly, in the light of the contribution of media coverage and education to environmental awareness, it is important that **scientific evidence about climate change be disseminated as broadly as possible to citizens, through academic and non-academic channels.**

Moreover, in the light of the contribution of the appreciation of financial losses caused by extreme weather episodes and the physical distress associated with raising temperatures, **citizens should also be guided towards better connecting the "experience" of global warming and extreme weather episodes to climate change.**

In this respect, **the UK is a leading example for reforms to the education system** (primary and secondary education), which can easily be imitated.

Policy conclusions

The negative impact of tertiary education on climate change attitudes might however be a signal that **efforts should be pursued also at the tertiary education level** (mitigation of *cognitive bias*)**.**

In this respect, given the sizable economic, financial, social, and political consequences of climate change, the **inclusion of climate change education into academic curricula in social sciences** appears to be not only sound, but also extremely urgent.

Moreover, **a broader coverage and better reporting of climate research findings in the mainstream media is also important.** The underreporting of climate findings and natural disruptions around the world appears to be a major impediment to information dissemination, which do require media coverage, in order to foster climate change awareness and counterbalance contrarian arguments, often channeled through nowcast media and electronically spread (Hamilton, 2011).

Policy conclusions

In this respect, **citizens should also be helped to question climate change information campaigns,** enacted or (openly or hiddenly) sponsored by industries which are highly responsible for greenhouse gas emissions and therefore in conflict of interest.

This is also **to contrast the politicization of climate change.** While the fact that conservative political leaders contribute to climate change skepticism among lay conservatives is a well-established fact for the U.S., our findings do provide further empirical evidence for Europe as well.

Policy conclusions

To conclude, at current levels of greenhouse gas emissions, less than a decade is left to limit the increase in global temperature to 1.5°C (IPCC, 2018). Yet these scenarios might even be optimistic, since greenhouse gas emissions are still increasing globally. International climate action is urgently needed.

Future research should then focus on the conative component of climate change cognition, in order to foster the personal, intentional climate mitigation action, i.e. the proactive behavioral response caused by the cognitive and affective experiences of the environmental concern.

This is also in the light of the fact that the **barriers to action on climate change are rooted in** enduring and incompatible **differences between positions or interests**, which can be resolved only through political mobilization and activism. The success of Greta Thunberg is telling in this respect.

Appendix: the data

The data

Our proxy variables for climate change concern are based on aggregate country figures, retrieved from the Special Eurobarometer surveys on Climate Change, collected every two years, over the period 2009-2019. We consider the following questions:

→ "Which of the following do you consider to be the single most serious problem facing the world as a whole?" (QB1a)

→ "Which others do you consider to be serious problems?" (QB1b)

In the cases of QB1a e QB1b we consider the percentage of interviewed that indicated "climate change"

→ "And how serious a problem do you think climate change is at this moment? Please use a scale from 1 to 10, with '1' meaning it is "not at all a serious problem" and '10' meaning it is "an extremely serious problem" (QB2).

In the cases of QB2, we consider the percentage of interviewed that assigned a score in the range 5-6 (QB2s) and 7-10 (QB2vs)

The data

- Moreover, we also aggregate the above figures and obtain three additional proxy variables.

- The aggregation of QB1a and QB1b yields the percentage of respondents who rank climate change as one of the four most important global challenges (QB1).

- The aggregation of QB2s and QB2vs yields the percentage of respondents who consider climate change at least a serious problem (QB2), giving a score within the range 5-10.

- **The interaction (product) of QB1 and QB2 yields a proxy for the percentage of respondents who rank climate change as one of the four most important challenges and at least of serious gravity (QB1QB2).**