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Context matters: The drivers of environmental concern in European regions

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ABSTRACT

Environmental concern is crucial as bottom-up support for policies that aim to tackle the multiple ecological crises. This paper investigates which characteristics of 206 European regions are robust drivers of generalized environmental concern. To this end, 25 Eurobarometer survey waves between 2009 and 2019 were combined with measures of the regional economy, population, geography, environmental quality, and meteorological events. Bayesian model averaging is used to systematically account for model uncertainty in the estimation of partial correlations. The results indicate that environmental concern increases with income level, a more equal distribution of income and wealth, and a less greenhouse gas-intensive industrial sector. Furthermore, regions with younger and better educated populations exhibit higher levels of environmental concern. In terms of environmental characteristics, both geographical vulnerability to natural hazards and meteorological events affect environmental concern. The results highlight the importance of the socio-economic and environmental context of opinion formation and have implications for designing and communicating environmental policies.

1. Introduction

Environmental concern is an important source of democratic legitimacy for climate action. Global warming of 1.5°C over pre-industrial levels will likely be reached between 2030 and 2052 and proceed further, given current greenhouse gas emission trajectories (IPCC, 2018). In fact, the nationally determined contributions to greenhouse gas reduction are not sufficient to limit warming even to 2°C, resulting in an emissions gap (UNEP, 2021). Wide public support for environmental policy plays a crucial role in closing the emissions gap by setting national contributions that are in line with the ultimate goal of the Paris Agreement (Schaffrin, 2011).

However, environmental concern remains low in many European regions. Fig. 1a shows the average fraction of the population that sees the environment, energy, and climate change as a priority for national policy-making (see Section 3.1). In Northern and Western Europe, concern levels increased until the financial crisis of 2008, plummeted in its aftermath, and took approximately ten years to recover to pre-crisis values. Since 2011, climate change and environmental issues have increasingly been prioritized across all regions, in particular in the Northwest, while the Southeast remains at relatively low levels (Fig. 1b).

Inglehart (1981, 1995, 2008) argues that the rise of environmental concerns is part of a wider transition from material to post-material concerns. According to the post-materialism hypothesis, values shift towards concern for less immediate issues once basic needs are socially guaranteed and a relatively high standard of living is reached. This argument describes a possible cultural micro-foundation underlying the Environmental Kuznets Curve which poses that environmental quality first declines, then rises with increasing income level (Bravo and Marelli, 2007). The decline in environmental concern in the aftermath of the recent recession led several studies to empirically investigate a possible environment-economy trade-off, mostly finding support for such a relationship (Marquart-Pyatt, 2012; Brulle et al., 2012; Scruggs and Benegal, 2012; Shum, 2012; Mildenberger and Leiserowitz, 2017; Duijndam and van Beukering, 2020).

A different strand of literature focuses on the influence of environmental factors on concern, in particular in terms of meteorological events associated with global warming (Brody et al., 2008; Li et al., 2011; Brulle et al., 2012; Demski et al., 2016; Howe et al., 2019). While analytical thinking is required to process statistical evidence regarding global warming and environmental quality, local events can activate experiential processing and provide more easily accessible information (Marx et al., 2007). Such information is applicable to availability heuristics and can cause a decline in the psychological distance to environmental issues (Spence et al., 2011; McDonald et al., 2015). Salient features of climate change, such as unusually high temperatures or dry spells, can accordingly increase environmental concern.

This paper investigates which socio-economic and environmental characteristics of European regions are robust contextual drivers of environmental concerns. While individual demographic, political, and

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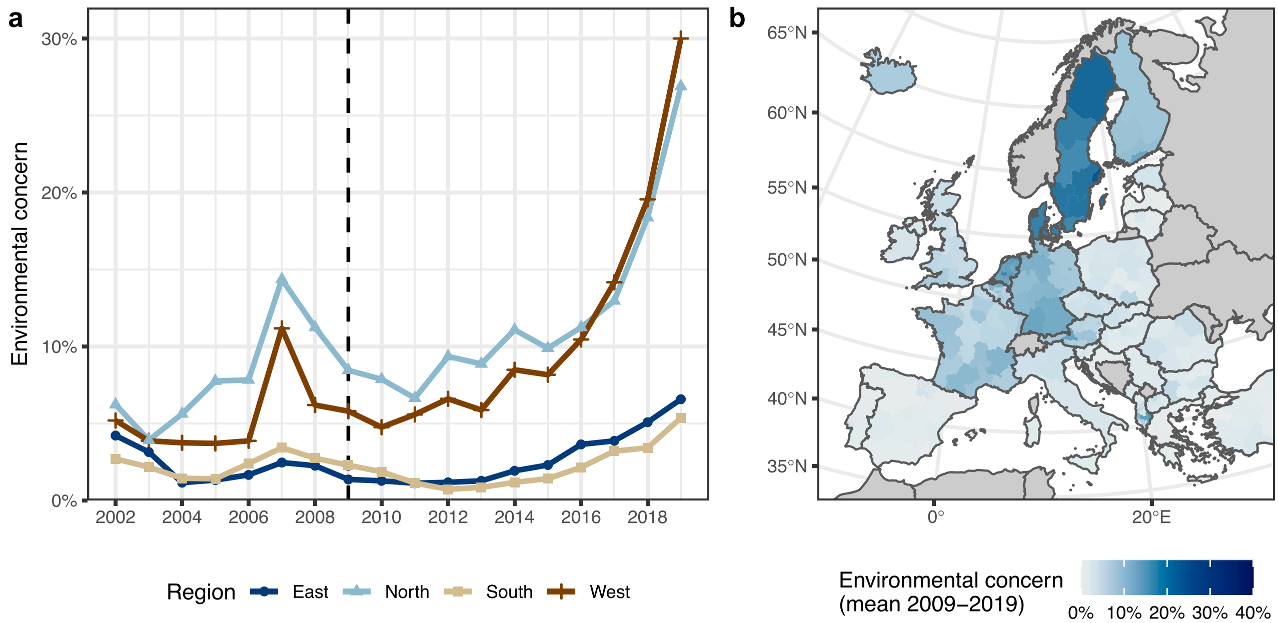

Fig. 1. Levels of environmental concern based on Eurobarometer surveys in percent. (a) Time trends of the average share of environmentally concerned population in Eastern, Western, Northern, and Southern Europe. The dashed line indicates the begin of the analysis. (b) Regional averages over the time period 2009–2019. Respondents are considered to be environmentally concerned if they rank 'environment, energy, and climate change' as one of the two priorities for national policy-making.

cultural variables are important determinants of environmental attitudes, individuals are embedded in economic, social, and geographical contexts that shape their preferences. For instance, priorities may shift from climate change mitigation to economic policy in times of recession. Given a large number of variables that potentially affect environmental concern, a key aspect in identifying relevant regional characteristics is model uncertainty regarding the selection of variables from all potential covariates into the model.

In addressing model uncertainty and employing a rich data set on sub-national level, the paper makes several contributions to the literature. First, Bayesian model averaging (BMA) is used to explore the model space that is defined by the set of models with all possible combinations of covariates. The averaged parameter estimates are not contingent on one particular model specification chosen by the researcher but instead systematically account for model uncertainty. While previous studies focus on a few possible contextual influences at a time, this approach allows for determining which partial correlations are robust to changes in model specification. Second, the joint consideration and standardization of potential covariates allows for a comparison of their effect sizes, contributing to the consolidation of the body of literature. Here, the relative importance of different contextual and individual influences on environmental concern can be assessed. Third, the evidence is based on a panel of 206 European regions from 26 countries, which captures the heterogeneity of the contextual variables on the sub-national level and environmental concern over 25 survey waves between 2009 and 2019.

The results indicate that both socio-economic and environmental factors are robust partial correlates of concern for the environment. In low- and middle-income regions, higher GDP levels markedly raise environmental concerns. Wealth and income inequality are detrimental to the prioritization of environmental policy, in particular at high levels of polarization. Environmental concern is higher in regions with low consumer price inflation and an industrial sector with low greenhouse gas intensity. Furthermore, regions with relatively young and well educated populations exhibit higher levels of concern. In terms of environmental characteristics, geographical vulnerability to natural hazards, such as low-elevation coast lines, and meteorological events, such as severe droughts, increase environmental concern. The findings should be interpreted as partial correlations, not causal effects, since endogeneity cannot be ruled out for some variables.

The remainder of the paper is structured as follows. Section 2 reviews the literature on the socio-economic and environmental contextual drivers of environmental concern. Section 3 describes the data and the empirical strategy. Section 4 summarizes the results of the BMA, discusses the findings, and highlights their possible limitations. Finally, Section 5 concludes.

2. Contextual drivers of environmental concern

Numerous studies have previously explored the aggregate, contextual determinants of environmental concern with various methodological approaches, data sources, and country samples. Table 1 provides an overview of explanatory variables included in the models and the direction of the estimated effects. Most studies in this body of literature only consider a few contextual variables in isolation and employ varying model specifications. Accordingly, some of the differences in previous findings are likely to be driven by differences in research designs. However, the choice of variables in the literature informs the design of the model space in the following analysis.

Environmental concern, defined by Dunlap et al. (2002) as "the degree to which people are aware of problems regarding the environment and support efforts to solve them and/or willingness to contribute personally to their solution", can be operationalized in different ways. Schaffrin (2011) identifies two strands of literature, one in political science with a focus on public support for environmental policy, one in psychology with a focus on the detailed conceptualization of individual mental processes. Leaning towards the first of these perspectives, environmental concern is measured here as explicit prioritization of environmental issues over other issues for national policy-making at the time of the interview (Section 3.1.1). As such, it represents the consideration of a trade-off and evaluation of environmental policy as relatively important (Inglehart, 1995). Other possible measures of environmental concern include willingness to pay for environmental protection, beliefs about humans' embeddedness in natural systems, and engagement with

Table 1
Literature review of contextual variables and the signs of their effects on environmental concern. If a study analyzes several aspects of environmental concern, the table indicates the results regarding an evaluation of the (relative) importance of environmental problems.

	Estimated effect on environmental concern		
	Negative	Insignificant	Positive
Economy			
GDP per capita	Gelissen (2007), Sandvik (2008), Givens and Jorgenson (2011), Arıkan and Günay (2021)	Bravo and Marelli (2007), Shum (2012), Kvaløy et al. (2012), Franzen and Vogl (2013), Kim and Wolinsky-Nahmias (2014), Mayer and Smith (2017)	Franzen (2003), Brulle et al. (2012), Shum (2012), Marquart-Pyatt (2012), Duijndam and van Beukering (2020)
GDP growth		Franzen (2003), Sandvik (2008), Duijndam and van Beukering (2020)	Gelissen (2007), Givens and Jorgenson (2011), Mayer and Smith (2017), Shum (2012)
Unemployment rate	Brulle et al. (2012), Hamilton et al. (2010), Duijndam and van Beukering (2020), Scruggs and Benegal (2012)	Mildenberger and Leiserowitz (2017)	
Income inequality		Förster and Müller-Benedict (2021)	
Industrialization			Marquart-Pyatt (2012)
Agricultural share		Hamilton et al. (2010)	
Energy price		Mildenberger and Leiserowitz (2017), Brulle et al. (2012)	
Urbanization		Franzen and Vogl (2013)	
Environmental quality			
Greenhouse gas emission	Zahran et al. (2006), Sandvik (2008), Marquart-Pyatt (2012), Duijndam and van Beukering (2020)	Kvaløy et al. (2012), Brody et al. (2008)	Givens and Jorgenson (2011)
Ecological footprint		Marquart-Pyatt (2012)	
Air pollution		Gelissen (2007), Marquart-Pyatt (2012)	
Water quality		Marquart-Pyatt (2012)	Gelissen (2007), Marquart-Pyatt (2012)
Environmental quality index		Franzen and Vogl (2013)	Marquart-Pyatt (2012)
Environment			
Temperature anomaly		Brulle et al. (2012), Mildenberger and Leiserowitz (2017)	Egan and Mullin (2012), Li et al. (2011), Shum (2012), Scruggs and Benegal (2012), Deryugina (2013), Akerlof et al. (2013), Hamilton and Stampone (2013), Brooks et al. (2014), Bergquist and Warshaw (2019), Hoffmann et al. (2022)
Dry spell		Brulle et al. (2012)	Hoffmann et al. (2022)
Wet spell		Brulle et al. (2012), Hoffmann et al. (2022)	
Flood			Demski et al. (2016), Spence et al. (2011)
Wildfire		Brody et al. (2008)	
Disasters	Kvaløy et al. (2012)	Arıkan and Günay (2021)	Brody et al. (2008), Zahran et al. (2006), Konisky et al. (2015)
Climate Extremes Index		Brulle et al. (2012), Marquart-Pyatt et al. (2014)	
Flood plain	Brody et al. (2008)		
Low-elevation coast	Zahran et al. (2006)		Brody et al. (2008)
Climate change vulnerability	Kim and Wolinsky-Nahmias (2014)	Mayer and Smith (2017)	

pro-environmental activism (Marquart-Pyatt, 2015). Furthermore, environmental concern can refer to different spatial and temporal scales (Schaffrin, 2011). It may vary between local and global issues and between current and future issues. This paper analyzes concern about relatively abstract, global issues in the context of current national policy-making (see also Section 4.5).

In the following section, previous findings of contextual influences on environmental concern are discussed. For a review and meta analysis of individual-level covariates of environmental attitudes see, for instance, Hornsey et al. (2016). The review focuses on studies with similar measurement of environmental concern, that is, an evaluation of the (relative) seriousness of climate change and other abstract environmental issues while highlighting differences to environmental concern regarding local issues.

2.1. Economy and population

The post-materialism hypothesis of Inglehart (1990) states that values shift from material to immaterial concerns when income rises above subsistence level. The theory draws on Maslow's hierarchy of human needs and assumes environmental degradation to be a quality-of-life issue which is only attended to once basic needs are satisfied (Dunlap and York, 2008). In arguing that income growth enables environmental protection, the post-materialism hypothesis can be viewed as an ecological modernization theory (Givens and Jorgenson, 2011). Environmental quality here is conceptualized as a normal good for which demand increases with income level, in some cases as a superior good for which the share of allocated income increases with income level.

At the aggregate societal level, dominant values change through the replacement of older generations by younger ones that grow up under different socio-economic conditions, the so-called demographic metabolism (Lutz, 2013). Individual worldviews are assumed to be shaped by socialization and experiences in early life, for instance by material affluence or scarcity, and to only gradually change during adulthood (Inglehart, 1990). In this context, Lutz and Muttarak (2017) highlight the role of education to enable the large-scale transformations that climate change adaption entails.

Empirical studies suggest that the effect of the income level depends on the measurement of environmental concern. Concern with respect to general environmental problems relative to other general issues – the measurement also used in this study – rises with income level (Franzen, 2003; Brulle et al., 2012; Marquart-Pyatt, 2012; Duijndam and van Beukering, 2020). Franzen (2003) argues the reason for this finding could be twofold. Material affluence could indeed lead to the generational value shift hypothesized by Inglehart but also make it feasible to allocate more resources to environmental protection.

This does not imply, however, that environmental concern is limited to affluent regions. To accommodate the observed environmental concern in low-income contexts, Inglehart (1995) amended his theory to include environmental quality. In this objective problems–subjective values hypothesis, environmental concern is viewed as the product of two aspects: on the one hand of concrete, material problems, such as local pollution, and on the other hand of abstract, post-material values. Empirical evidence suggests that while prioritization of the environment in the abstract sense is positively related to income, concern for local environmental issues is also found in lower income contexts (Gelissen, 2007; Dunlap and York, 2008; Fairbrother, 2013).

While the income level has received much attention in the literature, the evidence regarding the role of the income distribution is relatively scarce. An extreme bounds analysis finds no robust impact of income inequality on water or air pollution (Gassebner et al., 2011). Using an index of willingness to contribute to environmental protection as outcome variable, Förster and Müller-Benedict (2021) suggest that the overall null effect could be the result of two opposing effects of income inequality. On the one hand, individuals as *rational* actors perceive environmental quality, that can generally be considered a public good, as increasingly private when inequality rises. They then could tend to be more willing to contribute to environmental protection since they can discriminate in its consumption and reduce free-riding to some extent. On the other hand, high economic inequality creates social tension and erodes public trust (Uslaner and Brown, 2005; Nannestad, 2008). Individuals as *social* actors could accordingly feel less tied to pro-environmental norms, thus exacerbating the free-rider problem due to lack of social cohesion.

Besides such relatively long-term processes, several studies investigate a short-term economy-environment trade-off, particularly in the context of economic instability (Inglehart, 1981). As apparent in Fig. 1a, there is considerable volatility of concerns over time which cannot be explained by slow-moving processes like changes in income level or distribution (Mildenberger and Leiserowitz, 2017; Scruggs and Benegal, 2012). Empirical studies find that unemployment rates are negatively related to environmental concern (Brulle et al., 2012; Hamilton et al., 2010; Scruggs and Benegal, 2012; Duijndam and van Beukering, 2020) while GDP growth rates are positively related (Gelissen, 2007; Shum, 2012; Mayer and Smith, 2017). Energy prices may be particularly salient with regard to a possible economy-environment trade-off, but the empirical evidence of such a link remains inconclusive (Brulle et al., 2012; Mildenberger and Leiserowitz, 2017).

2.2. Environmental quality

Some studies have investigated influences of environmental quality on attitudes following the objective problems–subjective values hypothesis. Brechin (1999) reports that residents of low-income countries perceived local issues like air, water, and soil pollution as more severe than residents of high-income countries, while he finds no significant difference with regard to abstract, global problems. Several studies find a negative correlation of greenhouse gas emissions and environmental concern (Zahran et al., 2006; Marquart-Pyatt, 2012; Duijndam and van Beukering, 2020), while others find no or a positive correlation (Brody et al., 2008; Givens and Jorgenson, 2011; Kvaløy et al., 2012). Similarly mixed are the results regarding measures of pollution, ecological footprint, or ecosystem well-being (Gelissen, 2007; Marquart-Pyatt, 2012). Since levels of greenhouse gas emissions and GDP are strongly positively correlated, Givens and Jorgenson (2011) test for effects of the ten-year change in emissions and find a small positive relationship while holding income constant.

Besides the multicollinearity of environmental degradation and economic output measures, most studies do not problematize the likely endogeneity of local environmental conditions and concerns. Furthermore, multidimensional indices and country-level measures are likely to cause aggregation bias and only poorly approximate local conditions. Due to the data and modeling limitations the results regarding the role of environmental quality in shaping environmental concern remain overall inconclusive.

2.3. Environmental change

A growing body of literature empirically links concerns and environmental change, in particular meteorological events in the context of climate change. The psychological mechanism underlying the relationships is conceptualized in terms of heuristics ('rules of thumb') and experience-based learning (Brooks et al., 2014). The premise of these hypotheses is that many pressing environmental issues today are of global scale and evolve over relatively long time spans, implying that individuals cannot immediately sense information to accurately assess the severity of the problems. Understanding issues like loss of biodiversity and global warming analytically, however, requires relatively abstract concepts and expert knowledge.

One possible strategy to reduce this cognitive complexity when judging the relative importance of such issues are availability heuristics (Tversky and Kahneman, 1973). Here an inaccessible attribute – the existence and seriousness of climate change for example – is substituted for a mentally associated, easily accessible one – the recent weather (Li et al., 2011; Deryugina, 2013). The closer in time and space an environmental attribute is, the more readily available it tends to be. In contrast to statistical evidence, direct sensory information activates experiential and emotional processing which tends to be more salient than rational processing (Marx et al., 2007). In turn, such higher issue salience is argued to reduce the psychological distance to climate change along spatial, temporal, social, and hypothetical dimensions (Spence et al., 2011; McDonald et al., 2015).

Most studies find a relatively modest, short-term effect of temperature anomaly on environmental concerns, ranging in duration from a week to a month (Howe et al., 2019). Li et al. (2011), for instance, report that experiment participants who thought it was warmer than usual had greater belief in climate change and were more concerned about it. In contrast, Deryugina (2013) finds exposure to temperature anomalies affect concerns only over longer time spans of several months. Brooks et al. (2014) draw attention to the possibly asymmetric effects of positive and negative temperature anomalies. They find that both colder and warmer weather lead to higher levels of concern, while Marlon et al. (2021) and Hoffmann et al. (2022) conclude that only positive anomalies and dry spells consistently affect climate change perception.

Furthermore, rapid-onset events such as floods and storms can sway public opinion. Using cross-sectional data, Spence et al. (2011) and Demski et al. (2016) show that British residents who experienced flooding were significantly more concerned about climate change. Konisky et al. (2015) reports a modest, positive impact of storms on concerns over a time span of one to four months. In a case study of Hurricane Irma, Hao et al. (2020) find that residents who perceived they were affected by the storm showed greater support for environmental policies, mediated by climate change belief. Studies with larger samples, however, do not find empirical evidence to support a generalization of the link of extreme events and climate change concern (Brulle et al., 2012; Marquart-Pyatt et al., 2014).

Finally, there are time-invariant region characteristics which can influence the prioritization of environmental issues. Static environmental factors that determine physical vulnerability to natural hazards have so far received relatively little attention in the literature (Kim and Wolinsky-Nahmias, 2014; Mayer and Smith, 2017). There is, however, tentative evidence that proximity to the coast and living in a low-elevation area that is susceptible to flooding positively correlates with climate policy support (Zahran et al., 2006) and climate change risk perception (Brody et al., 2008). Low-elevation coastal regions are more immediately exposed to some environmental hazards, in particular storm surges and the rising sea level.

Table 2
Variable description and summary statistics ($N = 455{,}931$). Level R indicates variables measured at regional level, N at national level, I at individual level. ARDECO is the Annual Regional Database of the European Commission, WID the World Inequality Database, EEA the European Environmental Agency, DFO the Dartmouth Flood Observatory, and FIRMS the Fire Information for Resource Management System.

Variable	Description	Level	Source	Min	25%	Mean	75%	Max	SD
Outcome									
Environmental concern	1 if environment, energy, and climate seen as priority	I	Eurobarometer	0.00	0.00	6.74	0.00	100.00	25.07
Economy									
GDP per capita	Gross domestic product (GDP), 10,000 EUR per capita at 2015 prices and purchasing power parity	R	ARDECO	7.77	18.45	27.61	33.90	81.88	12.44
GDP growth	Growth rate of real GDP per capita	R	ARDECO	−0.14	−0.01	0.01	0.03	0.27	0.04
Investment share	Share of gross fixed capital formation in GDP	R	ARDECO	0.08	0.18	0.21	0.23	0.71	0.04
Agricultural share	Share of agriculture (NACE A) in gross value added (GVA)	R	ARDECO	0.00	0.01	0.03	0.04	0.14	0.02
Industrial share	Share of industry (NACE B–F) in GVA	R	ARDECO	0.08	0.22	0.27	0.33	0.59	0.09
Agricultural GHG intensity	Greenhouse gas emission of agriculture (A), tonnes of CO_2 equivalents per 1000 euro real GVA	N	Eurostat	0.77	2.00	3.11	3.58	12.55	1.75
Industrial GHG intensity	Greenhouse gas emission of industry (B–F), tonnes of CO_2 equivalents per 1000 euro real GVA	N	Eurostat	0.26	0.61	1.20	1.45	4.87	0.94
Wealth inequality	Wealth of the top 10% over the wealth of the bottom 50%	N	WID	2.49	5.58	7.39	7.35	107.07	7.11
Wealth-income ratio	Ratio of net national wealth and net national income	N	WID	2.72	4.41	5.23	5.68	8.91	1.12
Income inequality	Income of the top 20% over the income of the bottom 20%	N	Eurostat	3.03	3.96	4.91	5.76	8.32	1.15
Unemployment rate	Unemployment rate	R	Eurostat	0.01	0.06	0.09	0.11	0.36	0.05
Consumer price inflation	12-month mean rate of change of all-item harmonized index of consumer prices (HICP)	N	Eurostat	−0.03	0.00	0.02	0.02	0.15	0.02
Energy price	Household price of 1 KWh electricity and 1 KWh gas	N	Eurostat	0.17	0.35	0.50	0.62	0.93	0.19
Population									
Share aged under 35	Share of population aged 34 or less	R	Eurostat	0.24	0.33	0.35	0.37	0.45	0.03
Urban population share	Share of population living in urban NUTS 3	R	Eurostat	0.00	0.00	0.33	0.61	1.00	0.36
Upper secondary edu. share	Share of population with ISCED 3–4	R	Eurostat	0.11	0.41	0.50	0.60	0.80	0.13
Tertiary education share	Share of population with ISCED 5–8	R	Eurostat	0.07	0.22	0.30	0.37	0.58	0.10
Land cover									
Flood plain	Share of area in 100-year flood plain	R	EEA	0.01	0.05	0.09	0.11	0.60	0.08
Low-elevation coast	Share of area in low-elevation coastal zone	R	EEA	0.00	0.00	0.10	0.13	0.94	0.15
Agricultural area	Share of area used for agriculture	R	EEA	0.01	0.35	0.47	0.63	0.85	0.18
Mining area	Share of area used for open-pit mining	R	EEA	0.00	0.00	0.00	0.00	0.01	0.00
Natural area	Share of natural and semi-natural areas	R	EEA	0.02	0.25	0.40	0.54	0.92	0.20
Meteorological events									
Dry spell	12-month mean of dry spell intensity (SPEI3)	R	SPEIbase	0.00	0.21	0.43	0.59	1.88	0.30
Wet spell	12-month mean of wet spell intensity (SPEI3)	R	SPEIbase	0.00	0.11	0.31	0.45	1.67	0.26
Warm spell	12-month mean length of warm spells	R	ERA5	0.00	0.75	1.66	2.42	6.08	1.11
Cold spell	12-month mean length of cold spells	R	ERA5	0.00	0.00	0.51	0.75	3.00	0.54
Snowfall anomaly	12-month mean of monthly snowfall z-scores	R	ERA5	−0.91	−0.33	−0.12	0.01	1.61	0.32
Wind storm	12-month mean share of area affected by days with sustained wind of at least 9 Beaufort	R	ERA5	0.00	0.00	0.00	0.00	0.07	0.00
Flood	12-month mean fraction of area affected by major flood	R	DFO	−0.00	0.00	0.01	0.00	0.25	0.03
Wildfire	12-month mean fraction of area burned by wildfire	R	FIRMS	−0.00	0.00	0.00	0.00	0.01	0.00
Summer/fall	1 if survey conducted June to November	R	Eurobarometer	0.00	0.00	0.52	1.00	1.00	0.50
Individual									
Age	Age	I	Eurobarometer	15.00	34.00	48.33	63.00	99.00	17.82
Female	1 if female	I	Eurobarometer	0.00	0.00	0.54	1.00	1.00	0.50
Secondary education	1 if finished education aged 18–20	I	Eurobarometer	0.00	0.00	0.41	1.00	1.00	0.49
Tertiary education	1 if finished education aged 21 or older	I	Eurobarometer	0.00	0.00	0.34	1.00	1.00	0.47
Children in household	1 if any child aged 14 or less in household	I	Eurobarometer	0.00	0.00	0.27	1.00	1.00	0.44
Difficulty paying bills	1 if difficulty to pay bills	I	Eurobarometer	0.00	0.00	0.36	1.00	1.00	0.48
Worker	1 if working class occupation	I	Eurobarometer	0.00	0.00	0.12	0.00	1.00	0.33
Urban community	1 if living in urban or intermediate community	I	Eurobarometer	0.00	0.00	0.68	1.00	1.00	0.47
Unemployed	1 if unemployed	I	Eurobarometer	0.00	0.00	0.13	0.00	1.00	0.34

3. Data and Methods

Bayesian model averaging (BMA) summarizes different model specifications into estimates that capture the uncertainty that stems from changes in model specification. As such, it is an explorative approach that requires that the model space defined by the data allows for a wide range of plausible models. In the following, the choice of variables is informed by the previous literature as well as theoretical considerations (see also Section 4.5). The units of analysis are individual survey respondents that are nested in subnational regions and countries. For a detailed list of regions and summary of the dataset structure see Appendix A. If possible, the contextual variables are included at the regional level in order to capture heterogeneity within countries. Table 2 provides a concise variable description and summary statistics.

3.1. Data

3.1.1. Environmental concern

The Eurobarometer surveys from 2009 to 2019 are harmonized to obtain a measure of environmental concern in the European population.

The survey is a repeated cross-section of the European population, sampled using a random, multistage procedure (GESIS, 2020). The outcome measure is based on the question "What do you think are the two most important issues facing [our country] at the moment?". Respondents are considered to be environmentally concerned if they rank the environment, energy, and climate change as one of the two most important challenges. Other answer categories include for instance unemployment, crime, education, immigration, and public health.

3.1.2. Economy and population

The first set of variables measures regions' economic characteristics. The Annual Regional Database of the European Commission (ARDECO) provides indicators of regional income and its composition (Commission, 2020). GDP is at constant 2015 prices and adjusted for differences in purchasing power between countries. GDP per capita and its growth rate are included in order to capture both the overall level and yearly changes of income. Furthermore, the share of income that is generated in three sectors broadly characterizes the economic structure of regions, namely agriculture (NACE code A), industry (B–F), and services (G–U), the latter being the omitted category in the regression. Further included is the investment share in GDP that comprises gross fixed capital formation across all sectors.

Besides income level, growth, and composition, the model space contains a measure of income distribution. Income inequality is expressed here as the equivalized disposable income of the top 20% over the income of the bottom 20% of the household distribution (Eurostat, 2022). In contrast to the Gini coefficient, that is most sensitive to changes in the middle of the distribution, the quintile ratio describes the relation of its tails. Data on wealth inequality comes from the World Inequality Database (WID) (Chancel et al., 2021). Net personal wealth of the top 10% over the net wealth of the bottom 50% is included in the model space as measure of wealth inequality. While the income ratio reflects differences in the flow of economic assets, the wealth ratio indicates differences in the stock of accumulated capital between the top and bottom of the distribution. Additionally, the net national wealth-to-income ratio is included to capture the capital intensity of an economy.

Further included are the regional unemployment rate, consumer price inflation, and biannual energy prices for household consumers (Eurostat, 2022). The energy price is defined as the added cost of one kilowatt hour electricity in the 2500–5000 kilowatt hour band and of one kilowatt hour gas in the 20–200 gigajoule band, including taxes.

As a measure of the environmental quality of production, the greenhouse gas intensities of the agricultural and industrial sector capture how dependent the regional economy is on fossil technology (Eurostat, 2022). This variable is defined as the emission of greenhouse gases in the respective economic sector, measured in tonnes of CO_2 equivalents per 1000 euro real gross value added.

3.1.3. Population and individual characteristics

Levels of concern can also be affected by demographic factors, such as age structure, educational attainment, and urbanization. These characteristics are measured respectively by the share of the population that is aged under 35, that has obtained upper or post-secondary education (ISCED 3–4), tertiary education (ISCED 5–8), and that lives in urban NUTS 3 regions according to Eurostat's degree of urbanization typology (Eurostat, 2022; Eurostat, 2018).

The model space comprises all individual demographic characteristics that are consistently available from the Eurobarometer over the period of analysis. These include age, gender, and education. Instead of the highest attained degree, the Eurobarometer provides the age at which a respondent has finished formal education. Here it is assumed that those respondents who finished their formal education at age 18–20 have obtained a upper or post-secondary degree and those who finished their education at age 21 or higher have obtained a tertiary degree. For respondents who were still studying at the time of the interview their current age is taken to determine their current level of education. Other included individual covariates are dummies for whether a child lives in the household, whether respondents were struggling to the pay bills at some point in the last 12 months, whether they have a working class occupation, whether they are currently unemployed, and whether they live in an urban or intermediate community.

3.1.4. Land cover, environmental quality, and meteorological events

Several variables capture time-variant and time-invariant regional characteristics that are related to vulnerability to natural hazards, the environmental quality of production technology, and exposure to meteorological events.

The time-invariant environmental variables approximate regional vulnerability to natural hazards. The regional fraction that is located within a 100-year flood plain measures the area that would be flooded every 100 years in the absence of protection measures (EEA, 2020b). The regional fraction within a low-elevation coastal zone refers to the area that is within 10 km distance from the coast and has an elevation of less than 50 meters (EEA, 2007). These areas are likely to be directly affected by sea level rise and other climate change-related extreme events. Furthermore, factors related to regional land use patterns are included based on the CORINE land cover map (EEA, 2020a). Four variables measure the share of artificial surfaces (CORINE 1–6, 8–11), open-pit mining (7), arable land, pastures, and agro-forestry (12–22), and natural and semi-natural areas (23–38), the first being the omitted category.

The time-variant variables gauge the meteorological conditions 12 months prior to a survey wave. The source of temperature data is the ERA5-Land reanalysis (Hersbach et al., 2020). It provides an 0.1° resolution grid that is interpolated from weather data using a global climate model. A warm spell is defined as a series of at least three days that exceed the 95th percentile of local, daily temperature means for the respective month in the reference period of 1971–2000. Similarly, a cold spell refers to at least three consecutive days below the 5th percentile. Dry and wet spells are captured by the monthly Standardized Precipitation-Evapotranspiration Index (SPEI) which is a measure of anomaly of the water balance, the potential evaporation and transpiration by vegetation subtracted from water input, accumulated over three months (Beguería et al., 2010). The measure is standardized using a log–logistic distribution for each month with 1971–2000 as reference period. Snowfall anomalies are monthly z-scores, given the same reference period (Hersbach et al., 2020). A variable indicating whether the survey was conducted in summer or fall is added to the model space to account for a possible seasonality of concerns.

The model space includes three types of rapid-onset events. The Dartmouth Flood Observatory (DFO) provides georeferenced data on areas affected by flood events (Brakenridge, 2019). It contains information on riverine and pluvial floods with an estimated return period above 20 years. The variable indicates the average fraction of a region that was affected by a flood event over the past 12 month. Similarly, the wildfire measure captures the average fraction of a region that was burned over past 12 month as indicated by the Fire Information for Resource Management System (FIRMS) (Giglio et al., 2018). Storms are derived from hourly 10 meter wind speeds of ERA5-Land (Hersbach et al., 2020). Storm intensity is measured as the daily mean fraction of the area that was affected by sustained wind above 9 Beaufort. Wind of this speed is considered to cause at least minor damage of vegetation and buildings.

3.1.5. Bivariate correlations of contextual variables

Fig. 2 visualizes the bivariate correlations of contextual variables, highlighting that most pairs exhibit only low levels of correlation with some exceptions. Notably, GDP per capita correlates strongly negatively with the agricultural share in gross value added (GVA), the greenhouse gas intensity of industrial production, and to a lesser extent with the unemployment rate, the industrial share in GVA, the income inequality, and energy price. Regions with higher GDP tend to have a higher share

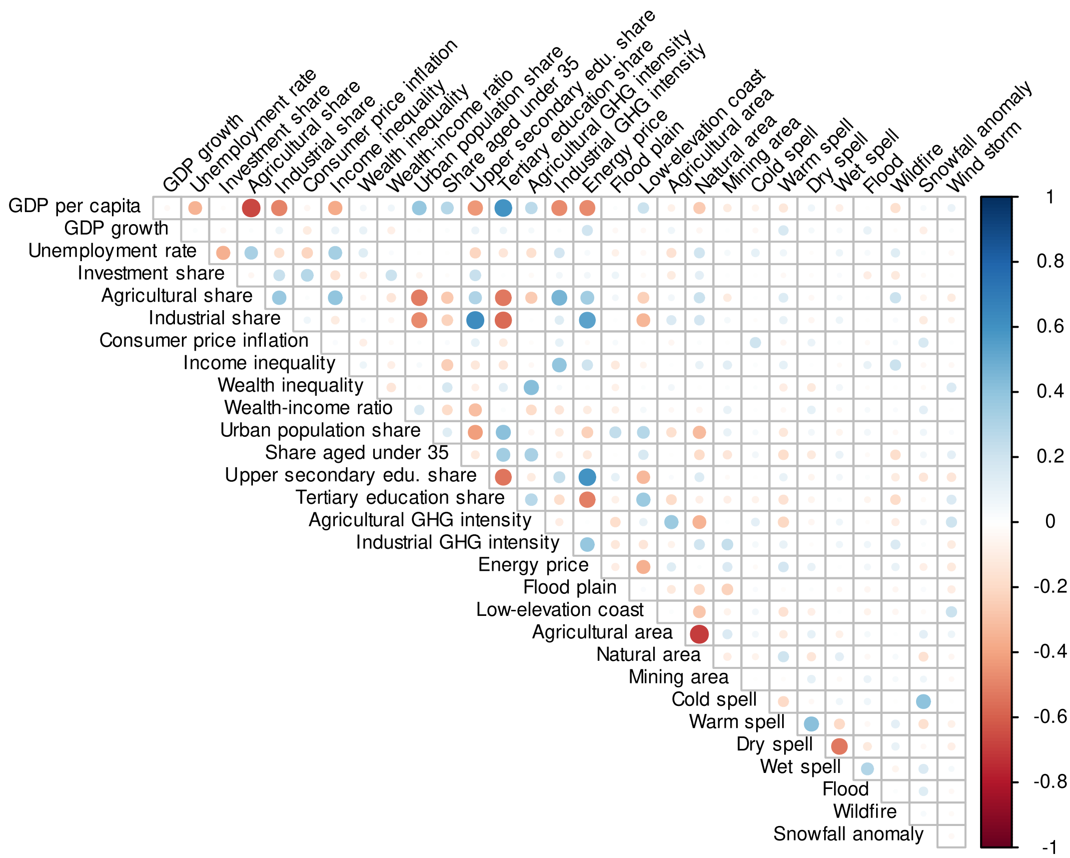

Fig. 2. Correlations of contextual variables as described in Table 2.

of population located in urban and intermediate settlements and with tertiary education. The unemployment rate correlates positively with the agricultural share in GVA and income inequality, and correlates negatively with the secondary education share as well the share of capital formation in GVA.

In regions with a strong economic focus on the agricultural sector, relatively few people live in urban settlements and have attained tertiary education. These regions tend to have a relatively high income inequality and greenhouse gas-intensive industrial production. Similarly, the importance of industrial production correlates negatively with urbanity and tertiary education but correlates positively with secondary education and the energy price. Capital-intensive countries, as indicated by a high net wealth-to-income ratio, have less greenhouse gas-intensive economies, a lower share of population with only secondary education, and lower wealth inequality. Among the environmental variables, agricultural land use and semi-natural areas correlate strongly negatively. Furthermore, the correlations indicate that warm spells tend to coincide with droughts as well as wet spells with flood events. Positive snowfall anomalies are associated with cold spells.

3.2. Empirical strategy

The linear model

$$y = \alpha + X\beta + T\delta + \varepsilon \tag{1}$$

is estimated where y indicates whether a respondent is environmentally concerned, X is the $N \times K$ matrix of covariates, and T is a matrix of year dummies which account for the European-wide trend. In addition to the variables summarized in Table 2, X includes the quadratic term of each continuous variable to account for possible non-linearities. Dependent sampling from the model space and BMA are used to determine which of the variables in X are robust partial correlates of environmental concern (Fernandez et al., 2001; Zeugner and Feldkircher, 2015). Sampling from the model space is necessary since it is computationally not feasible to average over all 2^K possible models.

The posterior distribution of the coefficients based on these models is

$$p(\beta_l|y) = \sum_r p(\beta_l|y, M_r)p(M_r|y) \tag{2}$$

where $p(\beta_l|y)$ is an average over all sampled models M_r, weighted with the posterior probability of the respective model $p(M_r|y)$. Accordingly, those models that fit the data well given their size receive a higher weight in the summary statistic than those that fit relatively poorly. The prior of β_l is $\mathcal{N}(0, \sigma^2(gX'X)^{-1})$, implying no assumption regarding the sign of the coefficient.

Using Bayes' rule, the posterior model probability (PMP) can be expressed as

$$p(M_r|y) = \frac{p(y|M_r)p(M_r)}{\sum_r p(y|M_r)p(M_r)} \propto p(y|M_r)p(M_r). \tag{3}$$

The PMP is proportional to the product of the marginal likelihood of the model $p(y|M_r)$ and the prior belief about the model probability $p(M_r)$ since the denominator is a normalizing constant which does not affect the shape of the posterior distribution.

The g-prior determines how strongly to penalize larger models given a particular goodness of fit, respectively how strongly to prefer models with better fit given a particular model size k (Zellner, 1986). The unit information prior $g = 1/N$ is chosen here suggesting that each observation carries equal information about β_l. In a simulation experiment, Fernandez et al. (2001) find that the unit information prior is appropriate if the number of observations is much larger than the number of potential covariates.

$p(M_r)$ can be set to $1/2^K$ if no prior information of model probabil-

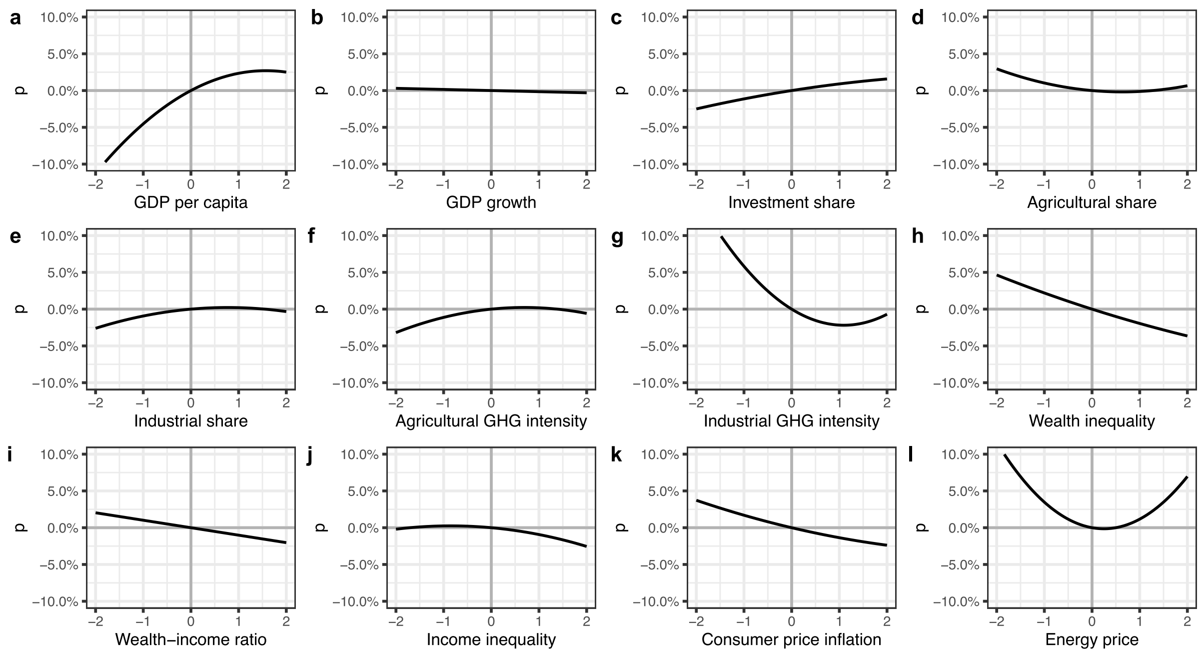

Fig. 3. Bayesian model averages of contextual economic effects on environmental concern with unit information prior and random θ with $\bar{k} = K/2$. The outcome variable indicates whether a Eurobarometer respondent sees the environment, energy, and climate change as priority for national policy-making. The continuous independent variables are centered and scaled to unit variance before estimation to obtain standardized parameters. Accordingly, a value of 1 on the x-axis refers to the value 1 standard deviation above the sample mean of the covariate. The slope of a curve indicates the marginal effect of a change in the respective covariate at the given level on the probability of a respondent being concerned in percentage points. Table B.4 in the appendix reports the posterior inclusion probability, the posterior coefficient means, the posterior standard deviation, and the transformed coefficient for each term included in the model.

ities exists since by assumption $\sum_r p(M_r) = 1$. This choice corresponds to $p(M_r) = \theta^k(1-\theta)^{K-k}$ with $\theta = 1/2$ where θ is the inclusion probability of each covariate and k the model size of M_r. Fixing θ at this value implies that models of size around $K/2$ receive most of the weight because most possible combinations of covariates are around this model size. If the model space is relatively large, $K/2$ can be perceived as too large and motivate giving higher weights to more stringent models. In many other cases, there is no reason to have a specific preference regarding model size, motivating the use of hyper-priors that make the prior assumptions more flexible. θ is a priori assumed to follow a beta distribution $Be(a, b)$ with $a = 1$ and $b = (K - \bar{k})/\bar{k}$, where $\bar{k}$ is the expected model size (Ley and Steel, 2009). Here, $\bar{k}$ is set to $K/2$ which leads a uniform prior distribution of the the model size.

For sampling, a Random Walk Metropolis-Hastings algorithm is used that starts with the model of size $k = K$. Each step, the current model M_r is compared to a candidate model M_s that is formed by randomly selecting one of the K variables in X. Depending on whether this variable is already part of M_r, it is either added or dropped to form the candidate M_s. If M_s has a higher PMP, the algorithm moves to it, adopting it as M_r in the next step. If M_s has a lower PMP, the algorithm moves to it with the probability equal to the ratio of the PMPs of M_s and M_r. Higher order polynomials are treated as interaction terms and only considered jointly with the lower order polynomials. Accordingly, the interaction sampler follows the strong heredity principle of only including interaction terms with their parent terms (Chipman, 1996; Crespo Cuaresma, 2011). The first iterations of the sampling procedure (burn-ins) are discarded since the initial model could be far from the maximum of the PMP.

4. Results

The following section presents the BMA results with 1 million burn-in iterations which are discarded and 2 million iterations on which the posterior inference is based. The posterior mean and standard deviation (SD) of the coefficients are weighted averages of all iterations. Over 210,000 models are sampled from the 2^{81} possible models with a mean model size of 62, including the period effects and quadratic terms. The correlation between the PMPs of the top 500 models and their sampling frequencies is 0.99, indicating convergence to a maximum of the PMP. The posterior model mass is concentrated on relatively few models, with the top 100 models accounting for 41% of PMP, the top 500 models for 66%.

Covariates are selected as robust based on their posterior inclusion probabilities (PIP), which is the sum of posterior model probabilities of those models that include the respective variable, and their transformed coefficient, which is the absolute value of their Mean/SD. The criteria for selection are a PIP > 0.5 and Mean/SD > 1.6. The first criterion implies that more than half of the posterior model mass rests on models including the covariate, the latter mimics the 90% confidence interval of the frequentist approach (Raftery, 1995; Masanjala and Papageorgiou, 2008).

If only the linear term is robust to model uncertainty but not the corresponding quadratic term, a linear partial correlation of the covariate with environmental concern is assumed. If both the linear and the quadratic term of a variable meet the selection criteria, the covariate is interpreted to have quadratic relationship with the outcome. Accordingly, the more complex functional form is only selected if it sufficiently improves model fit over the linear form, given the larger model size.

Figs. 3–5 based on Table B.4 in the appendix visualize the estimates. All continuous independent variables are centered and scaled to unit variance before estimation, resulting in standardized coefficients. The slope of a curve indicates the marginal effect of a change in the respective covariate at the given level on the probability of a respondent being concerned in percentage points. Marginal effects refer here to robust partial correlations. Period effects and non-robust correlates are not shown.

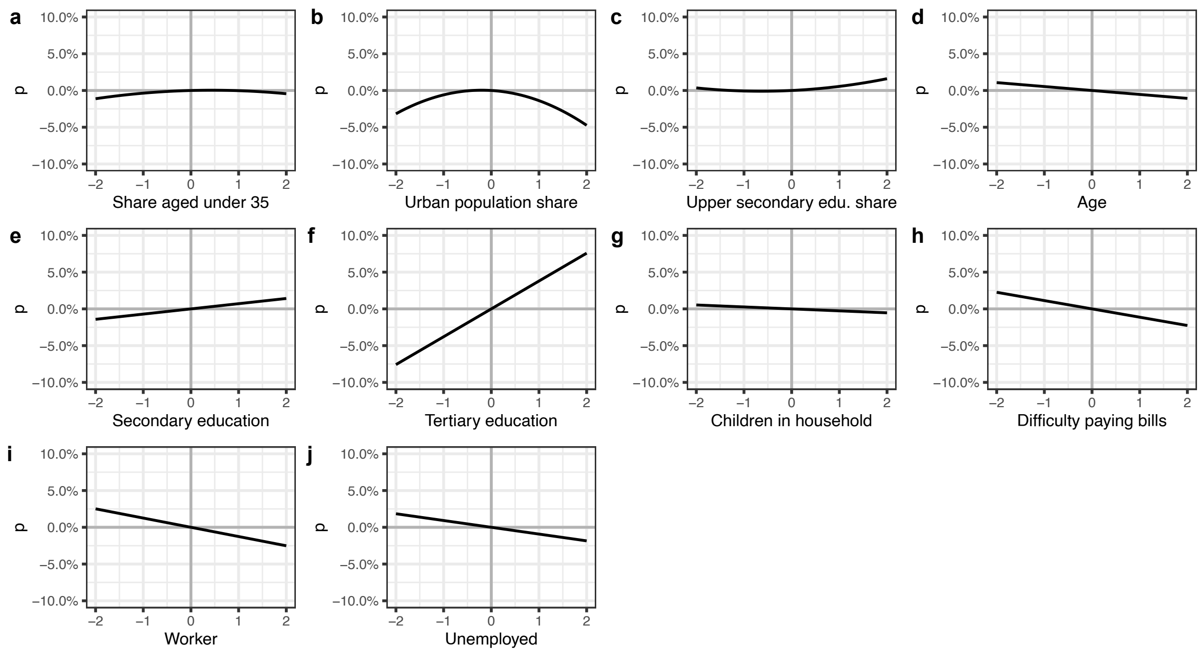

Fig. 4. Bayesian model averages of demographic effects on environmental concern with unit information prior and random θ with $\overline{k} = K/2$. The outcome variable indicates whether a Eurobarometer respondent sees the environment, energy, and climate change as priority for national policy-making. The continuous independent variables are centered and scaled to unit variance before estimation to obtain standardized parameters. Accordingly, a value of 1 on the x-axis refers to the value 1 standard deviation above the sample mean of the covariate. The slope of a curve indicates the marginal effect of a change in the respective covariate at the given level on the probability of a respondent being concerned in percentage points. Table B.4 in the appendix reports the posterior inclusion probability, the posterior coefficient means, the posterior standard deviation, and the transformed coefficient for each term included in the model.

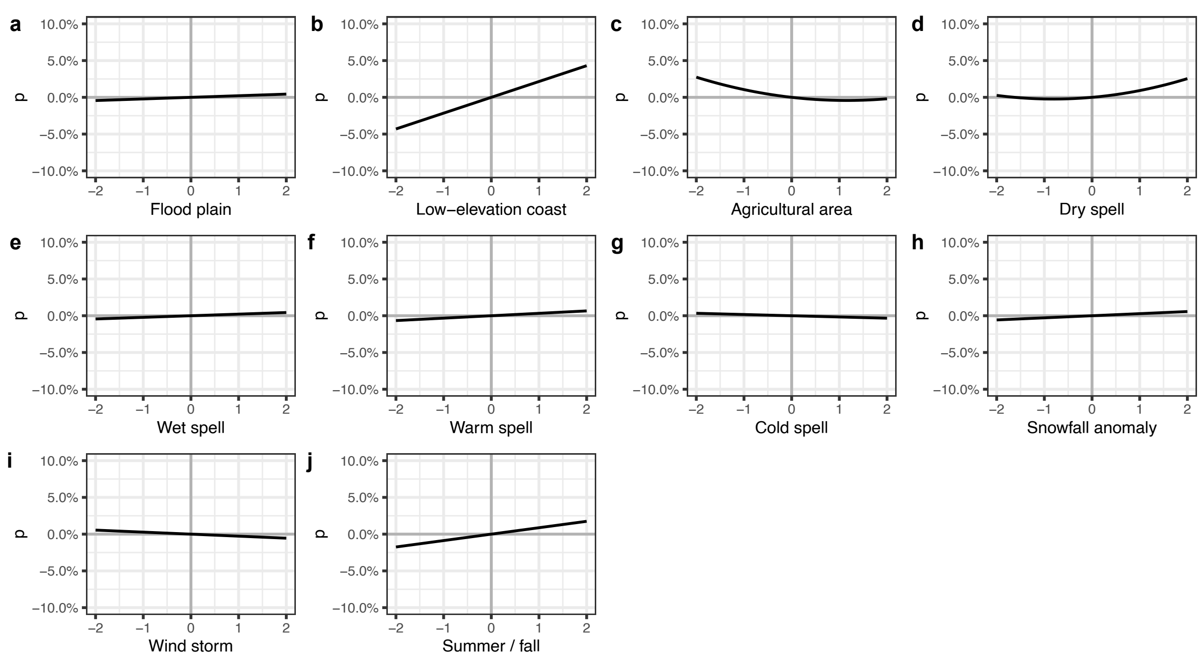

Fig. 5. Bayesian model averages of contextual environmental effects on environmental concern with unit information prior and random θ with $\overline{k} = K/2$. The outcome variable indicates whether a Eurobarometer respondent sees the environment, energy, and climate change as priority for national policy-making. The continuous independent variables are centered and scaled to unit variance before estimation to obtain standardized parameters. Accordingly, a value of 1 on the x-axis refers to the value 1 standard deviation above the sample mean of the covariate. The slope of a curve indicates the marginal effect of a change in the respective covariate at the given level on the probability of a respondent being concerned in percentage points. Table B.4 in the appendix reports the posterior inclusion probability, the posterior coefficient means, the posterior standard deviation, and the transformed coefficient for each term included in the model.

4.1. Economic covariates

The results indicate that macro-economic conditions affect respondents' probability of prioritizing environmental policy (Fig. 3). Rising GDP level has a large positive effect on environmental concern in low- and middle-income regions (panel a). The effect, however, diminishes and GDP does not further contribute to environmental concern beyond an income of about 40 thousand euro per capita. Similar diminishing effects are estimated for measures of economic composition and production technology (panel c–g). Increases in the investment and industrial share positively affect concern in regions with low capital formation and industrialization. As the agricultural sector becomes economically less important and more greenhouse gas-intensive, environmental concern increases but only initially. While agricultural greenhouse gas-intensity has a positive slope, industrial emission intensity has a strong negative effect which diminishes to zero at higher levels.

Not only the income level of a region, also the distributions of income and wealth robustly correlate with environmental concern (panel h–j). While wealth inequality exhibits an almost linear negative effect, income inequality becomes particularly detrimental to concerns when it reaches high levels. Furthermore, environmental concern declines in countries with higher capital intensity, that is, when the ratio of the accumulated capital to net income rises.

Consumer price inflation in general and energy prices in particular are found to be robust partial correlates of environmental concern (panel k–l). The negative slope of inflation is moderate and close to linear. Energy prices, however, have strong negative effects on the prioritization of environmental policy only at low prices but positive effects once prices reach a certain level, resulting in a u-shaped curve.

4.2. Population and individual covariates

Several demographic characteristics affect environmental concern (Fig. 4). Younger respondents and those living in regions with a higher share of its population below age 35 have a slightly higher probability of indicating concern (panel a and d). Urbanization correlates positively with concerns in relatively rural regions, a relationship that is reversed in relatively urban contexts (panel b). Secondary education at both individual and population level slightly increases environmental concern (panel c and e). Much stronger, however, is the positive effect of individual tertiary education which increases the probability of being concern with environmental policy by 3.8 percentage points, compared to finishing formal education under the age of 18 (panel f).

While the regional unemployment rate does not robustly correlate with concerns, individuals who are unemployed, have a working class occupation, struggle to pay the bills, and live with young children in the household show a lower probability of being concerned with environmental policy (panel g–j). Gender is found not to have a robust correlation with concern in the European context, corroborating the results of Duijndam and van Beukering (2020).

4.3. Environmental covariates

Of the time-invariant environmental characteristics, low-elevation coast lines and flood plains raise environmental concern, the former markedly (Fig. 5, panel a and b). As such, the vulnerability of a region to environmental hazards related to these two variables can be considered to be an important driver of concerns. Similar to the agricultural share in GVA, agricultural land use correlates negatively with concern (panel c). Of the time-variate environmental variables, severe droughts increase environmental concern while milder dry spells do not have an effect (panel d). Wet spells, temperature anomalies, snowfall anomalies, and wind storms have robust coefficients but their effect size is small (panel e–i). As shown in panel j, there is some seasonal variation in environmental concerns, with the probability of prioritizing environmental policy increasing by 0.9 percentage points in the summer and fall months, compared to winter and spring.

4.4. Discussion

The results lend support to a Maslowian finite pool of worry in which concern about immediate needs like economic security displaces concern about higher-level needs like environmental protection (Marx et al., 2007). Individuals with only few economic resources show a lower probability of being concerned, as indicated by the negative effects of being unemployed, having a working class occupation, and struggling to pay the bills. Also rising prices of household consumption, in particular of relatively cheap energy, are found to be detrimental to environmental concern. The increase in environmental concern at high energy prices could be related to the measurement of the outcome variable which encompasses energy policy. The u-shaped curve could explain why previous studies that considered only a linear function did not find a significant effect of energy prices (Mildenberger and Leiserowitz, 2017; Brulle et al., 2012). More research is needed to better understand this relationship which is of high relevance given the transformation of the energy sector towards renewable sources and recent geo-political conflicts.

The direction of the aggregate income level effect is consistent with the prediction of the post-materialism hypothesis that favorable economic conditions bolster concerns. This finding, however, comes with the important qualification that higher GDP levels only contribute to environmental concern until a certain standard of living is reached. Not only the income level of a region, also its economic structure matters. In terms of composition, regions with a higher share of investment and of the industrial sector in real GVA tend to exhibit higher levels of environmental concern, potentially due to the economic opportunities that capital formation provides (Marquart-Pyatt, 2012). The negative effects of agricultural land use and agricultural GVA mirror these effects and could reflect the rise of environmental concerns as GDP increases and the economic composition shifts away from the primary sector.

As drivers that have so far received relatively little attention, income and wealth inequality have sizable negative effects on environmental concern. Since the quintile ratio captures the divide between the bottom and top of the income distribution, it arguably acts as a proxy for social cohesion and generalized trust, partly because the income extremes are likely to shape the perception of social inequality (Nannestad, 2008). In particular the relatively unequally distributed income in most former Soviet countries coincides with low trust in public institutions and low politicization of green issues (Marquart-Pyatt, 2012; McCright et al., 2015). Similarly, a high wealth-income ratio could relate to the polarization of society. Following the argument of Förster and Müller-Benedict (2021), this implies that in Europe social norms play a bigger role in determining environmental attitudes than the privatization of environmental quality, presumably since it is hardly possible to privatize accountability for global collective action problems like climate change mitigation and adaptation. The increasing marginal effect size of income inequality, however, suggests that Europeans only consider income inequality in the formation of their environmental attitudes once it passes a certain level. This is in contrast to the negative effects of wealth inequality and the wealth-income ratio that are detrimental to the prioritization of environmental policy regardless of their level.

Notable in terms of its size is the negative effect of industrial greenhouse-gas intensity. If the regional industry is relatively dependent on fossil technology, the costs of implementing mitigation policies could be perceived as relatively high (Brody et al., 2008; Duijndam and van Beukering, 2020). The higher transition costs could then lead to a crowding out of environmental concern if they are perceived as a relatively high burden for citizens in terms of immediate public costs or lower economic competitiveness during the transition (Zahran et al., 2006; Sandvik, 2008).

The estimated partial correlations of the demographic variables suggest that education and age structure of a region matter. In particular tertiary education markedly raises environmental concern. This could be the joint outcome of better science literacy, improved abstract thinking skills, and social norms in this group (McCright, 2010; Brulle et al., 2012; Marquart-Pyatt, 2012). Both on aggregate regional level and on individual level, concern declines with age. This reflects either a generational shift of more recent cohorts towards greater environmentalism or a life course process in which individuals' attitudes change as they get older. While these effects are not straightforward to disentangle due to the perfect multicollinearity of age, period, and cohort, previous findings suggest that individuals' aging drives the decline in environmental concern, possibly due to a greater acceptance of the status quo (Gray et al., 2019; Johnson and Schwadel, 2019).

In terms of meteorological events, the findings support the hypothesis that availability heuristics play a robust, but only small role in shaping environmental concern. Experience of salient attributes of climate change, such as heat and extreme weather, is expected to have a positive impact since such events are cognitively readily available when judging the relative importance of environmental policy (Marx et al., 2007; Spence et al., 2011; McDonald et al., 2015). In particular, severe droughts have a sizable positive impact in the European context but not milder dry spells. In the agricultural context, short-term adaptation to milder events may be possible while there is limited adaptation potential to severe droughts with regard to some crops in Europe, even in the long run (Moore and Lobell, 2014). Moreover, climate change is likely to be more salient in warm summer weather, while cold episodes may reduce its salience due to the mental connection of climate change with global warming. Besides higher issue salience, possible mechanisms underlying the weather and season effects are affect activation and a decreased psychological distance to climate change and environmental degradation (Sisco, 2021).

Besides such relatively minor effects, among the fixed geographical characteristics in particular low-elevation coastal zones are associated with considerably higher probability of ranking environmental policy as highly important. This could indicate that both past experiences of meteorological events and anticipation of future events make residents more concerned. This is likely related to the necessity of building and maintaining protective infrastructure like embankments. Beltrán et al. (2018) show that flood risk decreases the value of properties in the affected areas, in particular, in regions with recent flood events which could partly account for the increased prioritization of environmental policy. Given that Saari et al. (2021) find that risk perception and knowledge impact environmental concern, these two variables are plausible channels of the environmental effects.

4.5. Limitations

While there are stark differences in economic and environmental conditions between European regions in the sample, a limitation of this analysis is the range of observed regional characteristics. Europe represents a context of lower middle to upper income level. Accordingly, the results may not be generalizable to lower income contexts with absolute poverty which are likely to be qualitatively different. Inglehart (1981,1995) stated the post-materialism hypothesis explicitly for the global income distribution. Nevertheless, Europe offers considerable variation in regional context for which the results are applicable. For instance, the interquartile range of GDP adjusted for purchasing power ranges from 18 to 34 thousand euro per capita in the sample.

With regard to the model space, the dataset includes all potential economic and environmental variables that have been identified by the literature review and can be assumed to not be strongly affected by concerns in the short term. As such, measures that are likely to be direct results of individual environmental concern are not included. This applies, for instance, to the environmental quality of household consumption such as its greenhouse gas intensity (Marquart-Pyatt, 2012; Saari et al., 2021), political expression such as voting decisions (Marquart-Pyatt, 2012; McCright et al., 2015; Duijndam and van Beukering, 2020; Hoffmann et al., 2022), and media coverage of climate change (Brulle et al., 2012). Variables of environmental quality that are plausibly not immediately affected by the attitudes of the survey respondents, however, are included, for example the greenhouse gas intensity of industrial production and land use patterns. While the focus on explanatory variables that are not direct outcomes of individuals' concern for the environment can reduce endogeneity, it cannot rule it out. Accordingly, the results should be interpreted as robust partial correlations, not as causal effects.

The Eurobarometer trend question allows to construct a comprehensive dataset of Europeans' attitudes but is limited with regard to the detailed measurement of the multidimensional aspects of environmental concern. The answer category used to construct the outcome variable groups together attitudes about the environment generally, energy issues, and climate change, resulting in a relatively wide policy domain. Skogen et al. (2018) find that the concrete environmental issues of concern differ between social strata but that there is a large overlap of the most important elements of environmental protection, namely climate change in general, global warming, extreme weather, biodiversity loss, and pollution of air and water. Furthermore, the Eurobarometer question captures only concerns with regard to national policy-making that likely is focused more on abstract, global than on concrete, local issues.

Also the data on respondents' characteristics and attitudes that is collected in the Eurobarometer is limited and not suitable for a detailed analysis of individual-level drivers of environmental concern. For instance, respondents' value orientation is not available that has been argued to be an important source of coherence between different related environmental attitudes, in particular the New Ecological Paradigm scale (Stern et al., 1995; Hornsey et al., 2016; Xiao et al., 2018). This also applies to other possible psychological antecedents of environmental concern, namely environmental knowledge, risk perception, and the attitude towards science (Vainio and Paloniemi, 2014; Saari et al., 2021).

5. Conclusion

This paper investigates which regional characteristics are robust determinants of environmental concern in European regions from 2009 to 2019. The model space of socio-economic and environmental covariates is analyzed using Bayesian model averaging in order to obtain parameter estimates that take into account model uncertainty. The results overall lend support to the ecological modernization theory of Inglehart, underscoring that favorable economic conditions on both individual and aggregate level are a prerequisite for the prioritization of environmental protection. Besides the level of income, its distribution and sectoral structure robustly correlate with regional environmental concern.

Given the wide model space, the findings allow an assessment of the relative importance of the covariates of environmental concern in European regions. In low- and middle-income regions, GDP is one if the strongest drivers of concern. However, wealth and income inequality, industrial greenhouse gas intensity, consumer price inflation, and energy prices have effects of similar magnitude, highlighting the multifaceted nature of the socio-economic influences. Of the environmental variables, low elevation coastal zones and summer months are found to exhibit the biggest effects. In comparison to these economic and environmental determinants, the exposure to most types of extreme weather events, such as warm, cold, or wet spells, is negligible. More research is needed, however, to better understand some of the relationships, in particular those with pronounced non-linearities. For instance, the detrimental impact of wealth and income inequality on environmental concern is so far understudied.

The findings highlight the embeddedness of people into a socio-economic and environmental context with important implications for the design and communication of policy. Environmental policies that lead to lower income level, more inequality, or higher energy prices are likely to be unpopular and decrease environmental concern in favor of economic interests. Thus, co-benefits of the efforts to curb global warming and environmental degradation in general should be emphasized. For instance, positive employment effects of renewable energy production can be communicated more prominently to avoid the crowding out of environmental concerns in the transition away from fossil infrastructure.

Furthermore, regional environmental events can help to better communicate climate policy. The estimates indicate that in particular severe droughts positively correlate with concern. Accordingly, unusually dry and warm periods can illustrate future consequences of climate change and appeal to experiential processing. This, in turn, could help to reduce Europeans' psychological distance to abstract notions of environmental degradation and ultimately bolster individual behavioral change as well as the support for pro-environmental policy.

Data and code availability

The data and R script to generate and visualize the results reported in this study are available at the Harvard Dataverse: 10.7910/DVN/N6JQM0. All used libraries are cited in the script.

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Data description

Table A.3 provides a summary of the structure of the unbalanced panel that is used in the aggregate level analysis. The region grouping is used in Fig. 1 to visualize time trends across Europe. The number and level of Nomenclature des unités territoriales statistiques (NUTS) regions indicates how many units are included for each country and at what level the data is aggregated, mostly NUTS 2, depending on what information is available from the Eurobarometer raw data. The number of surveys and start of the time series indicates how many survey waves included the relevant trend question and in what year the first survey of the series was conducted.

The survey data from the Eurobarometer and the meteorological data is assigned to a panel of NUTS regions with monthly frequency. The regional and national variables that are measured annually or biannually are included at a six-month lag to further reduce potential endogeneity. The environmental variables are aggregated over the 12 months preceding each survey wave in a region. For those variables that are measured at national level, the same value is assigned to each corresponding region-month. Similarly, individuals are nested in regions and countries for the linear probability model.

Although the Eurobarometer series reaches further back as shown in Fig. 1, 2009 was chosen as the starting point based on the availability of the covariates that span the model space. For three relatively time-invariant variables missing values were imputed by carrying the last observation forward, then backward if no previous observation is available. This applies to the Eurostat data sets regarding educational attainment (edat_lfs_9918) and age structure (demo_r_pjangrp3) on regional level and sectoral greenhouse gas emissions on country level (env_ac_ainah_r2).

The dataset includes the following regions:

Austria: Burgenland (AT11), Niederösterreich (AT12), Wien (AT13), Kärnten (AT21), Steiermark (AT22), Oberösterreich (AT31), Salzburg (AT32), Tirol (AT33), Vorarlberg (AT34), **Belgium**: Région de Bruxelles-Capitale/ Brussels Hoofdstedelijk Gewest (BE10), Prov. Antwerpen (BE21), Prov. Limburg (BE22), Prov. Oost-Vlaanderen (BE23), Prov. Vlaams-Brabant (BE24), Prov. West-Vlaanderen (BE25), Prov. Brabant wallon (BE31), Prov. Hainaut (BE32), Prov. Liège (BE33), Prov. Luxembourg (BE34), Prov. Namur (BE35), **Bulgaria**: Severozapaden (BG31), Severen tsentralen (BG32), Severoiztochen (BG33), Yugoiztochen (BG34), Yugozapaden (BG41), Yuzhen tsentralen (BG42), **Croatia**: Croatia (HR), **Cyprus**: Kypros (CY00), **Czechia**: Praha (CZ01), Strední Cechy (CZ02), Jihozápad (CZ03), Severozápad (CZ04), Severovýchod (CZ05), Jihovýchod (CZ06), Strední Morava (CZ07), Moravskoslezsko

Table A.3
Summary of the data structure. The region column indicates the grouping used in Fig. 1. The number and level of NUTS regions refers to the Nomenclature des unités territoriales statistiques. The number of surveys and the series start indicate how many Eurobarometer waves are included and when the first included one was conducted in a given country. The number of observations refers to the number of respondents included in the analysis.

	Country	Region	Num. NUTS	NUTS level	Num. surveys	Series start	Obs.
1	Bulgaria	East	6	2	24	2009	19689
2	Croatia	East	1	0	24	2009	19389
3	Czechia	East	8	2	25	2009	20110
4	Estonia	East	1	2	24	2009	19902
5	Latvia	East	6	3	24	2009	20264
6	Lithuania	East	10	3	15	2013	11779
7	Poland	East	17	2	25	2009	19663
8	Romania	East	8	2	25	2009	16703
9	Slovakia	East	4	2	24	2009	20278
10	Slovenia	East	12	3	21	2010	16770
11	Denmark	North	1	0	24	2009	18823
12	Finland	North	4	2	24	2009	18777
13	Ireland	North	1	0	16	2009	10693
14	Sweden	North	8	2	24	2009	19031
15	United Kingdom	North	12	1	25	2009	26355
16	Cyprus	South	1	2	24	2009	7774
17	Greece	South	10	2	25	2009	15840
18	Italy	South	5	1	24	2009	15265
19	Portugal	South	5	2	25	2009	10162
20	Spain	South	16	2	25	2009	13471
21	Austria	West	9	2	24	2009	19219
22	Belgium	West	11	2	24	2009	18258
23	France	West	21	2	25	2009	18947
24	Germany	West	16	1	25	2009	29501
25	Luxembourg	West	1	2	24	2009	9387
26	Netherlands	West	12	2	25	2009	19881

(CZ08), **Denmark**: Denmark (DK), **Estonia**: Eesti (EE00), **Finland**: Länsi-Suomi (FI19), Helsinki-Uusimaa (FI1B), Etelä-Suomi (FI1C), Pohjois- ja Itä-Suomi (FI1D), **France**: Île de France (FR10), Centre - Val de Loire (FRB0), Bourgogne (FRC1), Franche-Comté (FRC2), Basse-Normandie (FRD1), Haute-Normandie (FRD2), Nord-Pas-de-Calais (FRE1), Picardie (FRE2), Alsace (FRF1), Champagne-Ardenne (FRF2), Lorraine (FRF3), Pays-de-la-Loire (FRG0), Bretagne (FRH0), Aquitaine (FRI1), Limousin (FRI2), Poitou–Charentes (FRI3), Languedoc-Roussillon (FRJ1), Midi-Pyrénées (FRJ2), Auvergne (FRK1), Rhône-Alpes (FRK2), Provence-Alpes-Côte d'Azur (FRL0), **Germany**: Baden-Württemberg (DE1), Bayern (DE2), Berlin (DE3), Brandenburg (DE4), Bremen (DE5), Hamburg (DE6), Hessen (DE7), Mecklenburg-Vorpommern (DE8), Niedersachsen (DE9), Nordrhein-Westfalen (DEA), Rheinland-Pfalz (DEB), Saarland (DEC), Sachsen (DED), Sachsen-Anhalt (DEE), Schleswig–Holstein (DEF), Thüringen (DEG), **Greece**: Attiki (EL30), Kriti (EL43), Anatoliki Makedonia, Thraki (EL51), Kentriki Makedonia (EL52), Dytiki Makedonia (EL53), Ipeiros (EL54), Thessalia (EL61), Dytiki Ellada (EL63), Sterea Ellada (EL64), Peloponnisos (EL65), **Ireland**: Ireland (IE), **Italy**: Nord-Ovest (ITC), Sud (ITF), Isole (ITG), Nord-Est (ITH), Centro (ITI), **Latvia**: Kurzeme (LV003), Latgale (LV005), Riga (LV006), Pieriga (LV007), Vidzeme (LV008), Zemgale (LV009), **Lithuania**: Vilniaus apskritis (LT011), Alytaus apskritis (LT021), Kauno apskritis (LT022), Klaipedos apskritis (LT023), Marijampoles apskritis (LT024), Panevezio apskritis (LT025), Siauliu apskritis (LT026), Taurages apskritis (LT027), Telsiu apskritis (LT028), Utenos apskritis (LT029), **Luxembourg**: Luxembourg (LU00), **Netherlands**: Groningen (NL11), Friesland (NL12), Drenthe (NL13), Overijssel (NL21), Gelderland (NL22), Flevoland (NL23), Utrecht (NL31), Noord-Holland (NL32), Zuid-Holland (NL33), Zeeland (NL34), Noord-Brabant (NL41), Limburg (NL42), **Poland**: Malopolskie (PL21), Slaskie (PL22), Wielkopolskie (PL41), Zachodniopomorskie (PL42), Lubuskie (PL43), Dolnoslaskie (PL51), Opolskie (PL52), Kujawsko-Pomorskie (PL61), Warminsko-Mazurskie (PL62), Pomorskie (PL63), Lódzkie (PL71), Swietokrzyskie (PL72), Lubelskie (PL81), Podkarpackie (PL82), Podlaskie (PL84), Warszawski stoleczny (PL91), Mazowiecki regionalny (PL92), **Portugal**: Norte (PT11), Algarve (PT15), Centro (PT16), Área Metropolitana de Lisboa (PT17), Alentejo (PT18), **Romania**: Nord-Vest (RO11), Centru (RO12), Nord-Est (RO21), Sud-Est (RO22), Sud - Muntenia (RO31), Bucuresti - Ilfov (RO32), Sud-Vest Oltenia (RO41), Vest (RO42), **Slovakia**: Bratislavský kraj (SK01), Západné Slovensko (SK02), Stredné Slovensko (SK03), Východné Slovensko (SK04), **Slovenia**: Pomurska (SI031), Podravska (SI032), Koroska (SI033), Savinjska (SI034), Zasavska (SI035), Posavska (SI036), Jugovzhodna Slovenija (SI037), Primorsko-notranjska (SI038), Osrednjeslovenska (SI041), Gorenjska (SI042), Goriska (SI043), Obalno-kraska (SI044), **Spain**: Galicia (ES11), Principado de Asturias (ES12), Cantabria (ES13), País Vasco (ES21), Comunidad Foral de Navarra (ES22), La Rioja (ES23), Aragón (ES24), Comunidad de Madrid (ES30), Castilla y León (ES41), Castilla-la Mancha (ES42), Extremadura (ES43), Cataluca (ES51), Comunidad Valenciana (ES52), Illes Balears (ES53), Andalucía (ES61), Región de Murcia (ES62), **Sweden**: Stockholm (SE11), Östra Mellansverige (SE12), Småland med öarna (SE21), Sydsverige (SE22), Västsverige (SE23), Norra Mellansverige (SE31), Mellersta Norrland (SE32), Övre Norrland (SE33), **United Kingdom**: North East (UKC), North West (UKD), Yorkshire and The Humber (UKE), East Midlands (UKF), West Midlands (UKG), East of England (UKH), London (UKI), South East (UKJ), South West (UKK), Wales (UKL), Scotland (UKM), Northern Ireland (UKN).

Appendix B. Additional results

Table B.4
Bayesian model averages of contextual environmental effects on environmental concern with unit information prior and random θ with $\bar{k} = K/2$. Robust terms are indicated by bold font. The outcome y indicates whether a Eurobarometer respondent sees the environment, energy, and climate change as priority for national policy-making. The continuous independent variables are centered and scaled to unit variance before estimation to obtain standardized parameters.

Variable	PIP	Post. mean	Post. SD	Mean/SD
Age	1.000	−0.537	0.045	11.952
Age^2	0.275	0.030	0.053	0.572
Agricultural area	1.000	−0.735	0.110	6.673
Agricultural area^2	1.000	0.318	0.062	5.145
Agricultural GHG intensity	1.000	0.653	0.142	4.610
Agricultural GHG intensity^2	1.000	−0.472	0.032	14.542
Agricultural share	1.000	−0.575	0.124	4.633
Agricultural share^2	1.000	0.452	0.033	13.613
Cold spell	0.941	−0.167	0.095	1.751
Cold spell^2	0.238	−0.020	0.039	0.521
Consumer price inflation	1.000	−1.527	0.078	19.616
Consumer price inflation^2	1.000	0.168	0.017	9.988
Dry spell	1.000	0.570	0.070	8.093
Dry spell^2	1.000	0.351	0.028	12.510
Energy price	1.000	−1.155	0.091	12.655
Energy price^2	1.000	2.318	0.052	44.994
Flood	0.009	0.000	0.006	0.058
Flood plain	1.000	0.218	0.125	1.745
Flood plain^2	0.333	0.020	0.030	0.655
Flood^2	0.000	0.000	0.001	0.014
GDP growth	0.914	−0.151	0.062	2.460
GDP growth^2	0.042	0.002	0.010	0.189
GDP per capita	1.000	3.437	0.171	20.072
GDP per capita^2	1.000	−1.092	0.051	21.241
Income inequality	1.000	−0.586	0.077	7.647
Income inequality^2	1.000	−0.344	0.049	7.030
Industrial GHG intensity	1.000	−3.997	0.130	30.801
Industrial GHG intensity^2	1.000	1.825	0.045	40.907
Industrial share	1.000	0.569	0.079	7.178
Industrial share^2	1.000	−0.368	0.046	8.045
Investment share	1.000	1.019	0.058	17.649
Investment share^2	1.000	−0.115	0.014	8.456
Low-elevation coast	1.000	2.152	0.093	23.043
Low-elevation coast^2	0.153	0.014	0.036	0.394
Mining area	0.156	−0.019	0.047	0.396
Mining area^2	0.002	0.000	0.001	0.038
Natural area	1.000	−0.127	0.119	1.074
Natural area^2	1.000	−0.542	0.063	8.544
Share aged under 35	1.000	0.170	0.055	3.114
Share aged under 35^2	1.000	−0.195	0.030	6.528
Snowfall anomaly	1.000	0.285	0.093	3.051
Snowfall anomaly^2	0.638	0.056	0.046	1.198
Tertiary education share	0.791	−0.213	0.136	1.569
Tertiary education share^2	0.779	0.134	0.079	1.685
Unemployment rate	1.000	0.016	0.094	0.166
Unemployment rate^2	1.000	0.326	0.027	12.279
Upper secondary edu. share	0.971	0.313	0.096	3.265
Upper secondary edu. share^2	0.968	0.244	0.070	3.476
Urban population share	1.000	−0.392	0.091	4.287
Urban population share^2	1.000	−0.989	0.095	10.409
Warm spell	1.000	0.329	0.058	5.640
Warm spell^2	0.016	−0.001	0.007	0.105
Wealth inequality	1.000	−2.072	0.175	11.824
Wealth inequality^2	1.000	0.124	0.012	10.321
Wealth-income ratio	1.000	−1.016	0.060	16.905
Wealth-income ratio^2	0.008	−0.000	0.005	0.059
Wet spell	0.986	0.219	0.062	3.532
Wet spell^2	0.101	−0.006	0.020	0.309
Wildfire	0.006	0.000	0.004	0.038
Wildfire^2	0.000	0.000	0.000	0.006
Wind storm	1.000	−0.274	0.118	2.314
Wind storm^2	0.204	−0.004	0.008	0.471

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