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Popular support for environmental protection: A life-cycle perspective*

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Abstract
Support for environmental protection is generally perceived as driven by cohort or generational effects. We argue and empirically illustrate that such attitudes *also* fluctuate over the life cycle. Using rotating panels of the Norwegian Election Studies (1989-2013), our analysis is able to identify such life-cycle effects *while controlling for cohort and period effects* through a methodological innovation exploiting the first-derivative properties of the environmental concern function. Our main findings provide strong evidence of an inverted U-shape over the life cycle, which implies that substantial population aging in advanced economies may partially offset any generational shift towards a greater emphasis on protecting the environment.

Key words: Population aging, Environment, Age-Period-Cohort.

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“Global warming is a total, and very expensive, hoax!”
(Donald J. Trump at age 67, 6 December 2013)

1. Introduction

Political preferences are often believed to be molded early in life, typically shaped by prevailing economic or other circumstances in this period (e.g., Inglehart 1971, 1981, 1990; Inglehart and Abramson 1994). For instance, birth cohorts socialized in times of relative abundance – such as the ‘baby boomers’ – are expected to have a stronger appreciation for non-material values including environmental protection. Earlier cohorts that “experienced war and economic hardship in their childhood years” are instead believed to be more materialistically oriented (Pampel and Hunter 2012: 422). A direct implication of such a generational focus is that political attitudes linked to non-material values – including support for environmental protection – will thrive in the immediate future as older materialist generations are replaced by younger cohorts with different values.

A vast literature has tried to pin down this proposition using (repeated) cross-sectional datasets on popular support for environmental protection (e.g., Gelissen 2007; Franzen and Meyer 2010; Pampel and Hunter 2012; Nawrotzki and Pampel 2013; Johnson and Schwadel 2019). However, such analyses must invoke heroic assumptions to separate between cohort, life-cycle and period effects due to the linear dependency of age and birth cohort at any point in time (Bell and Jones, 2014; Neundorf and Niemi 2014; Cheng et al. 2015). This is important since *life-cycle* effects may lead individuals to put different levels of emphasis on protecting the environment depending on their age and stage in life (Jagodzinski 1983; Torgler and Garcia-Valiñas 2007; Franzen and Meyer 2010).

Theoretically, we argue that investments in environmental protection yield long-term benefits, but are costly in the short term by constraining the use of natural resources and swaying investments away from more immediately profitable ventures. As long-term benefits are discounted more when one’s remaining life-span is shorter (Trostel and Taylor 2001; Read and Read 2004), the elderly will be less interested in investments in environmental protection – as indicated by Donald J. Trump's tweet cited above. However, young people may also discount the future more (Rogers 1994; Steinberg et al. 2009; de Water et al. 2014). They do not yet produce offspring (which reduces discounting of future environmental benefits; Read and Read 2004) and may not yet know or understand how risky/safe their world really is (which from an evolutionary perspective implies they are better off acting 'as if there is no tomorrow'; Sozou and Seymour 2003). Either way, moving from young- to middle-adulthood may then decrease intertemporal discounting. As such, the life-cycle effect might well be inverted U-shaped and reach its peak during middle age. This line of argument is consistent with research into time discounting over the lifespan, which finds that "older people discount more than younger ones, and that middle aged people discount less than either group" (Read and Read 2004: p. 22). We return to the various potential shapes of the life-cycle effect – and which of these we can identify empirically – below.

Our analysis revisits this important and persistent scholarly debate (Abramson 2011) and pushes the boundaries of the existing literature in two ways. First, from a theoretical and conceptual perspective, we shift focus from cohort to life-cycle effects in order to draw attention to differences in environmental concerns between age groups. The potential implications of finding inverted U-shaped life-cycle effects may be considerable. Whereas Inglehart's generational hypothesis for most advanced economies implies that public opinion gradually shifts towards a greater emphasis on protecting the environment, any inverted U-shaped life-cycle effect entails that aging populations in these economies may profoundly counteract this tendency. Second, from a methodological perspective, we uniquely rely on overlapping panels in the Norwegian Election Studies (1989-2013) to analyze repeated observations of the *same* individuals rather than cross-sectional data (as in earlier work). These panel data facilitate a novel analysis able to identify life-cycle effects by exploiting the first-difference properties of the environmental concern function. While this approach does not resolve the Age-Period-Cohort problem, it *does* allow identification of specific shapes of life-cycle effects while controlling for period effects (by de-trending the data) and cohort effects (by analyzing the change in, rather than level of, individuals' environmental attitudes) (Cheng et al., 2015).[1] This approach is very different from those employed in the existing literature, and offers a novel tool in setting where a panel dataset is available.

2. Dataset and dependent variable

The Norwegian Election Studies are conducted by Statistics Norway every four years in line with the national electoral cycle. They are based on a random sample taken from the nationwide population register. The surveys consistently achieve response rates above 50% and the resulting samples are representative of the Norwegian population between 18-79 years. Each survey includes detailed background information about respondents (including year of birth and age at the time of the survey) and covers questions about the elections as well as individuals' political attitudes and policy preferences. Since 1989, a question on respondents' preferences for protecting the environment has been included, which we employ as the basis for our dependent variable. The formulation used in the 1989 and 1993 surveys was as follows:

> *[Imagine] the issue of nature conservation and environmental protection. The value 1 expresses the desire to see more done for environmental protection, even if people's standard of living is reduced to a considerable extent, yourself included. The value 10 expresses the desire that environmental protection measures should not be taken so far as to affect our standard of living. Where would you place yourself on this scale, or have you not you given this issue much thought?*

[1] This directly controls for any existing cohort effects – even though we cannot exactly identify them – since the same individual naturally remains part of the same birth cohort over time.

In the 1997 survey, the answer scale was extended such that it now started at 0 rather than 1. In the 2001, 2005, 2009 and 2013 surveys, the order of the preference options was reversed. For consistency, we recoded answers provided during the first three surveys (1989, 1993 and 1997) to match the response order of the survey format used from 2001 onwards.

Important for our purposes, half of the sample in each survey wave is interviewed again four years later. This creates high-quality rotating panels of approximately 500 to 700 respondents (see table 1), which we exploit to study repeated observations of the *same* individuals. Note, however, that the small changes in the survey design documented above create concerns about the rotating panels around the 1997 survey. With the scale reversal in 2001, respondents included in both 1997 and 2001 faced 10 as both a negative and positive statement. Moreover, the scale's extension in 1997 implies that respondents in both 1993 and 1997 faced (slightly) different scales. Both issues might affect their answers over time, which is our key interest in the analysis (see below). Hence, both the 1993-1997 and 1997-2001 rotating panels are excluded from our final sample, leaving us with four rotating panels spanning a 24-year period (see table 1). Figure A.1 in the appendix shows that most respondents shift preferences at least somewhat over these four-year periods (i.e. less than 30% show no change at all). Some even document very substantial changes (we return to this below). These changes over time within the same individual are the main dependent variable in our analysis.

Table 1: Structure of the rotating panel

Panel indicator	1989	1993	1997	2001	2005	2009	2013	Total
1989-1993	686	686	-	-	-	-	-	1372
2001-2005	-	-	-	666	666	-	-	1332
2005-2009	-	-	-	-	635	635	-	1270
2009-2013	-	-	-	-	-	489	489	978
N	686	686	-	666	1301	1124	489	4952

Note: The response order and coding on our main variable of interest changed slightly in 1997, which undermines the comparability of the responses within the 1993-1997 and 1997-2001 rotating panels. As each individual appears in two subsequent surveys, the number of individual respondents equals 2476. Note also that 2013 is the latest available survey at the time of writing.

3. Empirical analysis

3.1. Method: Identification of the life-cycle effect

Our aim is to identify a life-cycle effect in environmental concerns *independent of any cohort and time effects*. As mentioned, the key problem is the linearly dependent relationship Age = Time – Cohort, which makes independent identification of these three elements extremely challenging (Bell and Jones, 2014). Our approach to nonetheless identify a life-cycle effect is to focus on the first-difference of the environmental concerns function. Clearly, cohort effects are eliminated by first-differencing the data because the same individual remains in the same birth cohort over time. Taking out cohort effects is a price we are willing to pay for being able to identify life-cycle effects.

Although the slope of the first-difference (i.e. the second-difference) can be empirically identified, the first-difference itself can only be estimated up to a constant. The reason is that potential time-specific effects (see figure A.2 in the Appendix) could still contaminate the estimate of the life-cycle effect. The basic issue is that when four years have passed everyone is exactly four years older. This implies an unclear assignment of age and time effects when including time effects alongside age effects in an empirical model, such that the age at which environmental concerns reach a peak (or bottom) cannot generally be identified. We follow Cheng et al. (2015) to address this problem by running a first-stage regression with the within-person change in environmental concerns as the dependent variable, and a full set of time dummies as independent variables (whereby survey years represent the time effects). The residuals from this regression reflect individuals' de-trended change in environmental concerns. Any time-specific effects are eliminated from these residuals as the individual-level changes are scaled down by the average change in the data within a period.[2] We then run a second-stage regression with the de-trended change in environmental concerns as the dependent variable, and age as the independent variable. What we identify then is the effect of a change in age – over and above the average time and age effects within a period – on the change in environmental concerns independent of any cohort effects. With subscripts *i* and *t* referring to individuals and time, respectively, this estimation approach can be written as:

$$\Delta Pref_{it} = \beta_0 + \beta_t time\ dummies + \varepsilon_{it} \qquad (1)$$

$$\hat{\varepsilon}_{it} = \alpha_0 + \alpha_1 Age_{it}\ \ (+\alpha_2 Controls_{it}) + \mu_{it} \qquad (2)$$

where $\Delta Pref_{it}$ equals within-person changes in environmental preferences, and $time\ dummies$ is a full set of survey year indicator variables. $\hat{\varepsilon}_{it}$ is the residual from estimating equation (1), and indicates de-trended changes in environmental concerns.[3] Age_{it} is respondents' age at the time of the second survey. Importantly, $\alpha_1 \neq 0$ reflects non-linear life-cycle effects in environmental concerns. In particular, a combination of $\alpha_0 > 0$ and $\alpha_1 < 0$ is consistent with a positive first-difference at young ages and a negative first-difference at old ages (i.e. an inverted U-shape over the life-cycle). Note that $\alpha_1 = 0$ need not imply the absence of life-cycle effects, only that non-linear effects do not find support in the data. Any potential linear life-cycle effects cannot be identified independently of time effects, and are taken out of the estimations by the de-trending procedure.

[2] This average change can be attributed to *either* an average age effect in a period *or* a time effect, as these two effects are inseparable in the data.

[3] Note that the residual in equation (1) is not independent of the time dummies as these, on purpose, take out any common effects across individuals within a period. That is, β_t include any average age effects. In Appendix B, we assess the robustness of our main findings via two alternative estimation approaches.

Although control variables are not strictly necessary, we sometimes extend our specification with two time-changing variables capturing respondents' real income (in 100.000 NOK; base year 2013) and education level (measured in three stages as 'lower than secondary', 'secondary' or 'higher' education). These have been extensively analyzed as potential determinants of environmental preferences by, among others, Gelissen (2007), Franzen and Meyer (2010), Pampel and Hunter (2012), Jorgenson and Givens (2014), Lo (2014), and Johnson and Schwadel (2019). Summary statistics for all relevant variables are included in table 2.

Table 2: Summary statistics

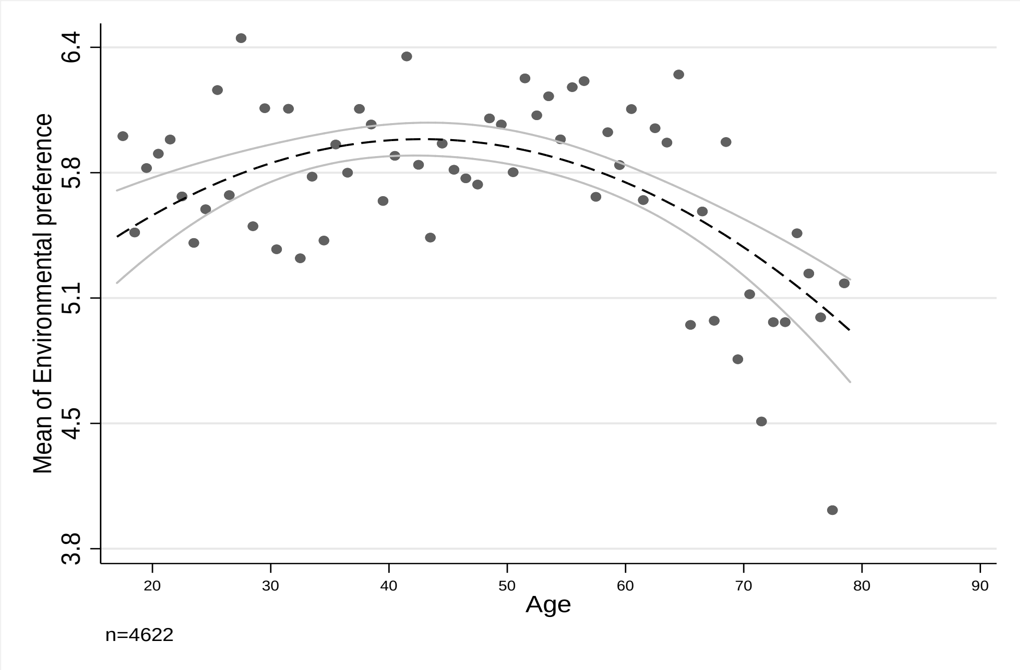
Variable	N	Mean	St. Dev.	Min	Max
$Pref_{ict}$: Preference for environmental protection	4622	5.752	2.235	0	10
$\Delta Pref_{ict}$: Change in preference for environmental protection	2311	-0.168	2.357	-10	9
Age	4622	45.900	14.732	17	79
Income	4622	5.793	3.644	0	51.301
Education	4622	2.203	0.740	1	3

Note: *Preference for environmental protection* is coded from 0 ("Environmental protection measures should not be taken so far as to affect our standard of living") to 10 ("More should be done for environmental protection, even if it means people have their standard of living reduced to a considerable extent, yourself included"). *Change in preference for environmental protection* is the within-person change in environmental concerns across two survey waves. *Income* measures respondents' real income in 100.000 NOK (base year 2013), while *Education* is measured in three stages as 'lower than secondary', 'secondary' or 'higher' education. The data derives from a fully balanced rotating panel including surveys from 1989-1993 and 2001-2013.

3.2. Main findings

We start our analysis by briefly looking at the cross-sectional relation between age and individual preferences for environmental protection in figure 1. The figure shows a strong inverted U-shaped environmental concern function, which reaches its maximum value at 42.82 years.

Figure 1: Cross-sectional relation between age and preferences for environmental protection



Note: The figure depicts the relation between respondents' age and their preferences for protecting the environment measured on an 11-point scale. Dots reflect average preferences in one-year age bins, while the dotted line is a simple quadratic function fitted through the underlying data (with 95% confidence intervals). Data cover a fully balanced rotating panel including surveys from 1989-1993 and 2001-2013.

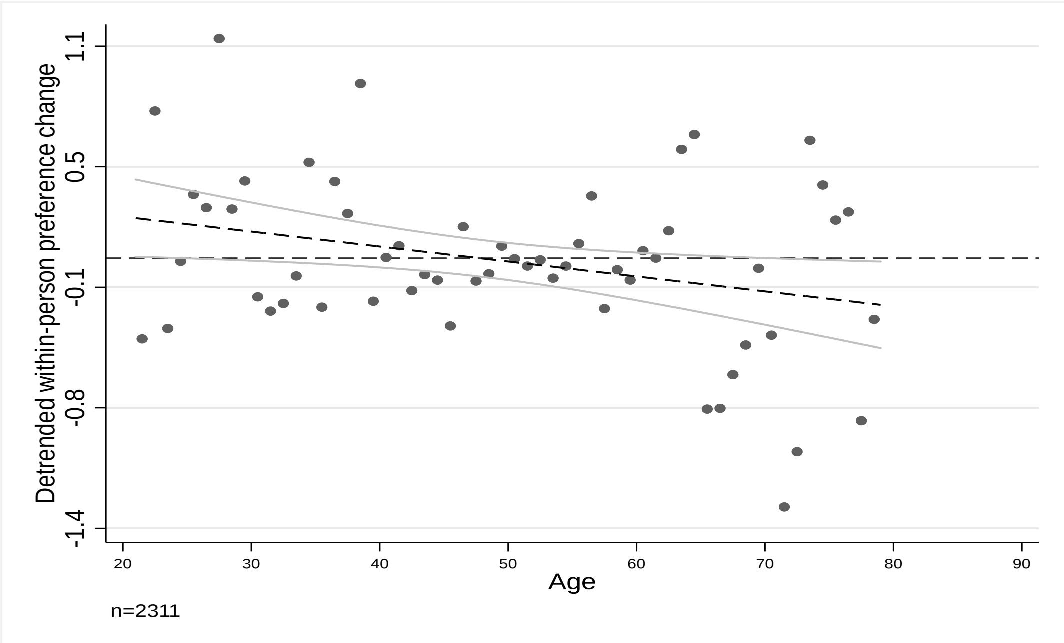
Figure 1 provides some initial, suggestive verification that especially older individuals put less emphasis on protecting the environment. Yet, this figure obviously conflates time, cohort and life-cycle effects. To gain a better understanding of life-cycle effects independent from cohort and time effects, we estimate equations (1) and (2) using the fully balanced rotating panel covering the period 1989-1993 and 2001-2013. The key findings are summarized in figure 2 (and table A.1 in the Appendix).[4]

The downward sloping line in figure 2 indicates a negative relationship between the (de-trended) change in support for environmental protection and individuals' age. Further, we find the first-difference to be positive at young ages and negative at old ages. As argued above, these results provide strong evidence of an inverted U-shaped life-cycle effect in environmental

[4] Table A.1 in the Appendix also covers the results from a number of robustness checks. Specifically, we show that excluding individuals with extreme changes in their expressed environmental preferences over time (i.e. shifts of nine or more on the 11-point scale) leaves our results unaffected. Similarly, excluding respondents from the 1989-1993 surveys (which had a slightly narrower response scale; see above) does not affect our findings. Finally, our results are likewise robust to including additional controls for individuals' income and education.

concerns. In terms of effect size, remember that our first-difference model effectively considers the survey-to-survey rate of change in expressed preferences. As such, each dot in figure 2 is the average change in support for environmental protection among all people in the sample of a specific age. Given the four-year gap between surveys, the predicted decline in environmental preferences for 64-year olds is 0.168 compared to when they were 60 years old.[5] Extrapolating, the preferences of 72-year olds are predicted to be 0.624 lower than those of 60-year olds. At a mean value for environmental preferences of 5.7, this can be considered substantively meaningful decline. Referring back to figure 1, it indicates that a substantial share of the decline in environmental preferences between 60-72 years of age may be due to life-cycle effects.

Figure 2: Gradient of change in preferences for environmental protection by age



Note: The vertical axis depicts the de-trended within-person change in respondents' preferences for protecting the environment (with these preferences measured on an 11-point scale), while the horizontal axis depicts respondents' age at the time of the second survey. Dots reflect averages in one-year age bins, while the dotted line is a linear function fitted through the underlying data (with 95% confidence intervals). The dataset covers a fully balanced rotating panel including surveys from 1989-1993 and 2001-2013.

[5] Table A.2 in the Appendix provides more detailed predicted (four-year) changes in environmental preferences across age groups, expressed as a percentage of the standard deviation of observed preference changes.

Our findings are important as the observed life-cycle effects will work to mitigate at least in part any cohort effect towards higher environmental concerns (Inglehart 1971, 1981, 1990; Inglehart and Abramson 1994). Especially in rapidly aging societies – such as most advanced economies – and the concomitant increase in the median voter's age, this may have a considerable impact on future environmental policies.[6]

4. Conclusion

Environmental protection is a costly investment in the short term, but may yield substantial long-term benefits. As both the elderly (due to shorter remaining life spans) and the young (due to lack of offspring and deficient knowledge/understanding of environmental risks) may discount these future benefits more, popular support for environmental protection might display an inverted U-shaped life-cycle effect that reaches its peak during middle age. Within rapidly ageing Western societies, this may make future policies *less* rather than *more* environmentally friendly. As such, it could mitigate any cohort effects tending towards higher concerns about environmental protection among more recent generations.

We are the first study on environmental concerns to employ panel data. This is important since it facilitates identification of *non-linear* life-cycle effects independent of cohort and time effects (Cheng et al., 2015). Furthermore, we provide an important methodological contribution to the literature by exploiting the first-derivative properties of the environmental concern function. Based on data from overlapping panels embedded in the Norwegian Election

[6] We experimented with a replication of our analysis on the German SOEP dataset (1984-2016). While this covers annual surveys of a large sample of individuals (N≈85,000), it unfortunately has a number of limitations for our analysis. First, the panel witnesses extensive attrition and roll-over (e.g., 50% of respondents answers four or fewer survey rounds), which induces important concerns about self-selection (e.g., 5% of respondents answers 25 or more surveys) and sample representativeness. Second, the key question of relevance in the dataset is "How concerned are you about the environment?". Its three answer options – i.e. 'very concerned'; 'somewhat concerned'; 'not at all concerned' – induce strong clustering on the middle option (55% of all responses) and drastically limit within-person variation over time (65% of year-on-year 'changes' is zero). Even so, replicating the analysis using this dataset confirms our negative and statistically significant point estimate for the age variable. Yet, it is substantively small and suggests that – unlike in Norway – ageing plays only a trivial role for the temporal variation in environmental concerns in Germany. Full details available upon request.

Survey data over the period 1989-2013, our results provide evidence of an inverted U-shaped life-cycle effect in environmental concerns. Particularly among the elderly we observe that becoming older has a substantively meaningful negative effect on expressed preferences for environmental protection. Extrapolating from our main findings, ageing is predicted to reduce the environmental preferences of 72-year old by roughly 11% relative to 60-year olds.[7]

Although our panel dataset provides crucial benefits over previous work using repeated cross-sections, it has some limitations. Ideally, we would prefer to observe individuals' environmental preferences over a much longer time frame (e.g., from age 18 to their late 70s or 80s) and cover a wider range of indicators of environmental preferences (including behavioural indicators such as consumption patterns). This would strengthen confidence in the estimated effects attributable to age, and also allow the generation of more sophisticated measures as well as cross-referencing results across indicators. Unfortunately, however, this ideal dataset at present remains elusive and should be considered an important investment for future scholarship.

Finally, it is important to observe that our non-linear life-cycle effect does not necessarily negate changes over time arising from generational differences. We cannot assess this since our approach is unable to identify such cohort effects. Future research should aim at disentangling the *relative* importance of cohort versus life-cycle influences on environmental attitudes. Based on our findings, this is critical to predict future developments in preferences towards environment-friendly policies. This is emphatically *not* a simple task; it requires individual-level survey data covering long timespans as well as innovative research designs.

[7] It would be interesting in future research to assess whether, and to what extent, this result depends on individuals having (grand)children.

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ONLINE APPENDIX TO

Popular support for environmental protection: A life-cycle perspective

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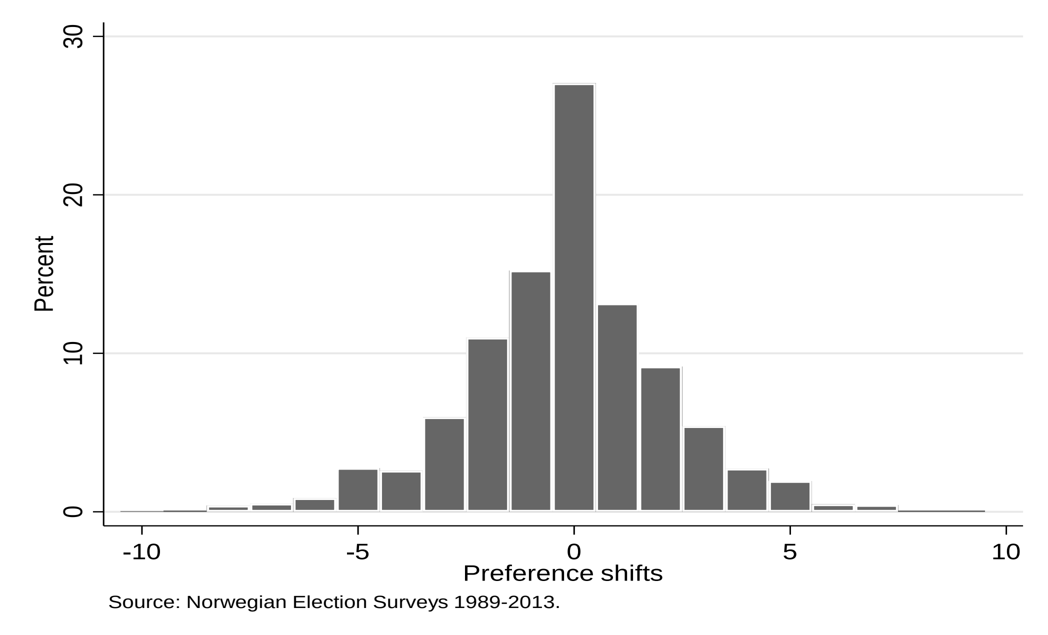
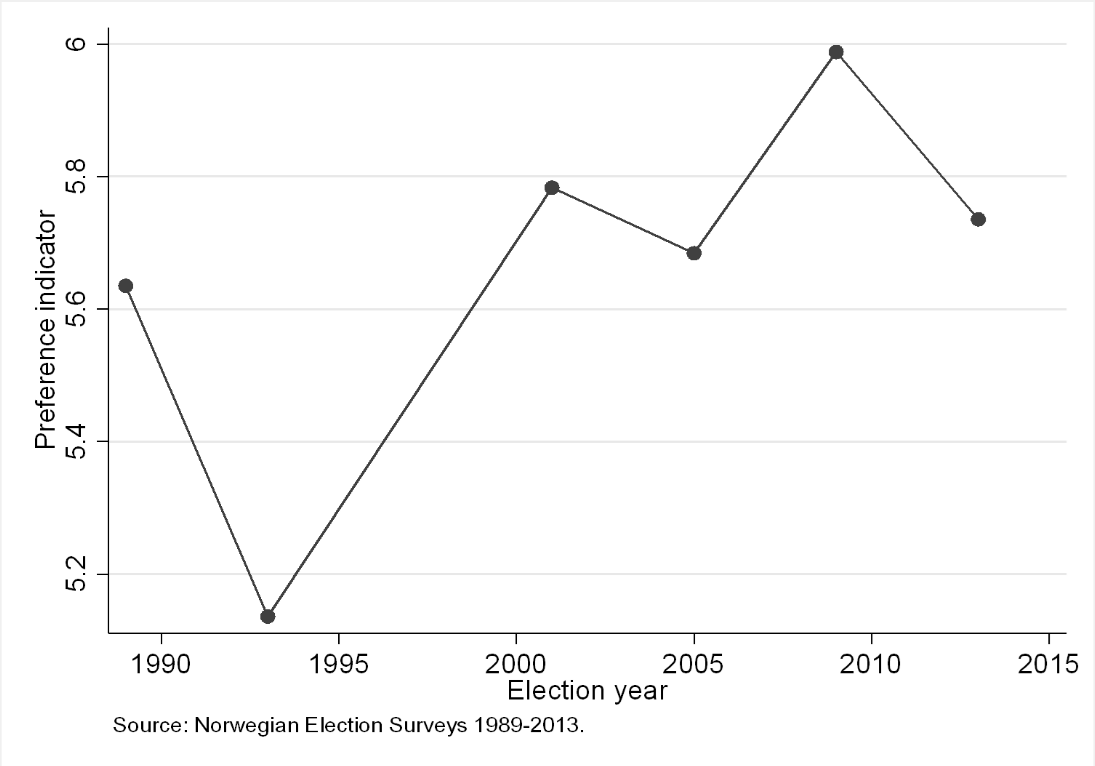
Appendix A. Summary statistics and key regression results

Figure A.1: Shifts in preferences for environmental protection within individuals across surveys



Note: The figure displays respondents' shifts in preferences for environmental protection across surveys, defined as their response to the environment question (described in the main text) during their second inclusion in the survey minus their response recorded four years before during their first inclusion in the survey. Given the response scale, this variable can range from -10 (a move from very positive to very negative about environmental protection) to 10 (a move from very negative to very positive about environmental protection). The sample covers a fully balanced rotating panel including surveys from 1989-1993 and 2001-2013 (N=2311). Including individuals with missing control variables (N=2476) provides similar results.

Figure A.2: Environmental protection preferences 1989-2013



Note: The figure presents the mean value of respondents' preferences for protecting the environment during each survey of the Norwegian Election Studies (1989-2013). The data cover the fully balanced rotating panel including surveys from 1989-1993 and 2001-2013 used in the main analysis.

Table A.1: Main estimation results (cf. figure 2 in main text)

Variable	*Panel I: Surveys 2001-2013*			*Panel II: Surveys 1989-1993 & 2001-2013*		
	Full sample	Excluding extremes (± 9)	Including controls	Full sample	Excluding extremes (± 9)	Including controls
	(1)	(2)	(3)	(4)	(5)	(6)
Age	-0.010 **	-0.009 **	-0.009 **	-0.008 **	-0.007 **	-0.007 **
	(-2.40)	(-2.33)	(-2.30)	(-2.20)	(-2.04)	(-2.01)
Gender	-	-	0.177	-	-	0.100
			(1.60)			(1.02)
Income	-	-	-0.016	-	-	-0.008
			(-1.15)			(-0.62)
Education	-	-	0.033	-	-	0.050
			(0.36)			(0.63)
Intercept	0.472 **	0.456 **	0.401	0.371 **	0.340 **	0.228
	(2.35)	(2.28)	(1.23)	(2.15)	(2.00)	(0.84)
N	1625	1623	1625	2311	2306	2311

Note: The dependent variable is the de-trended within-person change in respondents' preferences for protecting the environment (with these preferences measured on an 11-point scale). All models in Panel I employ a fully balanced rotating panel including the surveys from 2001-2013. In Panel II, we additionally include the rotating panel covering the surveys from 1989-1993 (as reported in the main text). Columns (1), (3), (4) and (6) employ the full estimation sample, while columns (2) and (5) exclude individuals with extreme changes in their expressed preferences over time (i.e. shifts of nine or more steps on the 11-point scale). t-values based on robust standard errors between brackets. *** p<0.01; ** p<0.05; * p<0.1.

Table A.2: Predicted four-year changes in environmental preferences across age groups.

Age	22	26	30	34	38	42	46	50	54	58	62	66	70	74	78	82
Percent change	8,7	7,3	5,9	4,4	3	1,6	0,1	-1,3	-2,7	-4,2	-5,6	-7	-8,5	-9,9	-11,3	-12,7

Note: The table provides predicted four-year changes in environmental preferences across ages groups, expressed as a percentage of the standard deviation of observed preference changes. Predictions are based on Column (4) in Table A.1. The data derives from a fully balanced rotating panel including surveys from 1989-1993 and 2001-2013.

Appendix B. Alternative empirical specifications

In the main text, our identification strategy relies on a first-difference estimation on de-trended data to uncover an inverted U-shape for environmental preferences over the life-cycle. Here, we assess the robustness of our main findings via two alternative identification strategies.

The time-period random effects model

If we assume that time-period effects (γ_t) are independent of any respondent's age, we can model the period-effects as a random variable. The model can then be estimated by a mixed model approach using the first-difference environmental preferences as response variable, and including respondent age, time-varying controls and time-period random-effects in the regression model.

$$\Delta Pref_{it} = \gamma_0 + \gamma_a Age_{it} \ (+\gamma_1 Controls_{it}) + [\gamma_t + \omega_{it}] \qquad \text{(B.1)}$$

Given the assumption of uncorrelated period-shocks, our estimates using (B.1) should then correspond to the results presented in the main text. Results using this approach are presented in Table B.1. Across all specifications, the coefficient estimates of respondents' age are strikingly similar to those presented in Table A.1. This suggests that the period shocks to environmental attitudes are very likely to be uncorrelated with respondents' age, lending additional support to our key findings in the main text.

The respondent fixed effects model

In this specification, we regress environmental preferences against respondent age while controlling for generational effects by including respondent fixed effects. This approach is related to work by, for instance, Sørensen (2012) and can be expressed as follows (with subscripts *i*, *c* and *t* referring to individuals, cohorts and time, respectively):[8]

$$Pref_{it} = \beta_i + \beta_t + \beta_a Age_{it} \ (+\beta_1 Controls_{it}) + \varepsilon_{it} \qquad \text{(B.2)}$$

Where Age_{it} and $Pref_{it}$ equal, respectively, the age and preference for environmental protection of individual *i* (who is by birth in cohort *c*) surveyed at time *t*. The inclusion of individual fixed effects (β_i) in the model has two main implications. First, they entail that we – as in the main text – effectively focus on variation in individuals' preferences over time. Second, as individuals' birth cohort does not change across surveys, any cohort-specific effects are picked up by the fixed effects. As in the main text, we estimate the model with and without additional controls for respondents' real income (in 100.000 NOK; base year 2013) and education level (in three stages as 'lower than secondary', 'secondary' or 'higher' education).

[8] Sørensen, R.J. (2012). Does aging affect preferences for welfare spending? A study of peoples' spending preferences in 22 countries, 1985-2006. *European Journal of Political Economy* 29: 259-271.

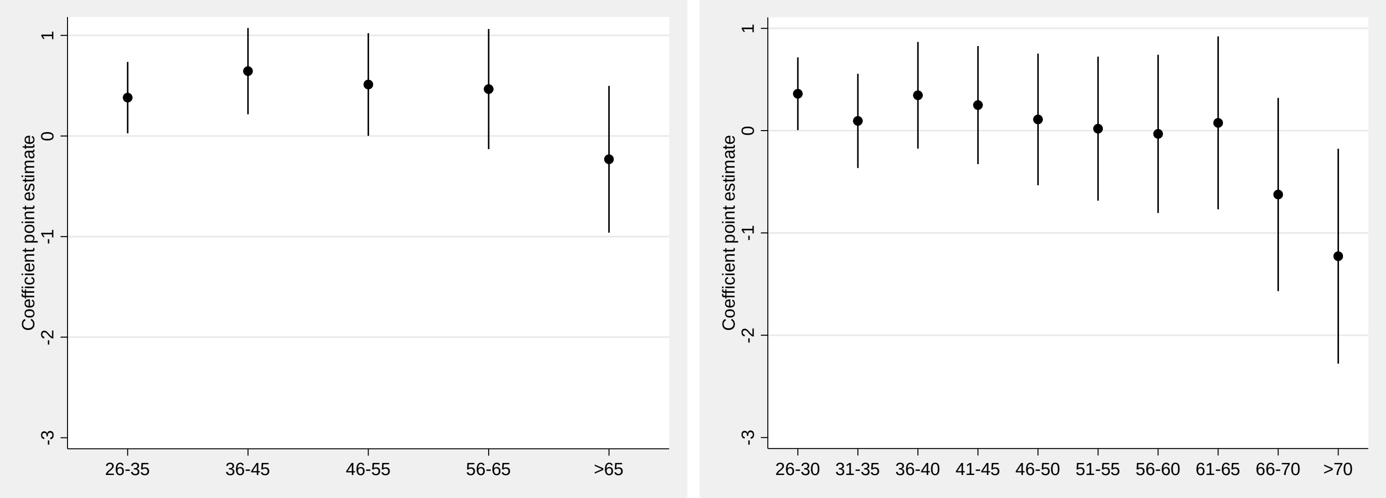
Following the approach in the main text, we first eliminate any time-specific effects by de-trending the data. The modified estimation approach can be written as:

$$Pref_{it} = \beta_0 + \beta_t time\ dummies + \varepsilon_{it} \quad \text{(B.3)}$$
$$\hat{\varepsilon}_{it} = \beta_i + \beta_a Age_{it}\ (+\beta_2 Controls_{it}) + \mu_{it} \quad \text{(B.4)}$$

Where $time\ dummies$ is a full set of survey dummies and all other variables are defined as above. Before discussing the results, it is important briefly to discuss the differences and similarities between the approach in equations (B.3) and (B.4), and the approach used in the main text. The central difference lies in the starting point of both models. The model in the main text eliminates cohort effects at the onset and can only be used to identify a *non-linear* life-cycle relationship. The model given by (B.3) and (B.4) can in principle be used to estimate *linear* age effects, but cannot identify this as only an age effect due to the relationship between age and cohort (though this problem can be 'mitigated' by grouping people into cohorts of more than one year, as we do in some specifications below).

Figure B.1 summarizes the estimated life-cycle effects (β_a) from equation B.4 using either ten-year (left-hand panel) or five-year (right-hand panel) age-groups and birth cohorts. The estimates using five-year groups/cohorts remain rather imprecise due to limited group/cohort sizes, but nonetheless show a substantively meaningful decline in the point estimates for the two oldest age groups. The point estimate is also statistically significantly negative for the oldest age group in the analysis. This is consistent with life-cycle effects whereby aging individuals put less emphasis on protecting the environment (Torgler and Garcia-Valiñas 2007; Franzen and Meyer 2010). The estimates using ten-year groups/cohorts are more precisely estimated and display a clear inverted U-shaped life-cycle effect (note that the point estimate for the oldest age group is statistically significantly different from all other age groups except the youngest one and the 26-35 group (p=0.106)). This is confirmed in table B.2, where we use one-year age-groups and birth cohorts. The non-linear specification of the life-cycle effect in columns (4) to (6) consistently outperforms the linear specification in columns (1) to (3), confirming the presence of an inverted U-shaped life-cycle effect. Overall, therefore, the results in figure B.1 and table B.2 are qualitatively similar to those reported in the main text, and verify the robustness of our main findings.

Figure B.1: Life-cycle effect in environmental protection preferences - fixed effects model



Note: The figure reports point estimates (with 95% confidence intervals based on standard errors clustered at respondent level) from a fixed effects panel regression using respondents' preferences for protecting the environment measured on an 11-point scale as the dependent variable. Controls for income, education level, birth cohort and survey year included throughout. Left-hand figure employs ten-year age groups and birth cohorts, while right-hand figure employs five-year age groups and birth cohorts. All models employ a fully balanced rotating panel including surveys from 1989-1993 and 2001-2013.

Table B.1: Estimation results - random effects model

Variable	Full sample (1)	Excluding extremes (± 9) (2)	Including controls (3)
Age	- 0.010 *** (-3.13)	-0.0096 *** (-3.14)	-0.0095 *** (-4.63)
Income	-	-	-0.0002 * (-1.68)
Education	-	-	0.041 (0.35)
Survey year RE	0.160 (0.056)	0.157 (0.056)	0.165 (0.055)
N	1625	1624	1625

Note: The dependent variable is the first difference in respondents' preferences for protecting the environment measured on an 11-point scale. All models employ a fully balanced rotating panel including surveys from 1989-1993 and 2001-2013. Columns (1), (3) employ the full estimation sample, while columns (2) exclude individuals with extreme changes in their expressed preferences over time (i.e. shifts of nine or more steps on the 11-point scale). The estimates for survey year random effects (RE) are standard errors. Robust z-values are presented between brackets. *** p<0.01; ** p<0.05; * p<0.1.

Table B.2: Estimation results - fixed effects model

Variable	Full sample (1)	Excluding extremes (± 9) (2)	Including controls (3)	Full sample (4)	Excluding extremes (± 9) (5)	Including controls (6)
Age	- 0.010	-0.009	-0.018	0.081 *	0.73 *	0.069
	(-0.84)	(-0.78)	(-1.34)	(1.95)	(1.78)	(1.60)
Age squared	-	-	-	-0.001 **	-0.001 **	-0.001 **
				(-2.24)	(-2.06)	(-2.04)
Income	-	-	-0.002	-	-	-0.008
			(-0.15)			(-0.48)
Education	-	-	0.144	-	-	0.106
			(1.57)			(1.21)
Respondent FE	YES	YES	YES	YES	YES	YES
N	4622	4612	4622	4622	4612	4622

Note: The dependent variable is respondents' (de-trended) preferences for protecting the environment measured on an 11-point scale. All models employ a fully balanced rotating panel including surveys from 1989-1993 and 2001-2013. Columns (1), (3), (4) and (6) employ the full estimation sample, while columns (2) and (5) exclude individuals with extreme changes in their expressed preferences over time (i.e. shifts of nine or more steps on the 11-point scale). t-values based on standard errors clustered on respondent between brackets. *** $p<0.01$; ** $p<0.05$; * $p<0.1$.