Discussion Paper No. 14-042

Direct and Indirect Effects of Weather Experiences on Life Satisfaction – Which Role for Climate Change Expectations?

Daniel Osberghaus and Jan Kühling

ZEW
Zentrum für Europäische
Wirtschaftsforschung GmbH
Centre for European
Economic Research

Discussion Paper No. 14-042

Direct and Indirect Effects of Weather Experiences on Life Satisfaction – Which Role for Climate Change Expectations?

Daniel Osberghaus and Jan Kühling

Direct and Indirect Effects of Weather Experiences on Life Satisfaction – Which Role for Climate Change Expectations?

Daniel Osberghaus (ZEW Mannheim)

and Jan Kühling (Carl von Ossietzky University of Oldenburg)

July 2014

Corresponding author

Daniel Osberghaus
Centre for European Economic Research (ZEW); L7, 1, 68161 Mannheim, Germany
Telephone: +49-621-1235205
Email: osberghaus@zew.de

Abstract

This paper deals with the effect of (i) damage experience from extreme weather events and (ii) expectations concerning future climate change on subjective well-being (SWB). We use data of a large representative survey amongst German households. The effect of experienced weather events on SWB of the heads of the households is only significant for heat waves; not for storms, heavy rain, and floods. Concern about future climate change on the household level has a substantial negative impact on current SWB. Moreover, we divide the impact of experience into direct effects of damage and indirect effects, which affect current SWB via the channel of expectations regarding future climate change. Both direct and indirect effects of weather experiences are quantified. It becomes apparent that the indirect effect is significant but small compared to the direct effect.

Keywords

Climate change; subjective well-being; extreme weather events; household survey

JEL-Classification

Q54, Q51, D03

1. Introduction

Climate change and extreme weather events such as heat waves, storms, and floods affect the living conditions of private households and individuals worldwide. Climatologists expect an average global temperature rise of 1.0 to 3.7°C by 2100 relative to 1986-2005 (IPCC 2013), which is likely to imply an increase in frequency and severity of extreme weather events (Field et al. 2012). This paper deals with the effect of extreme weather events and climate change on subjective well-being of individuals (SWB). We analyse the SWB-effects of (i) weather-related material and health damage experiences and (ii) expectations about future climate change. While the experience analysis focusses on the role of past events for current SWB, the expectations of climatic conditions take account of the individuals' current concerns regarding future effects of global warming.

While there is body of literature available on the SWB-effects of weather events, we are not aware of any study which has tested the role of expectations about future climate change for current SWB. It is, however, a plausible hypothesis that relatively high concern (i.e. expectation of negative impacts of climate change) goes along with a significant downward shift in current SWB. We will test and quantify this effect by using two formulations of the concern variable, each focusing on a different aspect of future climate change.

Beside the separate analysis of the effects of experiences and expectations, it is an interesting question how these two dimensions of climate change perception interact with each other. In the literature on climate change risk perception, it is shown empirically that experiences with extreme weather events imply higher concern about future global warming (Akerlof et al. 2013, Whitmarsh 2008, Bichard and Kazmierczak 2012). If this relation is present, the effect of damage experience on SWB may be separated into a direct and an indirect effect – the former as the immediate effect of a negative event, the latter as a collateral effect via an experience-driven concern about future climate change. Hence, the introduction of concern about future climate change into happiness research allows a deeper analysis of the interactions of damage experience, concern about future outcomes, and SWB.

Figure 1 depicts the hypothesised relations between damage experience, climate change expectations, and SWB.

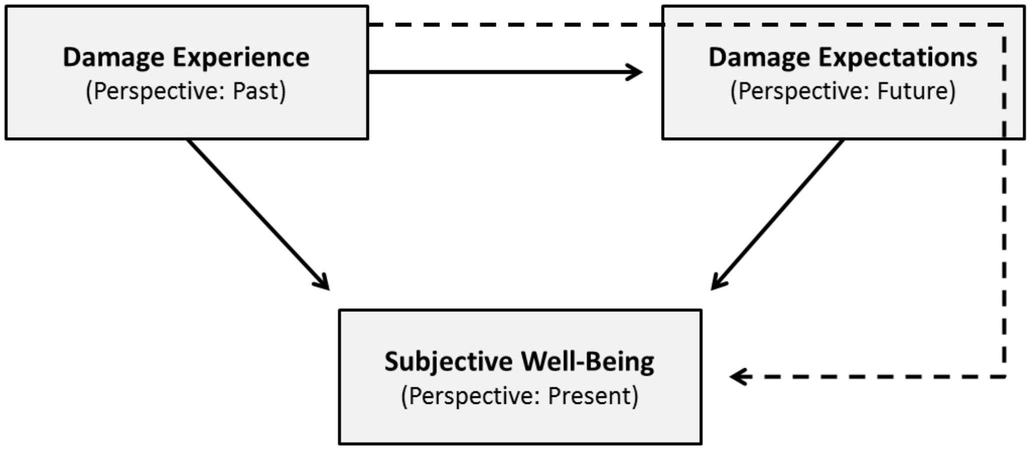

Figure 1: Hypothesised effects between past damage experience, expectations of future climate change, and subjective well-being. Direct relationships are depicted by solid arrows, indirect ones by dashed arrows.

As for the effect of experienced extreme weather events (EWE) on SWB, there is a growing body of literature.[1] Amongst the most harmful extreme weather events are typhoons and hurricanes as recently demonstrated once again by typhoon Haiyan in the Philippines. A study conducted by Kimball et al. (2006) shows in the case of hurricane Katrina that people report lower levels of life satisfaction even though they were not personally involved but informed about the hurricane and its consequences. Floods cause human and material losses. Luechinger and Raschky (2009) find in a panel regression analysis with 16 European countries between 1973 and 1998 a negative impact of floods on SWB and calculate on the basis of the life satisfaction approach a monetary value of 6.505 US dollar to compensate an individual for a sure flood event. Not only too much precipitation but also a lack of it has detrimental effects if the occurrence of droughts leads to direct and indirect losses in the agricultural sector. In this context, Carroll et al. (2009) estimate a negative effect of a spring drought that is comparable to 14.500 US dollar for a person living in a rural area of Australia. Additionally, forest fires as a result of droughts evoke diverse damages for humans and nature like losses of human lives, animals, and land use. In a study covering South and West Europe, Kountouris and Remoundou (2011) find - despite

[1] Welsch and Kühling (2009) give an overview about some of the following EWE papers and discuss them in more detail in an environmental valuation framework using the happiness approach. An update of the literature review is available in Welsch and Ferreira (2014).

problems in measuring damage experience - a significant negative effect of a fire incident on life satisfaction valued with 2.900 US dollar for a representative Spanish household.

Regarding the effects of climate on SWB that are typically addressed by temperature, precipitation, sun, and wind variables in a more long-term perspective a wide range of literature exists. In an early study on the relationship between climate variables and SWB, Frijters and van Praag (1998) identify the costs in Russian regions exposed to adverse climate conditions that are at least partially compensated by higher income. Other studies focusing on climate conditions in single countries are: Brereton et al. (2008), finding significant positive influence of extreme temperature and significant negative influence of wind speed on a highly disaggregated regional level in Ireland; Ferreira and Moro (2010), calculating a willingness to pay of 4.230 euros for an average individual for a rise in January temperature by 0.3 °C despite accounting for possible compensations via housing prices and wages also in Ireland; Cuñado and de Gracia (2012), estimating significant negative impacts of July temperature and precipitation in Spain; Ambrey and Fleming (2011) detecting a preference for seasonal variation and a significant negative effect of sunshine hours in Australia; Feddersen et al. (2012) finding climate variables not to be significant determinants of SWB as opposed to weather variables in Australia. Additionally to single country studies, there are international studies using multi country data like: Grün and Grunewald (2010) estimating positive effects of higher temperatures in the coldest months and negative effects of cloud covered days in Latin America; Rehdanz and Maddison (2005) showing in general that individuals have preferences for lower temperatures in summer and higher temperatures in winter as well as for higher precipitation in the driest months on the basis of 67 countries around the world leading to a majority of countries suffering from expected climate change while a minority of countries might benefit; Maddison and Rehdanz (2011) arguing more recently on the basis of 79 countries that deviations from a base temperature of 18.3°C in both directions are associated with significant losses in SWB resulting in highest welfare losses for African countries in the context of global warming; Becchetti et al. (2007) analysing climate conditions in different cities around the world with negative effects of wind speed, number of foggy days, and higher temperatures on SWB and an inverted U-shaped relationship between rainy days and SWB with a turning point around 220 annual rainy days.

Hence, our contribution to the literature is threefold: First, we examine the SWB-effect of past EWE in Germany (so far the SWB-analyses for Germany have mostly concentrated on the impact of long-term climate variables). Second, we quantify the relation of concern about future climate change and current SWB. To our knowledge, this study is the first attempt in this regard. Third, we disentangle the SWB-effect of damage experience into a direct effect and an indirect effect via the channel of expectations about future climatic conditions.

2. Theoretical Model

A key finding from literature on happiness research is that data on SWB may be used as an empirical approximation of utility (see for example Frey and Stutzer 2002). Given this finding, it is possible to translate the above considerations into the following theoretical framework:

$$U = f(V, Z) \tag{1a}$$

$$Z = g(V) \tag{1b}$$

whereas *U* denotes present *utility, V* stands for *damage experience* in the past and *Z* for *damage expectations* in the future. The theoretical model given by equation (1a) and (1b) is the mathematical analogue to Figure 1 and provides the theoretical basis for disentangling and estimating the effects extreme weather events (EWE) have on individual SWB.

$$\frac{dU}{dV} = \frac{\partial U}{\partial V} + \frac{\partial U}{\partial Z} \cdot \frac{\partial Z}{\partial V} \tag{2}$$

In equation (2), the left-hand side measures the total effect of EWE. The first summand on the right-hand side is the direct effect of EWE experience, whereas the second summand is its indirect effect via an experience-driven change in expectations towards negative climate impacts. It should be noted that the direct effect is the marginal utility of experience, whereas the indirect effect consists of the marginal utility of expectation times the marginal effect that experience has on expectations.

3. Data

We use cross-section data from a survey amongst German households. In total, 6404 households were interviewed via either an online or TV-based questionnaire. As only heads of households have been interviewed, the sample is largely representative in terms of households, but not on the level of individuals. The survey was conducted in October and November 2012. Towards the end of the survey period, the landfall of hurricane Sandy at the US East coast occurred. This event and the resulting substantial damages were an important issue in the German media. 4.4% of the sample was interviewed after the landfall of hurricane Sandy. As a cross-section, the data set cannot directly depict the time dimension. However, the key variables (SWB, experience, expectations) are quasi-temporal by explicitly asking for current SWB, damage events in the past, and expectations for the future. An aggregated overview of the data and more information on the survey, including the questionnaire (in German language) are available in Osberghaus et al. (2013). For the present analysis, we use the key variables presented in Table 1 and a number of control variables presented in Table 5 in the appendix. In the following, the key variables are described in more detail.

Subjective Well-Being

SWB is measured by a single question as the first item of the questionnaire. Participants were asked to rate their current individual life satisfaction (LS) on an 11-point Likert-scale ranging from “totally dissatisfied” to “totally satisfied”.[2] This approach was deemed as a valid and efficient method to elicit SWB i.a. by Diener et al. (1985).[3] The distribution is left skewed which is a typical pattern for this kind of formulation.

[2] This and other questions which are relevant for eliciting the key variables are available in Table 8 in the appendix.

[3] From here on, we will use the term “Life Satisfaction” (LS) for approximating SWB.

Damage Experience

For measuring past damage experience, the participants stated whether they have suffered any financial or health damage due to heat waves, storms, heavy rains, and floods. The terms “heat wave”, “storm”, and “heavy rain” were further explained by indicating short illustrative situations how the event may affect personal life. The health damage was restricted to cases where participants have consulted a doctor. Thus, the data is an objective measure of the stated damage occurrence due to weather events, albeit without indicating the severity or time of the damage. This is due to the fact that the questionnaire should be kept short and simple.

Climate Change Expectation

For measuring expectations regarding future climate change and damages from weather events, two different approaches have been used: First, participants rated the expected consequences of climate change on their personal living conditions in the next decades on a 5-point Likert-scale from “very negative” to “very positive”. This approach implies a broad perspective on climate change (without a focus on any specific impact), but with the restriction on the personal conditions. Second, the participants were asked for their expectation of the global mean temperature change from preindustrial time to 2100.

Table 1: Descriptive statistics of key variables

Variable in the model	Variable in the data	Mean	Median	Std. dev.	Min.	Max.	Obs.
Subjective well-being (present)	Self-rated life satisfaction (LS)	7.177	8	1.960	0 (totally dissatisfied)	10 (totally satisfied)	6397
Damage experience (past)	Participant has already experienced financial or health damage by…						
	… heat wave	.040	0	.195	0 (no)	1 (yes)	6366
	… storm	.226	0	.418	0 (no)	1 (yes)	6367
	… heavy rain	.267	0	.442	0 (no)	1 (yes)	6365
	… flood	.115	0	.319	0 (no)	1 (yes)	6368
Climate change expectation (future)	Expected consequences of climate change on individual living conditions in the next decades	3.550	4	.660	1 (very positive)	5 (very negative)	5336
	Expected global temperature increase in °C by 2100[4]	3.466	3	2.837	-6	20	4926

4. Empirical Strategy

The empirical analogue to Figure 1 and the theoretical model (equation (1a) and (1b)) can be formulated as in the following. First consider equation (1a). Under the assumption that data on LS is a proxy for utility that can be used as dependent variable, given that data on damage experience is a binary variable and data on damage expectations is an ordinal variable with five values, the empirical analogue to equation (1a) is

$$LS_i = \alpha + \beta \cdot E_i + \sum_{j=1}^{5} \gamma_j \cdot D_{ij} + \delta \cdot X_i + \varepsilon_i \qquad (3)$$

$$D_{ij} = 1 \quad if \quad C_i = j \text{ ; } otherwise \;\; D_{ij} = 0$$

, where E_i is a dummy variable taking the value of one if observation i has experienced any climate-related damage. D_{ij} is a set of five dummy variables which take the value of one if observation i exhibits damage expectations (C_i) of the level

[4] The raw data of the temperature change vary between a temperature decrease by 40°C and an increase by 50°C. To clean the data from presumably non-serious answers, we only include observations between the percentiles .5 and 99.5 of the distribution (which means in total one percent is defined as outliers). Robustness checks with the full sample have been conducted, see footnote 7.

j, where $j = 1,...,5$. The parameters α, β, γ_j, and δ are coefficients which can be estimated. To avoid perfect multicollinearity one of the γ_j has to be set to zero (in the following, $\gamma_3 = 0$). X_i denotes a set of control variables and ε_i the error term. Then, two testable hypotheses can be formulated with respect to equation (3):

Hypothesis a) Individuals who have suffered financial or health damage from extreme weather events in the past tend to exhibit lower LS today (β < 0).

Hypothesis b) Individuals who expect negative impacts of climate change for the future tend to exhibit lower LS today ($\gamma_{4,5} < 0$, as $\gamma_3 = 0$ denotes neutral climate expectations).

For testing hypotheses a) and b), we use OLS regressions and ordered probit regressions as robustness checks. As can be seen from Table 5 in the appendix, part of the variable set X_i are personal attitude variables capturing the subjective importance of certain topics for the respondent, including environmental issues and the individual economic situation. Such attitude variables have proved to be important determinants of LS and are beyond that correlated with inherited personality traits (Ferrer-i-Carbonell and Gowdy 2007). Therefore they are, from a practical perspective, included in the regression analyses as they may work as proxies for otherwise unobserved personality trait variables (see for example Welsch and Kühling 2010).

Turning to the proposed indirect effects of damage experiences, the estimation of expectations (i.e. the empirical analogue of equation (1b)) becomes relevant:

$$C*_i = \kappa + \lambda \cdot E_i + \mu \cdot W_i + \varepsilon_{1i} \qquad (4)$$

, where $C*_i$ is a latent continuous variable capturing climate expectations, and W_i is a set of control variables which includes X_i from equation (3) and further variables which are assumed to correlate with $C*$ but not with LS. These variables include environmental and political attitudes, and information sources for daily news. The unobserved variable $C*_i$ is transferred to the observed ordinal variable C_i by equation (5):

$$C_i = j \quad if \quad \omega_{j-1} < C*_i - \kappa \leq \omega_j ; \tag{5}$$
$$j = 1,...,5 ; \ \omega_0 = -\infty ; \ \omega_5 = +\infty$$

, with ω_j as the thresholds of the latent variable. As none of the thresholds is fixed to a value, they incorporate the constant κ which has to be subtracted from $C*_i$.

The functional form of equation (4) and selection of control variables W_i is inspired by the literature on climate risk perception or risk awareness, such as Akerlof et al. 2013, Whitmarsh 2008, and Bichard and Kazmierczak 2012. In these studies, experience is often measured by binary variables (having experienced any climate-related damage or not), as in our empirical application. The intuition behind the formulation is that the mere damage experience is the driving force for climate expectations, rather than severity or time of the damage occurrence. Furthermore, control variables which are expected to correlate with climate change expectations and which are measured in most published studies as well as in ours, include socio-demographic variables, political, environmental, and risk attitudes as well as information source.

If equations (3), (4) and (5) are combined, the empirical model can be extended to a recursive system of equations, with equation (5) being the first stage:

$$LS_i = \alpha + \beta \cdot E_i + \sum_{j=1}^{5} \gamma_j \cdot D_{ij} + \delta \cdot X_i + \varepsilon_{2i} \tag{6a}$$

$$D_{ij} = 1 \quad if \quad C_i = j \quad \Leftrightarrow \quad \omega_{j-1} < \lambda \cdot E_i + \mu \cdot W_i + \varepsilon_{1i} \leq \omega_j ; \ otherwise \ \ D_{ij} = 0 \tag{6b}$$
$$j = 1,...,5 ; \ \omega_0 = -\infty ; \ \omega_5 = +\infty$$

For checking whether an indirect effect of damage experience on SWB is detectable in our data, the following term has to be evaluated (which is the empirical analogue to equation (2)):

$$\beta = \beta_{dir} + \beta_{ind} = \beta_{dir} + \sum_{j=1}^{5} \gamma_j * (\frac{d \Pr(C_i = j)}{dE_i}) \tag{7}$$

, hence the indirect effect of E_i on LS_i is the sum of marginal effects of E_i on the estimated probabilities that observation i takes the expectation level of j, times the marginal effects of these expectation levels on LS_i.

On the basis of the extended empirical model (equation (6a) and (6b)) hypothesis c) can be derived:

Hypothesis c) The effect described in hypothesis a) (β) can be divided into a direct effect β_{dir} from the mere damage experience and an indirect effect β_{ind} via an experience-driven change in expectations towards negative climate impacts ($\beta_{ind} < 0$; $\beta_{dir} = \beta - \beta_{ind} < 0$).

For estimating the magnitude and significance of the indirect effect β_{ind}, as a first step we combine the coefficients from separate regressions of (6a), which is estimated by OLS, and (6b) which is an ordered probit model. For deriving the term $\frac{d\,\Pr(C_i = j)}{dE_i}$, one could set the covariates at some representative values and calculate the marginal effect for this representative household. However, for some of the control variables the choice of a representative value is not obvious, hence we use average marginal effects with all covariates as observed.

As the error terms ε_{2i} and ε_{1i} may correlate with each other due to unobserved personality traits of the respondents, we also estimate the system of equations (6a) and (6b) simultaneously by the user-written Stata command cmp (Roodman 2011). This command allows the simultaneous estimation of coefficients with different estimation techniques and data levels, while taking account of a possible correlation of the error terms. The simultaneous regression also provides an estimate for the correlation of the error terms which can be used as an indicator for the necessity of a simultaneous approach.

5. Results

First, we run a regression of LS without the key variables in order to show the pure effects of the control variables. For regressions of LS we use ordinary least squares (OLS). We check the robustness of the OLS results by running ordered probit regressions (not reported in detail, all results not reported in detail are available on request). As expected, the differences between OLS and ordered probit estimates are minor (Ferrer-i-Carbonell and Frijters 2004). For the presentation and discussion of the results, we prefer the OLS estimates, as they are more intuitive to interpret and highlight eventual differences in the sign and significance levels of estimated coefficients for key variables. The results of the controls-only-estimation are summarised in Table 6 and Table 7 in the appendix.[5] The significant coefficient estimates have the expected signs; in particular, the data show a U-shape-effect of age, a positive effect of income and high education, and negative effects of unemployment and bad status of health. In the ordered probit regressions these effects are either confirmed or even higher significant than in the OLS regression.

In the next step, we include damage experience in the estimation. The respective results regarding the key variables are presented in the column “Model 1” in Table 2.[6] The results show that LS decreases significantly with the experience of damages caused by heat waves. Damage experience caused by other extreme weather events shows negative, albeit insignificant effects on LS. This will be further elaborated in the section “Discussion”.

The specifications named “Model 2a” and “Model 2b” in Table 2 focus on the relationship between damage expectations for the future and current LS. The two different specifications measure damage expectations by expected general consequences on personal living conditions and expected global temperature change, respectively. The coefficients for negative expectation levels in terms of personal consequences are significant and show the expected signs ($\gamma_{4,5} < \gamma_3 = 0$, see equation (3)). Also the temperature expectation variable exhibits the expected sign and is statistically significant, however not in the ordered probit specification.[7]

[5] Table 6 depicts estimation results with all available observations per specification. Table 7 shows the results with a reduced sample as it is available in the most comprehensive specification (Model 3). There are no large differences with regard to signs and significance levels of the estimates.

[6] Complete results of the regressions are presented in Table 6 (full sample) and Table 7 (reduced sample) in the appendix.

[7] The raw data for temperature expectations have been cleaned from outliers as explained in footnote 4. Robustness checks with the full sample, after recoding the variable into quartiles in order to account for the highly uneven distribution of the full sample data show no differing results.

"Model 3" includes all variables on damage experience and damage expectations. The estimates of an effect of heat wave experience and expectations of general consequences for personal living conditions stay significantly different from zero, while the temperature expectation variable does not show a significant effect any more.

In all specifications presented in Table 2, control variables are included. For the full estimation results, see Table 6 and Table 7 in the appendix. Table 7 (here the sample stays identical across specifications) shows that signs, magnitudes, and significance levels of control variables do not change substantially after including the climate variables.

Table 2: OLS regression results. Dependent variable: Life satisfaction (LS). Estimations with robust standard errors.

Variable in the model	Variable in the data	Model 1	Model 2a	Model 2b	Model 3
Damage experience (past)	Participant has already experienced financial or health damage by…				
	… heat wave	-.662*** (.159)	-	-	-.674*** (.177)
	… storm	-.0475 (.0655)	-	-	-.0558 (.0736)
	… heavy rain	-.0228 (.0628)	-	-	.00975 (.0700)
	… flood	-.163 (.0855)	-	-	-.129 (.0979)
Climate change expectation (future)	Expected consequences of climate change on individual living conditions in the next decades				
	- very positive ($j=1$)	-	.481 (.888)	-	.549 (.883)
	- rather positive ($j=2$)	-	-.0253 (.177)	-	-.0981 (.191)
	- neither positive nor negative($j=3$)	reference group			
	- rather negative ($j=4$)	-	-.192*** (.0579)	-	-.179*** (.0634)
	- very negative ($j=5$)	-	-.509*** (.144)	-	-.465*** (.159)
	Expected global temperature increase by 2100 in °C	-	-	-.0222** (.0110)	-.0162 (.0119)
Control variables		included	included	included	included
Observations		4766	4223	4015	3548
R^2		.148	.148	.134	.150

Standard errors in parentheses. The stars (*/**/***) denote significance levels of 10/5/1%, respectively.

For the identification and quantification of an indirect effect of damage experience on LS, we concentrate on the effect of heat waves (however keep the other damage variables in the estimations). The expectation variable indicating the expected consequences on individual living conditions was shown to be the more relevant for LS, so we focus on this variable and omit expected global temperature change from the following regressions for reasons of sample size.

First, let us evaluate the indirect effect via separate regressions of LS and climate expectations C_i. The LS regression is almost identical to Model 3 in Table 2; the only omitted variable is expected global temperature increase (which was insignificant in Model 3). Consequently, the results are almost identical in terms of signs, magnitudes, and significance levels of coefficients and model fit. Due to less missing observations, the sample size increases to N=3954. Complete results are reported as "Model 4" in Table 6 and Table 7 in the appendix.

Key results of the ordered probit estimation of climate damage expectations (equation (6b)) are presented in Table 3. Beside all control variables from the LS regression, further control variables are included (descriptive statistics see Table 5 in the appendix). The results suggest that high personal damage expectations go along with low household income, non-homeownership, risk aversion, overweight, pro-environmental attitudes, left-wing partisanship, not using internet as daily information source, and with damage experience by heat waves (all relations are significant at least on the 10% level). Note that the same sample has been used as in the separate LS regression.

Table 3: Ordered probit regression results. Dependent variable: Climate damage expectations ($C_{i.}$).

Variable in the model	Variable in the data	Coefficients (robust standard errors)
Income	Ln of Household income in €	-.170*** (.0442)
Homeownership	Ownership of the residence	-.0837* (.0441)
Health	Underweight	-.0344 (.233)
	Normal weight	reference group
	Overweight	.0871** (.0422)
	Obesity	.0837 (.0532)
Personal attitudes	Own health status is very important	.0747* (.0436)
	Protection of the nature and environment is very important	.108*** (.0417)
	Combatting climate change is very important	.511*** (.0419)
	Stated general time preference (high values: high patience)	-.0139* (.00805)
	Stated general willingness to take risks	-.0297*** (.00975)
	Partisanship of a left wing party	.104*** (.0388)
	Agreement with anthropogenic climate change	.397*** (.0393)
	Agreement with building of new coal power plants	-.132** (.0515)
	Information source for daily news: Internet	-.0800** (.0376)
Damage experience (past)	Participant has already experienced financial or health damage by…	
	… heat wave	.291*** (.101)
	… storm	.0564 (.0465)
	… heavy rain	.0224 (.0451)
	… flood	-.0413 (.0622)
Further control variables (see Table 5 in the appendix)		included
Threshold 1 (ω_1)		-4.604 (.457)
Threshold 2 (ω_2)		-3.439 (.434)
Threshold 3 (ω_3)		-1.350 (.430)
Threshold 4 (ω_4)		.390 (.429)
Observations		3954
Pseudo-R²		.0783

The stars (*/**/***) denote significance levels of 10/5/1%, respectively.

The results of the ordered probit model enhance the calculation of average marginal effects for each climate damage expectation level (see Table 4, column 2). The marginal effects show the expected signs, with decreasing probabilities for low expectation levels and increasing probabilities for higher expectation levels if heat wave damage occurs. Multiplying these probability changes with the LS-effects of the respective expectation levels (column 3 of Table 4, taken from Model 4 in Table 6) yields the indirect LS-effects of damage experience for each level (column 4 of Table 4), which in sum amount to the total indirect effect β_{ind} (see equation (7)).

Table 4: Calculation of the indirect effect of damage experience on LS. Robust standard errors of marginal effects and coefficients in parentheses.

Climate damage expectation levels (C_i)	Average marginal effect (change of estimated probability with regard to heat wave experience)	LS-effect of expectation level	Indirect effects
$C_i = 1$	-.00121* (.000638)	.427 (.901)	-.000516 (.00108)
$C_i = 2$	-.0154*** (.00555)	-.0277 (.182)	.000428 (.00281)
$C_i = 3$	-.0880*** (.0304)	0 (reference group)	0
$C_i = 4$	.0727*** (.0251)	-.218*** (.0596)	-.0158*** (.00433)
$C_i = 5$	.0320*** (.0112)	-.469*** (.150)	-.0150*** (.00294)
Sum over expectation levels (β_{ind})	n.a.	n.a.	-.0309*** (.00713)

The stars (*/**/***) denote significance levels of 10/5/1%, respectively. Standard errors in column 4 have been calculated manually using the error propagation formulas given in Taylor (1997).

Hence, the indirect effect of past damage experience on LS via the channel of future damage expectations is small, but significantly different from zero (p<.01). Compared to the total effect β , the indirect effect amounts to ca. 5% of the total effect.

In the next step, we repeat the two regressions (on LS and damage expectations) in a simultaneous equations model using the Stata command cmp by Roodman (2011). The results (available upon request) do not confirm a correlation of the error terms, indicating that a simultaneous estimation of the two regressions is not necessary. However, if conducted, the simultaneous estimation shows similar results as presented above. The indirect effect is small but existent (albeit on a lower significance level, p<.1).

6. Discussion of Results

The presented results allow novel insights into the interrelationships of life satisfaction (LS), damage experience due to EWE, and worry about future climate change (damage expectations). We will discuss the following topics separately: LS-effects of damage experience, LS-effects of damage expectations, and finally the disentangling of direct and indirect LS-effects of damage experience.

LS-Effects of Damage Experience

It was shown that the experience of financial or health damage due to heat waves in the past has a significant and non-negligible effect on current LS, keeping everything else equal (Model 1 and Model 3 in Table 2). The effect – which is robust over all specifications – is in the same order of magnitude like being unemployed.[8] This result is even more striking as damage experiences from other extreme weather events (floods, storms, and heavy rain) do not show significant effects on LS.[9] The discrepancy could be explained by the fact that damages due to heat waves are presumably rather health-related, whereas damages from the other events are rather of a financial nature. Recall that health-related damage was defined by the necessity of consulting a doctor, while financial damage was not restricted by a lower limit. Hence, heat wave damages could be *per se* more severe than (possibly low financial) damages from the other events. Furthermore, material damages may be more easily compensated either by savings or by insurance companies. In Germany, there is a private insurance market for storm and hail damage covering almost all private homes. In case of floods, the insurance density is lower (around 30%), which repeatedly has brought the government to release substantial relief payments. The fact that direct financial compensation is generally possible in case of material damage is an important difference to health-related effects, as heat waves presumably have. Another explanation focusses on the temporal dimension. Possibly, health-related damages exhibit enduring effects on LS, while financial damages have only temporary implications for LS.[10] As we do not know when the damages in our sample occurred, we can only speculate on this issue but in our view it is a plausible assumption that the missing (significant) effect of financial damages is due to this discounting phenomenon, whereas health-related damage has a LS-effect

[8] The inclusion of various interaction variables (age, sex, health status, farmer households) showed no significant interaction with the LS-effect of experiencing heat wave damage. Figure 2 in the appendix shows that Germany’s summer mean temperatures indeed varied considerably in the last 20 years. Locally, the variations were even larger.

[9] There is still no significant LS-effect of damage experience when flood, storm, and heavy rain damage experiences are aggregated to one variable.

[10] Extreme heat exposure may aggravate several chronic diseases, including cardiovascular, respiratory, renal and gastroenterology diseases (Centres for Disease Control and Prevention (2010), Hansen et al. (2008), Manser et al. (2013)).

which is lasting longer than financial losses. We see, however, scope for further research on the temporary dimensions of LS-effects of extreme weather events. Another caveat of the dataset is the limited information on the health status of participants, although health should be captured to some extent by the control variables body-mass-index, outdoor activities and risk aversion regarding health.

LS-Effects of Damage Expectations

The relationships of expectations regarding future climate change impacts and current LS were analysed using two different specification notions of expectations. Those participants who expect adverse effects of climate change on individual living conditions in the next decades, tend to be less satisfied (Model 2a in Table 2). The magnitude of the relationship is a bit lower than the effect of damage experience but highly significant. This means that concern about future climate impacts on personal living conditions affects LS even today by a non-negligible amount. A qualitatively similar, albeit less significant relationship can be observed when another measure for expectations is used, namely the expected mean global temperature increase by 2100 (Model 2b in Table 2). This formulation of the expectations does not require that the participants are personally affected – it is rather the concern about global climate change in general which causes the LS to decline here. This suggests that the former measure of expectations, namely the expected severity of future climate impacts on personal living condition in the next decades, exhibits the strongest and most robust relationship to current LS. Regressions with both expectation variables confirm this notion since only the former variable keeps significant estimates – beside those for damage experience from heat waves (Model 3 in Table 2). Hence in our sample, the LS-effect of concern about global climate change can be fully captured by the effect of expected consequences of climate change which are directly relevant for the participant.

Direct and Indirect LS-Effects of Damage Experience

As presented in the introduction, previous literature has demonstrated that experiences of climate-induced EWE may influence LS. The explicit inclusion of damage expectations for the future provides a deeper analysis of this relationship. Our empirical results suggest that the LS-effect of damage experiences can indeed be divided into a direct effect, induced by the mere loss experienced in the past and a significant indirect effect via the channel of damage expectation for the future. This means hypothesis c) stated in the theory part is not rejected by our data. However, the estimations of the indirect effect show that, although direct and indirect effects are significant, the indirect effect is very small compared to the total effect (around 5%). This suggests that the LS-effect of climate damage experience stems mainly from the mere past damage experience and only to a small part from the experience-driven change in future damage expectations.

Climate Damage Expectations and Personal Attitudes

For estimating the effect of heat wave experience on climate expectations, an ordered probit regression has been conducted which – beside extreme weather experience – includes all controls of the LS regressions and a number of additional variables. The results shall briefly be reviewed here.

Our data suggest that individuals with high personal climate damage expectations can by tendency be characterised as follows: Politically, they are partisans of left-wing parties. They have strong pro-environmental attitudes, such as rating the importance of environmental protection and the combat against global climate change as very high, stating that climate change is mainly induced by mankind, and disliking new coal power plants. Furthermore, they are generally risk averse, have a higher than normal body-mass-index, and prefer other sources than internet for being informed about daily news. Economically, they are less well-situated, with relatively low income and no homeownership.

Apart from heat waves, damage experiences with extreme weather events do not show a significant effect on damage expectations. Our data do not confirm an effect of further socio-demographic variables on climate expectations, such as sex, education, occupation or family status.

Regarding the political and environmental attitudes, our data broadly confirm empirical results from previous studies (Brody et al. 2008; Leiserowitz 2006; Liu et al. 2014; Owen et al. 2012; Safi et al. 2012; Whitmarsh 2008). However, the significant negative effect of income on concern is mostly not present in previous studies.

7. Conclusions

This paper deals with the triangular interrelationships of damage experience in the past, climate-change-induced damage expectations for the future, and current subjective well-being (SWB). In particular, the following research questions are pursued: How does damage experience in the past affect current SWB? How do damage expectations for the future relate to current SWB? Is there an indirect effect of damage experience via the channel of damage expectations on SWB and – if present – how large is it? In particular the two last questions have rarely been addressed in the literature.

To answer these questions, we utilise data from a new large-scale survey amongst German households and perform various regression analyses.

The results can be summarised as followed. We find a strong and significant effect of heat wave damage experience on current SWB, whereas we do not find significant effects of other damage experience due to other extreme weather events (storms, hail and heavy rain, and floods). There are several possible interpretations for this insight, ranging from the possibility to insure material damage but not health damage to a discounting effect which is rather expected for material damage than for health-related effects. We also find a significant and robust relationship between climate change-induced damage expectations in the future with current SWB. This phenomenon is more pronounced and significant if climate change expectations are framed as individual climate change impacts than if the global climate change impacts are stressed. To our knowledge, this is the first analysis relating climate change-induced damage expectations with current SWB. Furthermore, the SWB-effect of experiences can be disentangled into a direct effect from the mere damage event and a small but significant indirect effect which affects current SWB via the channel of damage expectations for the future. The estimated ratio of this indirect effect over the total effect is around 5%.

The results suggest several directions for further research: First, the strong and robust SWB-effect of heat waves (as such, but also compared to the non-significant effects of other weather events) deserves a deeper analysis. One possibility is to analyse whether insurance coverage is able to attenuate or even offset SWB-effects of financial weather damage and/or how fast individuals adjust to material damage (discounting effect). Second, the relationship between individual SWB and future-regarding climate change expectations seems to be a relevant factor which has been understudied so far – not least for the acceptance of climate policies. Eventually, differences between countries could be established in international analyses of this relationship. We believe the present study is a first step in this regard.

References

Akerlof, K., Maibach, E. W., Fitzgerald, D., Cedeno, A. Y., & Neuman, A. (2013). Do people "personally experience" global warming, and if so how, and does it matter? *Global Environmental Change*, *23*(1), 81–91. doi:http://dx.doi.org/1.1016/j.gloenvcha.2012.07.006

Ambrey, C. L., Fleming, C.M. (2011): The influence of natural environment and climate on life satisfaction in Australia, 2011 Conference (55th), February 8-11, Melbourne, Australia 100548, Australian Agricultural and Resource Economics Society.

Becchetti, L., Castriota, S., Andrés, L. B. D. (2007): Climate Happiness and the Kyoto Protocol: Someone does not like it hot, Departmental working paper, Tor Vergata University, CEIS.

Bichard, E., & Kazmierczak, A. (2012). Are homeowners willing to adapt to and mitigate the effects of climate change? *Climatic Change*, *112*(3-4), 633–654. doi:1.1007/s10584-011-0257-8

Brereton, F., Clinch, J. P., Ferreira, S. (2008): Happiness, geography and the environment, *Ecological Economics*, 65(2), 386-396.

Brody, S. D., Zahran, S., Vedlitz, A., & Grover, H. (2008). Vulnerability and Public Perceptions of Global United States. *Environment and Behavior*, *40*(1), 72–95.

Carroll, N., Frijters, P., Shields, M. (2009): Quantifying the costs of drought: new evidence from life satisfaction data, *Journal of Population Economics*, 22(2), 445-461.

Centres for Disease Control and Prevention. (2010). Climate and Health. Atlanta, USA. Retrieved from http://www.cdc.gov/climateandhealth/effects/

Cuñado, J., de Gracia, F. P. (2012): Environment and Happiness: New Evidence from Spain, *Social Indicators Research*, 1-19.

Diener. E., Emmons, R.A., Larsen, R.J., Griffin, S. (1985) – The Satisfaction With Life Scale, *Journal of Personality Assessment*, 49(1), 71-75.

DWD (2014): Zeitreihen von Gebietsmitteln, Deutscher Wetterdienst, Data retrieved from http://www.dwd.de/bvbw/appmanager/bvbw/dwdwwwDesktop?_nfpb=true&_pageLabel=_dwdwww_klima_umwelt_klimadaten_deutschland&T82002gsbDocumentPath=Navigation%2FOeffentlichkeit%2FKlima__Umwelt%2FKlimadaten%2Fkldaten__kostenfrei%2Fdaten__gebietsmittel__node.html%3F__nnn%3Dtrue, 15.07.2014.

Feddersen, J. R., Metcalfe, R., Wooden, M. (2012): Subjective Well-Being: Weather Matters, Climate Doesn´t, *Melbourne Institute Working Paper No. 25.*

Ferreira, S., Moro, M. (2010): On the Use of Subjective Well-Being Data for Environmental Valuation, *Environmental & Resource Economics*, 46(3), 249-273.

Ferrer-i-Carbonell, A., & Frijters, P. (2004). How Important is Methodology for the Estimates of the Determinants of Happiness? *The Economic Journal*, *114*, 641–659.

Ferrer-i-Carbonell, A., Gowdy, J. M. (2007): Environmental degradation and happiness, *Ecological Economics*, 60, 509-516.

Field, C. B., Barros, V., Stocker, T. F., Dahe, Q., Dokken, D. J., Ebi, K. L., … Midgley, P. M. (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation*.

Frey, B.S., Stutzer, A. (2002): What can economists learn from happiness research? *Journal of Economic Literature* 40, 402-435.

Frijters, P., van Praag, B. M. S. (1998): The Effects of Climate on Welfare and Well-Being in Russia, *Climatic Change*, 39(1), 61-81.

Grün, C., Grunewald, N. (2010): Subjective Well-Being and the Impact of Climate Change, Proceedings of the German Development Economics Conference , Hannover 2010 61, Verein für Socialpolitik, Research Committee Development Economics.

Hansen, A. L., Bi, P., Ryan, P., Nitschke, M., Pisaniello, D., & Tucker, G. (2008). The effect of heat waves on hospital admissions for renal disease in a temperate city of Australia. International Journal of Epidemiology, 37(6), 1359–65. doi:10.1093/ije/dyn165

IPCC. (2013). *Climate Change 2013: The Physical Science Basis Summary for Policymakers*.

Kimball, M., Levy, H., Ohtake, F., Tsutsui, Y. (2006): Unhappiness after Hurricane Katrina, Working Paper 12062, National Bureau of Economic Research.

Kountouris, Y., Remoundou, K. (2011): Valuing the Welfare Cost of Forest Fires: a Life Satisfaction Approach, *Kyklos*, 64(4), 556-578.

Leiserowitz, A. (2006). Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values. *Climatic Change*, *77*(1-2), 45–72. doi:10.1007/s10584-006-9059-9

Liu, Z., Smith, W. J., & Safi, A. S. (2014). Rancher and farmer perceptions of climate change in Nevada, USA. *Climatic Change*, *122*(1-2), 313–327. doi:10.1007/s10584-013-0979-x

Luechinger, S., Raschky, P. A. (2009): Valuing flood disasters using the life satisfaction approach, *Journal of Public Economics*, 93(3-4), 620-633.

Maddison, D., Rehdanz, K. (2011): The impact of climate on life satisfaction, *Ecological Economics*, 70(12), 2437-2445.

Manser, C. N., Paul, M., Rogler, G., Held, L., & Frei, T. (2013). Heat Waves, Incidence of Infectious Gastroenteritis, and Relapse Rates of Inflammatory Bowel Disease: A Retrospective Controlled Observational Study. The American Journal of Gastroenterology, 108(9), 1480–1485. Retrieved from http://dx.doi.org/10.1038/ajg.2013.186

Osberghaus, D., Schwirplies, C., & Ziegler, A. (2013). *Klimawandel in Deutschland: Risikowahrnehmung, Wissensstand und Anpassung in privaten Haushalten*. Mannheim, Germany. Retrieved from http://www.rwi-essen.de/forschung-und-beratung/umwelt-und-ressourcen/projekte/eval-map/ergebnisse/

Owen, A. L., Conover, E., Videras, J., & Wu, S. (2012). Heat Waves, Droughts, and Preferences for Environmental Policy. *Journal of Policy Analysis and Management*, *31*(3), 556–577.

Rehdanz, K., Maddison, D. (2005): Climate and Happiness, *Ecological Economics*, 52(1), 111-125.

Roodman, D. (2011). Fitting fully observed recursive mixed-process models with cmp. *The Stata Journal*, *11*(2), 159–206.

Safi, A. S., Smith, W. J., & Liu, Z. (2012). Rural Nevada and climate change: vulnerability, beliefs, and risk perception. *Risk Analysis*, *32*(6), 1041–59. doi:10.1111/j.1539-6924.2012.01836.x

Taylor, J. R. (1997). An Introduction to Error Analysis (2nd ed.). Sausalito, USA: University Science Books.

Welsch, H., & Ferreira, S. (2014). Environment, Well-Being, and Experienced Preference (No. V – 367 – 14). Oldenburg, Germany.

Welsch, H., & Kühling, J. (2009): Using Happiness Data for Environmental Valuation: Issues and Applications, *Journal of Economic Surveys*, 23(2), 385-406.

Welsch, H., & Kühling, J. (2010): Pro-environmental behavior and rational consumer choice: Evidence from surveys of life satisfaction, *Journal of Economic Psychology*, *31*, 405-420

Whitmarsh, L. (2008). Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response. *Journal of Risk Research*, *11*(3), 351–374.

Appendix

Table 5: Descriptive statistics of control variables. Control variables for LS regressions are included in X_i; all control variables are included in W_i.

Variable in the model	Variable in the data	Mean	Min.	Max.	Obs.	Incl. in X_i
Age	Age	50.6	18	87	6404	Yes
Sex	Sex	.324	0 (male)	1 (female)	6404	Yes
Family status	Married, living together	.524	0 (no)	1 (yes)	6341	Yes
	Married, living separately	.032				
	Single	.288				
	Divorced	.123				
	Widowed	.033				
Successors	Children	.660	0 (no)	1 (yes)	5994	Yes
	Grandchildren	.219			6046	
Education	Graduated from “Hauptschule” or not graduated	.147	0 (no)	1 (yes)	6016	Yes
	Graduated from “Realschule” or rest	.376				
	Graduated from high school or university	.477				
Occupation	Full-time employed	.603	0 (no)	1 (yes)	5967	Yes
	Part-time employed	.139				
	Retired	.220				
	Unemployed, searching for employment	.014				
	Housewife /-husband	.005				
	Other unemployed	.019				
Income	Ln of Household income in €	7.824	5.521	8.657	5186	Yes
Homeownership	Ownership of the residence	.555	0 (no)	1 (yes)	6182	Yes
Personal attitudes	Own financial situation is very important	.478	0 (not very important)	1 (very important)	6396	Yes
	Own health status is very important	.620			6398	Yes
	Protection of the nature and environment is very important	.426			6397	Yes
	Security from crimes is very important	.490			6397	Yes
	Combatting climate change is very important	.522			6389	No
	Stated general time preference (high values: high patience)	6.883	1	11	6394	Yes
	Stated general willingness to take risks	5.826	1	11	6394	Yes
	Stated willingness to take risks regarding own health	4.394	1	11	6392	Yes
	Partisanship of a left wing party	.390	0 (no)	1 (yes)	5990	No
	Agreement with statement “Humans are mainly responsible for climate change”	.419			6007	No
	Agreement with building of new coal power plants	.189			6251	No
	Information source for daily news: Internet	.523			6004	No
Federal state	16 Dummy variables for each state	n.a.	0	1	6404	Yes
Health	BMI less than 18.5 (underweight)	.006	0 (no)	1 (yes)	5713	Yes
	BMI between 18.5 and 25 (normal)	.374				
	BMI between 25 and 30 (overweight)	.435				
	BMI higher than 30 (obesity)	.184				
	Daily outdoor leisure activities	.301	0 (no)	1 (yes)	6256	Yes

Table 6: OLS regression results. Dependent variable: Life Satisfaction (LS). Sample size varies, according to available observations.

Variable in the model	Variable in the data	Coefficients (robust standard errors)					
		Controls only	Model 1	Model 2a	Model 2b	Model 3	Model 4
Age	Age	-.0835*** (.0167)	-.0826*** (.0168)	-.0871 (.0178)	-.0973*** (.0185)	-.102*** (.0195)	-.0886*** (.0184)
	Age²	.0008*** (.0002)	.0008*** (.0002)	.0009*** (.0002)	.0010*** (.0002)	.0010*** (.0002)	.0008*** (.0002)
Sex	Sex (1 = female)	.233*** (.0648)	.245*** (.0648)	.215*** (.0692)	.143* (.0737)	.142* (0772)	.256*** (.0711)
Family status	Married, living together	-.0068 (.0925)	-.0142 (.0928)	.0567 (.0989)	.0050 (.102)	.0761 (.108)	.110 (.103)
	Married, living separately	-.0069 (.159)	-.0009 (.158)	.0454 (.168)	-.0270 (.180)	-.0104 (.188)	.0605 (.174)
	Single	Reference group					
	Divorced	-.185* (.112)	-.168 (.112)	-.147 (.119)	-.183 (.125)	-.127 (.131)	-.122 (.124)
	Widowed	-.171 (.179)	-.160 (.181)	-.304 (.189)	-.267 (.203)	-.389* (.213)	-.243 (.197)
Successors	Children (1 = Yes)	.0490 (.0771)	.0630) (.0774)	.0294) (.0814)	.0806 (.0843)	.0504 (.0876)	.0122 (.0845)
	Grandchildren (1 = Yes)	.0876 (.0780)	.101 (.0782)	.0725 (.0821)	.0391 (.0862)	.0300 (.0894)	.0718 (.0846)
Education	Graduated from “Hauptschule” or not graduated	.0850 (.0843)	.0691 (.0841)	.0803 (.0907)	.0976 (.0934)	.0853 (.0982)	.122 (.0925)
	Grad. from “Realschule” or rest	Reference group					
	Grad. from high school or university	.146** (.0613)	.142** (.0615)	.112* (.0647)	.141** (.0674)	.124* (.0706)	.105 (.0668)
Occupation	Full-time employed	Reference group					
	Part-time employed	.00947 (.0890)	.0241 (.0889)	.0606 (.0938)	.0487 (.0988)	.0946 (.104)	.0527 (.0977)
	Retired	.328*** (.102)	.328*** (.101)	.334*** (.110)	.274** (.112)	.249** (.118)	.336*** (.111)
	Unemployed, searching for employment	-.618** (.268)	-.594** (.265)	-.472* (.271)	-.636** (.299)	-.465 (.299)	-.445 (.279)
	Housewife /-husband	.0137 (.401)	-.0214 (.401)	-.0191 (.447)	-.311 (.499)	-.338 (.538)	-.0620 (.473)
	Other unemployed, not searching for employment	.313 (.227)	.343 (.229)	.226 (.241)	.322 (.253)	.248 (.262)	.199 (.252)
Income	Ln of Household income in €	.777*** (.0658)	.782*** (.0662)	.7775*** (.0696)	.778*** (.0740)	.776*** (.0775)	.797*** (.0733)
Homeowner ship	Ownership of the residence	.201*** (.0636)	.197*** (.0636)	.148** (.0681)	.165** (.0710)	.118 (.0754)	.110 (.0700)
Health	Underweight	-.677 (.435)	-.639 (.434)	-.688 (.449)	-.284 (.536)	-.219 (.556)	-.572 (.481)
	Normal weight	Reference group					
	Overweight	-.0545 (.0601)	-.0389 (.0600)	-.101 (.0633)	-.0555 (.0668)	-.076 (.0688)	-.0914 (.0646)
	Obesity	-.152** (.0765)	-.128* (.0765)	.206** (.0812)	-.152* (.0837)	-.161* (.0869)	-.199** (.0838)

Variable in the model	Variable in the data	Coefficients (robust standard errors)					
		Controls only	Model 1	Model 2a	Model 2b	Model 3	Model 4
	Daily outdoor leisure activities	.192*** (.0606)	.208*** (.0608)	.189*** (.0643)	.195*** (.0671)	.211*** (.0699)	.195*** (.0664)
Personal attitudes	Own financial situation is very important	-.188*** (.0588)	-.193*** (.0590)	-.0190*** (.0627)	-.140** (.0648)	-.161** (.0683)	-.153** (.0647)
	Own health status is very important	.126** (.0608)	.121** (.0609)	.163** (.0649)	.139** (.0670)	.153** (.0704)	.153** (.0667)
	Protection of the nature and environment is very important	.0419 (.0557)	.0425 (.0558)	.0522 (.0596)	.0504 (.0616)	.0609 (.0648)	-.0354 (.0612)
	Security from crimes is very important	.0569 (.0570)	.0648 (.0574)	.0227 (.0608)	.0567 (.0625)	.0394 (.0663)	-.0140 (.0631)
	Stated general time preference (high values: high patience)	.842*** (.0122)	.0841*** (.122)	.0790*** (.0131)	.0806*** (.0135)	.0753*** (.0143)	.0829*** (.0135)
	Stated general willingness to take risks	.160*** (.0152)	.162*** (.0153)	.152*** (.0164)	.145*** (.0168)	.143*** (.0178)	.149*** (.0168)
	Stated willingness to take risks regarding own health	-.0727*** (.0135)	-.0732*** (.0136)	-.0704*** (.0147)	-.0685*** (.0148)	-.0668*** (.0158)	-.0764*** (.0152)
Federal state	15 Dummy variables, reference group: Bavaria	Included					
Damage experience (past)	Participant has already experienced financial or health damage by…						
	… heat wave	-	-.662*** (.159)	-	-	-.674*** (.177)	-.581*** (.171)
	… storm	-	-.0475 (.0655)	-	-	-.0558 (.0736)	-.0637 (.0702)
	… heavy rain	-	-.0228 (.0628)	-	-	.00975 (.0700)	.0123 (.0673)
	… flood	-	-.163* (. 855)	-	-	-.129 (.0979)	-.154 (.0931)
Climate change expectation (future)	Expected consequences of climate change on individual living conditions in the next decades						
	- very positive	-	-	.481 (.888)	-	.549 (.883)	.427 (.901)
	- rather positive	-	-	-.0253 (.177)	-	-.0981 (.191)	-.0277 (.182)
	- neither positive nor negative	Reference group					
	- rather negative	-	-	-.192*** (.0579)	-	-.179*** (.0634)	-.218*** (.0596)
	- very negative	-	-	-.509*** (.144)	-	-.465*** (.159)	-.469*** (.150)
	Expected global temperature increase by 2100 in °C	-	-	-	-.0222** (.0110)	-.0162 (.0119)	-
Constant		1.553*** (.619)	1.567** (.624)	1.837*** (.656)	1.998*** (.690)	2.335*** (.725)	1.838** (.688)
Observations		4826	4766	4223	4015	3548	3954
R^2		.141	.148	.148	.134	.150	.152

Robust standard errors in parentheses. The stars (*/**/***) denote significance levels of 10/5/1%, respectively.

Table 7: OLS regression results. Dependent variable: Life Satisfaction (LS). Sample fixed to the model with the lowest number of observations (Model 3, N=3548).

Variable in the model	Variable in the data	Coefficients (robust standard errors)					
		Controls only	Model 1	Model 2a	Model 2b	Model 3	Model 4
Age	Age	-.108*** (.0196)	-.104*** (.0195)	-.106*** (.0195)	-.107*** (.0196)	-.102*** (.195)	-.102*** (.0194)
	Age²	.00110*** (.000204)	.00106*** (.000203)	.00108*** (.000204)	.00109*** (.000205)	.00103*** (.000203)	.00104*** (.000203)
Sex	Sex (1 = female)	.135* (.0773)	.142* (.0773)	.132* (.0772)	.142* (.0774)	.143* (.0772)	.138** (.0772)
Family status	Married, living together	.0919 (.109)	.0757 (.108)	.0908 (.108)	.0928 (.109)	.0761 (.108)	.0752 (.108)
	Married, living separately	.00997 (.190)	.0191 (.188)	-.0260 (.190)	.0172 (.190)	-.0104 (.188)	.0167 (.188)
	Single	Reference group					
	Divorced	-.119 (.131)	-.123 (.131)	-.121 (.131)	-.120 (.132)	-.127 (.131)	-.126 (.131)
	Widowed	-.382* (.213)	-.349 (.214)	-.429** (.211)	-.377* (.213)	-.389* (.213)	-.394* (.213)
Successors	Children (1 = Yes)	.0475 (.0878)	.0548 (.0876)	.0447 (.0878)	.0455 (.0878)	.0504 (.0876)	.0518 (.0875)
	Grandchildren (1 = Yes)	.0255 (.0900)	.0339 (.0901)	.0216 (.0893)	.0259 (.0899)	.0300 (.0894)	-.0296 (.0895)
Education	Graduated from “Hauptschule” or not graduated	.0943 (.0989)	.0877 (.0985)	.0890 (.0986)	.0978 (.0988)	.0853 (.0982)	.0828 (.0983)
	Grad. from “Realschule” or rest	Reference group					
	Grad. from high school or university	.128* (.0707)	.135* (.0705)	.120* (.0707)	.120* (.0708)	.124* (.0706)	.129* (.0705)
Occupation	Full-time employed	Reference group					
	Part-time employed	.0720 (.104)	.0823 (.104)	.0829 (.104)	.0759 (.103)	.0946 (.104)	.0928 (.104)
	Retired	.225* (.119)	.235** (.118)	.236** (.119)	.232* (.119)	.249** (.118)	.245** (.118)
	Unemployed, searching for employment	-.558* (.308)	-.522* (.301)	-.525* (.304)	-.516* (.307)	-.465 (.299)	-.492 (.299)
	Housewife /-husband	-.319 (.560)	-.350 (.560)	-.326 (.541)	-.296 (.553)	-.338 (.538)	-.355 (.542)
	Other unemployed, not searching for employment	.156 (.267)	.246 (.259)	.168 (.269)	.150 (.267)	.248 (.262)	.254 (.262)
Income	Ln of Household income in €	.798*** (.0779)	.795*** (.0777)	.780*** (.0776)	.793*** (.0780)	.776*** (.0775)	.779*** (.0775)
Homeownership	Ownership of the residence	.131* (.0758)	.139* (.0753)	.111 (.0759)	.126* (.0757)	.118 (.0754)	.120 (.0755)
Health	Underweight	-.277 (.572)	-.204 (.565)	-.290 (.561)	-.275 (.575)	-.219 (.556)	-.219 (.553)
	Normal weight	Reference group					
	Overweight	-.0959 (.0689)	-.0848 (.0687)	-.0886 (.0689)	-.0917 (.0690)	-.0760 (.0688)	-.0783 (.0687)
	Obesity	-.204** (.0880)	-.175** (.0875)	-.192** (.0873)	-.196** (.0879)	-.161* (.0869)	-.165* (.0870)

Variable in the model	Variable in the data	Coefficients (robust standard errors)					
		Controls only	Model 1	Model 2a	Model 2b	Model 3	Model 4
	Daily outdoor leisure activities	.205*** (.0702)	.214*** (.0699)	.203*** (.0702)	.205*** (.0702)	.211*** (.0699)	.211*** (.0699)
Personal attitudes	Own financial situation is very important	-.160** (.0686)	-.163** (.0683)	-.159** (.0685)	-.157** (.0686)	-.161** (.0683)	-.163** (.0682)
	Own health status is very important	.143** (.0710)	.140** (.0706)	.154** (.0707)	.147** (.0711)	.153** (.0704)	.151** (.0704)
	Protection of the nature and environment is very important	.00789 (.0643)	.0154 (.0641)	.0533 (.0649)	.0136 (.0645)	.0609 (.0648)	.0589 (.0648)
	Security from crimes is very important	.0402 (.0665)	.0433 (.0664)	.0363 (.0663)	.0402 (.0664)	.0394 (.0663)	.0391 (.0663)
	Stated general time preference (high values: high patience)	.0800*** (.0145)	.0777*** (.0144)	.0775*** (.0144)	.0798*** (.0145)	.0753*** (.0143)	.0753*** (.0143)
	Stated general willingness to take risks	.144*** (.0179)	.146*** (.0178)	.141*** (.0178)	.144*** (.0179)	.143*** (.0178)	.143*** (.0178)
	Stated willingness to take risks regarding own health	-.0675*** (.0159)	-.0676*** (.0158)	-.0662*** (.0159)	-.0681*** (.0158)	-.0668*** (.0158)	-.0663*** (.0158)
Federal state	15 Dummy variables, reference group: Bavaria	Included					
Damage experience (past)	Participant has already experienced financial or health damage by…						
	… heat wave	-	-.708*** (.179)	-	-	-.674*** (.177)	-.684*** (.177)
	… storm	-	-.0600 (.0739)	-	-	-.0558 (.0736)	-.0561 (.0736)
	… heavy rain	-	.00594 (.0701)	-	-	.00975 (.0700)	.00788 (.0699)
	… flood	-	-.127 (.0984)	-	-	-.129 (.0979)	-.128 (.0980)
Climate change expectation (future)	Expected consequences of climate change on individual living conditions in the next decades						
	- very positive	-	-	.548 (.902)	-	.549 (.883)	.556 (.909)
	- rather positive	-	-	-.0815 (.190)	-	-.0981 (.191)	-.0976 (.190)
	- neither positive nor negative	Reference group					
	- rather negative	-	-	-.189*** (.0631)	-	-.179*** (.0634)	-.189*** (.0630)
	- very negative	-	-	-.513*** (.159)	-	-.465*** (.159)	-.480*** (.158)
	Expected global temperature increase by 2100 in °C	-	-	-	-.0238** (.0118)	-.0162 (.0119)	-
Constant		2.060*** (.727)	2.030*** (.725)	2.298*** (.725)	2.182*** (.728)	2.335*** (.725)	2.262*** (.724)
Observations		3548	3548	3548	3548	3548	3548
R^2		.139	.145	.144	.140	.150	.150

Robust Standard errors in parentheses. The stars (*/**/***) denote significance levels of 10/5/1%, respectively.

Table 8: Questions and answer options of the key variables LS, damage experience, and damage expectations (translated from German). The "don't know"-option was possible in each question.

Variable in the data	Question	Options
Self-rated life satisfaction	In general, how satisfied are you currently with your life?	*Eleven categories, of which the lowest is named "totally dissatisfied" and the highest "totally satisfied"*
Damage experience from extreme weather events	In the following various natural events are listed. Please mark each which you have personally experienced at home, at work or during a journey.	- Heat waves (e.g. such that you did not want to be outside and changed your plans accordingly) - Storms (e.g. such that you have avoided leaving your home) - Heavy rain or hail (e.g. such that you have worried about your car, garden or house) - Floods or inundation
	If one or more of the events have been marked, the marked events have been presented again with this follow-up question: Please mark now for each event, whether you have suffered any financial or health damage (with consultation of a doctor) from the event.	
Expected consequences of climate change on individual living conditions in the next decades	According to your assessment, which consequences will climate change have for your very personal living conditions in the next decades?	- Very positive consequences - Rather positive consequences - Broadly equally negative and positive consequences - Rather negative consequences - Very negative consequences
Expected global temperature increase by 2100	According to your assessment, how is the average global temperature changing by 2100 (relative to the preindustrial times, i.e. ca. 1850)	- It is going to fall - It is going to stay broadly the same - It is going to rise
	If "Rise" or "Fall" was chosen, this follow-up-question was posed: And by how much do you expect it to rise/fall (in °C)? For remembrance: We are talking about the average global temperature change by 2100 relative to preindustrial times, i.e. ca. 185.	*All numerical values were allowed. The unit was fixed to °C.*

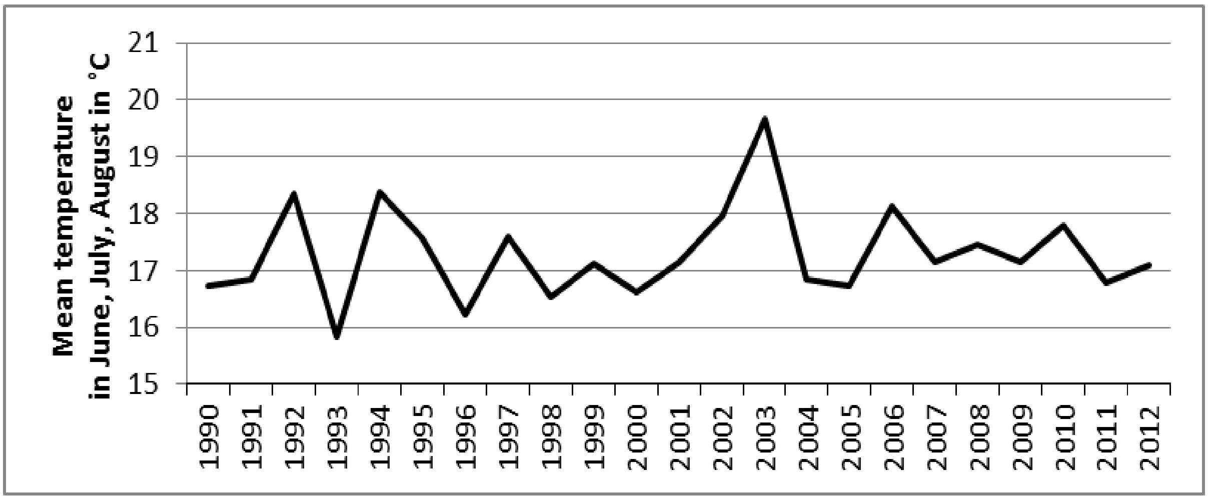

Figure 2: Mean air temperature in June, July and August between 1990 and 2012 in Germany. Source: DWD (2014).