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Analysis

Measuring impacts of extreme weather events using the life satisfaction approach

Charlotte von Möllendorff [a,*], Jesko Hirschfeld [b]

[a] Carl von Ossietzky University Oldenburg, Department of Economics, 26111 Oldenburg, Germany
[b] Institute for Ecological Economy Research (IÖW), Potsdamer Str. 105, 10785, Berlin, Germany

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A B S T R A C T

Extreme weather events cause harm among the aggrieved party that often goes beyond material damages. This paper studies the impact of extreme weather events on measures of self-reported life satisfaction. Focusing on Germany, we use representative panel data for 2000–2011 to study the effect of seven storm & hail events and five floods on subjective well-being in the affected NUTS 3 regions. Our results indicate that both weather experiences bear statistically significant negative externalities. Following an extreme weather event, life satisfaction is reduced by 0.020–0.027 on the 11-point scale. While the effect of storm & hail events is rather immediate in nature, the effect from floods persists much longer.

1. Introduction

In the past, we observed some destructive storms and floods that severely impacted on the population living in affected areas. With climate change, the magnitude and frequency of extreme weather events are expected to increase even further (Ciscar et al., 2009). The valuation of impacts imposed by extreme weather events usually focuses on economic aspects, such as damages on buildings, items and infrastructures and thereby neglects immaterial values such as mental distress, worries, health injuries or the loss of personal belongings (see e.g. Dehnhardt et al., 2008, Tapsell et al., 2002).

In this paper we study the impact of extreme weather events in Germany using evidence from subjective well-being data. Life satisfaction analysis has been increasingly used to evaluate environmental attributes and non-marketed goods (see e.g. Welsch and Ferreira, 2013 or Ferreira and Moro, 2010).

We analyse how life satisfaction changes in affected regions due to the occurrence of an extreme weather event using panel data from the German Socio-Economic Panel Study (SOEP, see Schupp et al., 2014). Using panel data permits to control for unobserved interpersonal heterogeneity. The importance of controlling for individual fixed effects in life satisfaction analysis has been emphasized by Ferrer-i Carbonell and Frijters, (2004). Our paper ties in with a small number of studies that analyse well-being effects of climate variables (Maddison and Rehdanz, 2011) and weather events like floods (Luechinger and Raschky, 2009), droughts (Carroll et al., 2009), hurricanes (Kimball et al., 2006) and forest fires (Kountouris and Remoundou, 2011). Luechinger and Raschky (2009) study the well-being effect of floods in Europe between 1973 and 2004 on NUTS 2 level and find a sizeable negative effect on life satisfaction. In a more recent analysis, Osberghaus and Kühling (2014) study indirect and direct effects of weather experiences in Germany – namely storms, floods, heavy rain and heat waves – on subjective well-being using a specifically designed and conducted one-time survey. They find a significant negative effect of climate-change induced damage expectations on subjective well-being while the direct effect is only significant in the case of heat waves.

In our analysis we focus on Germany using data from the SOEP for 2000–2011 which allows us to control for interpersonal heterogeneity and relevant socio-economic characteristics. We further use spatially disaggregated data (NUTS 3 level) from the German Insurance Association (GDV) on insured losses of five floods and seven storm & hail events. Hence, the main contribution of our paper is to study the well-being effects of different types of extreme weather events (floods and storm & hail) on a disaggregated level (NUTS 3) over a period of

* Corresponding author.
E-mail addresses: charlotte.moellendorff@uni-oldenburg.de (C. von Möllendorff), jesko.hirschfeld@ioew.de (J. Hirschfeld).

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12 years (2000–2011) using the rich dataset of the SOEP. Unlike earlier studies, we consider regional data on insurance density, distinguish different levels of regional impacts, analyse households in rented/owned property separately and control for movers/stayers. Our results indicate a significant negative effect of storm & hail events as well as floods on subjective well-being in affected regions, decreasing life satisfaction by about 0.02–0.027 on the 11-point scale. While the effect of storm & hail events dissipates after 6 months, floods affect life satisfaction much longer. Moreover, we find that the effect is particularly adhering to house owners and is lower in areas with high insurance rates.

The following sections are structured as follows: Section 2 presents the data and Section 3 describes the econometric approach. Section 4 reports and discusses the results while Section 5 concludes.

2. Data

The life satisfaction data along with the socio-economic control variables were made available by the German Socio-Economic Panel Study (SOEP) of the German Institute for Economic Research (DIW), Berlin. Since 1984, the SOEP conducts annual interviews surveying the socio-economic situation of German households. In each annual wave approximately 20,000 persons living in 11,000 households are surveyed (see Wagner et al., 2007). As for the panel structure of the survey study, the same set of respondents is reinterviewed each year. This facilitates to make longitudinal analyses of changes on the individual level and to control for unobserved time-invariant characteristics (Andreß et al., 2013). Especially by focusing on a longer time frame, the SOEP study faces some temporary or permanent drop-outs which are offset by including new respondents, i.e. the data is unbalanced. Our analysis is conducted based on an unbalanced subset of the SOEP, which is composed of 239,209 observations from 39,679 respondents that were interviewed during 2000 and 2011. The spatial level of the analysis refers to the NUTS 3 regions of Germany which coincide with the level of *Landkreise*/*Kreise* and *kreisfreie Städte*.[1] There are 402 NUTS 3 regions in Germany with an average size of 888 km^2. The life satisfaction data of the SOEP results from responses to the following question: "How satisfied are you with your life, all things considered?". The question can be answered on a scale from 0 (*completely dissatisfied*) to 10 (*completely satisfied*). In addition, we considered time-varying socio-economic control variables on the individual level, that were found to cause changes in individual well-being (see e.g. Frijters et al., 2004).[2]

With regard to extreme weather events we created a dataset that includes floods and storm & hail events that occurred in Germany during 1999 and 2010, with the most severe being the Elbe flood in 2002 and the storm Kyrill in 2007. The events are summarized in Table 1. The selection of events is based on their intensity which is approximated by the claims expenditure they caused for insurances. In our analysis we considered five floods that caused claims expenditures higher than 55 million and seven storm & hail events that caused claims expenditures higher than 230 million. The great difference in claims expenditure between both types of events is related to the insurance density. In Germany more than 90% of all buildings are insured against storm and hail events, while only 30% of all buildings have a natural hazard insurance, which covers, inter alia, damages due to floods (GDV, 2012). So the fraction of damages rendered by the insurances is higher for storm & hail events compared to floods. Furthermore, there is regional variation in insurance densities with regard to natural hazard insurances (see e.g. Kreibich et al., 2011 or Seifert et al., 2013). For this reason, we used data on regional insurance densities, which represent for each federal state the share of insured buildings in the highest risk zone (GDV, 2013).

Though we are analysing the period from 2000 to 2011 the storm Lothar that occurred in December 1999 is included in the analysis so as to study possible effects on self-reported life satisfaction in the interviews conducted in 2000. In the same line of reasoning 2011 is included in the analysis to track potential effects of events that occurred in 2010 on stated well-being in 2011. The thunderstorm Hilal is listed twice because some of the damages were covered by the natural hazard insurance, while others were covered by the building insurance.

The data we use refers to damages from floods and storm & hail events collected and provided by the German Insurance Association (Gesamtverband der deutschen Versicherungswirtschaft, GDV), Berlin. Storm & hail events are usually insured via building insurances while floods (due to extreme rainfall or overflowing) come under the natural hazard insurance. We used damage data of both insurance types to obtain information on storm & hail events as well as floods in Germany.[3] For each considered event the data was made available in the form of high-resolution maps showing the classified damage frequencies per NUTS 3 region (see Fig. 1 for corresponding maps of the Elbe flood, 2002 and storm Kyrill, 2007).

Damage frequency (DF) is defined as follows (GDV, 2012:43):

$$\text{Damage frequency (DF)} = \frac{\text{number of claims}}{\text{number of contracts}} \tag{1}$$

Thus, the damage frequency describes the number of contracts that were deployed to claim from the insurer in relation to the total number of running contracts per NUTS 3 region. By this, the variable implicitly controls for regional variation in insurance density. As the borders of the NUTS 3 regions are displayed in the maps, the information on damage frequency per NUTS 3 region and event could be extracted using a Geographic Information System (GIS).

The damage frequencies of the NUTS 3 regions are displayed in intervals which correspond to the incidence rates of the events ranging from *On one day there occurred as many damages as usually occur within 1 week (storm & hail)/1 month (floods)* to *On one day there occurred as many damages as usually occur within 1 year (storm & hail)/12 years (floods)*. To illustrate, consider the NUTS 3 region in Fig. 1(a) coloured in black which was most severely affected by the Elbe flood in 2002 (Sächsische Schweiz-Osterzgebirge): It exhibits a damage frequency higher than 200 which means that over 200 out of 1000 households insured against natural hazard events claimed from the insurer, an event whose corresponding incidence rate is 12 years. Taking a look at storm Kyrill, the map shows that most of the NUTS 3 regions (129) had a damage frequency between 38.7 and 77.4 meaning that in those regions there occurred more damages on one day than usually occur within six months, or rather the incidence rate is 6 months (see Table 2).

This exemplifies that the relation between damage frequency and incidence rate differs for floods and storm & hail events, respectively. So in order to combine the data on floods and storm & hail events and to get down to a common definition of extreme weather events we revert to the incidence rate. Based on this, we define an extreme event as follows: *On one day there occurred more damages as usually occur within a month*. This means that for each event we considered respondents as affected if they lived in a NUTS 3 region with a damage frequency higher than 0.4 in case of floods, and 6.4 in case of storm & hail events (see Table 2). This is the lowest threshold value commonly available for both types of events. If we increase the threshold level, we are likely to get down to the more severely impacted individuals which may

[1] NUTS stands for Nomenclature of Units for Territorial Statistics and is a geocode standard for referencing counties and regions in the European Union.

[2] See Appendix for summary statistics.

[3] For simplicity we refer to flood events throughout the paper. Strictly speaking the data describes all other natural hazard damages as well (backwater, earthquakes, land subsidence, landslide, snowslides, snow pressure, and volcanic eruption) which are generally, however, of minor relevance in Germany (GDV, 2012).