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Abstract

This paper examines the extent and the determinants of individual global climate change beliefs. In contrast to former studies, it is focused on China due to its crucial role in global climate policy and its responsibility as the worldwide biggest producer of CO_2 emissions. The empirical analysis is based on unique data from a survey among more than 1000 individuals from five cities in China, namely Beijing, Guangzhou, Chengdu, Wuhan, and Shenyang. In line with previous studies in other countries, our results suggest that the vast majority of almost 90% of the Chinese respondents believe in the existence of global climate change, which seems to be a convenient basis for ambitious climate policy in China. Our econometric analysis reveals that the personal experience with extreme weather events (and particularly heatwaves) alone is already sufficient to increase global climate change beliefs, although consequential personal physical or financial damages lead to stronger effects. A rising number of extreme weather events and consequential personal damages in the future might thus further decrease climate change skepticism. Our estimation results additionally reveal that females as well as people in medium ages, with higher household incomes, a lower education, and from Chengdu or Shenyang are more skeptical with respect to global climate change.

JEL-Classification: Q54, Q58

Keywords: Global climate change, beliefs and skepticism, extreme weather events, China, micro-econometric analysis

1. Introduction

The recently published Assessment Report of the Intergovernmental Panel on Global Climate Change (IPCC) (Summary for Policymakers of the Working Group I contribution to the IPCC Fifth Assessment Report 2013[1]) considers warming of the climate system as unequivocal. Many of the observed changes are unprecedented and human activities are very likely to have contributed not only to global climate change, but also to changes in the occurrence of extreme weather events. Global warming is also considered in most parts of the world as one of the crucial environmental and societal challenges due to its strong impacts on the natural environment and human lives, even though there are still important gaps in knowledge on the impacts of climate change, particularly on a regional scale. One indication of its impact is the number of people around the world affected by natural and especially weather disasters. From 1981 to 1985, less than 500 million people required international natural disaster assistance, whereas from 2001 to 2005 the number already reached 1.5 billion.

In China, for example, the frequency and intensity of short duration heatwaves, droughts, and floods due to intensive daily rainfalls have risen in recent decades with an increasing frequency of extreme rains in western and southern parts including the region of the Changjiang river, more frequent floods from the Changjiang river in the past decade and in the North-East since the 1990s, more intensive summer rains in the East, a severe flood in 1999, and a seven-fold increase in the frequency of floods since the 1950s (e.g. Zhai et al., 1999, Ding and Pan, 2002, Zhai and Pan, 2003, Zhai, 2004, Zhai et al., 2004, IPCC, 2007). These changing weather patterns are widely discussed in the Chinese and also international media and academia, particularly due to the contribution of global warming to this development and the consequential physical and financial damages for the affected people.

In order to limit the increase in global temperatures below two degrees Celsius as recognized, for example, in the Copenhagen Accord 2009, drastic reductions of greenhouse gas and par-

[1] http://www.climatechange2013.org/spm

ticularly CO_2 emissions are necessary (see also the Summary for Policymakers of the Working Group III contribution to the IPCC Fifth Assessment Report 2014[2]). In this respect, China plays a dominant role since it has overtaken the U.S. as the worldwide biggest producer of CO_2 emissions. According to the European Commission (Emission Database for Global Atmospheric Research, EDGAR[3]), China is responsible for 9,700,000 Ktons of CO_2 emissions compared to 5,420,000 Ktons caused by the U.S. The average Chinese individual was responsible for about seven tons of CO_2 emissions in 2012, which is similar to the average EU citizen.[4] As many other countries, China has taken a series of specific measures and policies to address global warming. In its highest priority national plan, namely the 12th Five-Year Plan (2011-2015), the Chinese government has included reduction targets for both energy consumption and CO_2 emissions. According to this, it is intended to reduce energy consumption per unit of GDP by 16% and CO_2 emissions per unit of GDP by 17% by 2015, both compared to 2010 levels.

However, policies and measures to combat (anthropogenic) climate change can certainly only be successfully implemented if individuals are willing to support these policies and also to voluntarily conduct climate protection activities. The necessary condition for the willingness to support climate policy measures is that people believe in the existence of global warming. Some studies have already examined the extent of climate change beliefs and skepticism for several countries worldwide (e.g. Carlsson et al., 2012). However, empirical analyses of the determinants of global climate change beliefs generally refer to the U.S. and Europe and thus have not been conducted for poor and lower-middle-income countries so far. In particular, China has not been considered in this respect up to now in spite of its pivotal role in global climate policy and its responsibility as the worldwide biggest producer of CO_2 emissions as aforementioned. Against this background, we empirically examine both the extent and partic-

[2] http://mitigation2014.org/report/summary-for-policy-makers

[3] http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2011

[4] http://www.theaustralian.com.au/news/world/china-passes-eu-in-carbon-pollution/story-fnb64oi6-1226763731532#

ularly the determinants of perceptions of Chinese individuals towards the existence of global climate change.

Our analysis is based on unique data from a survey among more than 1000 Chinese citizens in five economically important cities, namely Beijing, Guangzhou, Chengdu, Wuhan, and Shenyang. According to these data, the vast majority of respondents believes in global climate change, which is similar to the results in other countries. In line with some former studies for other countries, we consider the relevance of personal experiences with extreme weather events in our econometric analysis of the determinants of global climate change beliefs in China. In contrast to previous analyses, however, we additionally distinguish between the effects of experiences with extreme weather events with and without physical or financial damages due to such weather events. In addition, we examine the relevance of socio-demographic and socio-economic factors such as age, gender, or income in order to identify specific Chinese population groups with stronger global climate change beliefs or skepticism.[5]

The remainder of the paper is organized as follows: The next section reviews the relevant literature and develops several hypotheses for our empirical analysis. In the third section our new dataset is presented. The fourth section discusses some descriptive statistics and the results of the econometric analysis and the final section concludes.

2. Literature review and hypotheses

Several empirical studies for the U.S. and European countries show that a strong majority of households in these regions believes that global warming is already happening and will continue in the future (e.g. Lorenzoni and Pidgeon, 2006, Nisbet and Myers, 2007). In addition, the cross country analysis of Carlsson et al. (2012) suggests that U.S. Americans slightly differ from Swedes and Chinese on the issue of perceptions towards the existence of climate change. While 75.7% of the U.S. Americans believe that global temperatures have risen, the

[5] It should be noted that our analysis of global climate change skepticism refers to disbeliefs in general global warming and not necessarily in anthropogenic global warming.

shares in Sweden and China are 94.1% and 95.5%. In another international online survey on climate risk among more than 13,000 people across 13 countries in three continents, around 75% of the respondents state that global warming has already been scientifically proven (Ménioux and Zumsteeg, 2012).

With respect to the determinants of global climate change beliefs, several drivers have been examined such as media coverage (e.g. Iyengar and Kinder, 1987, Sampei et al., 2009) or scientific evidence (e.g. Neuman, 2004, Ranny et al., 2012). In this respect, particularly personal experiences with extreme weather events play a crucial role. While global warming is generally not consciously perceived, weather experiences are often considered to be strongly related to global climate change. For example, Leiserowitz et al. (2012a, 2012b, 2014) show that between half and three quarters of U.S. Americans agree that climate change is affecting the weather in the U.S.. In addition, based on local weather records with geocoded data from five representative surveys in the U.S., Egan and Mullin (2012) show substantial effects of weather experiences. Their empirical analysis suggests that the agreement to a solid evidence for global warming increases by one percentage point if local temperatures in the past week increase above normal by 3.1 degrees Fahrenheit. Other previous empirical analyses show a similar relationship (e.g. Hamilton and Keim, 2009, Joireman et al., 2010, Li et al., 2011). Furthermore, data from surveys in Australia reveal that people who live in areas that are frequently affected by extreme weather events are more convinced that global warming is a scientific fact (e.g. Ménioux and Zumsteeg, 2012). In summary, this leads to the following hypothesis that is examined in our econometric analysis:

Hypothesis 1: *Personal experiences with extreme weather events have positive effects on global climate change beliefs in China.*

However, it seems that the effects of experiences with extreme weather events on perceptions towards the existence of global warming are not identical across different weather events. In this respect, the studies of Leiserowitz et al. (2012a, 2012b) examine a series of single extreme weather events, namely extreme high winds, extreme rainstorms, extreme heatwaves, droughts, extreme cold temperatures, extreme snowstorms, tornadoes, floods, hurricanes, and bushfires. Furthermore, Whitmarsh (2008), Spence et al. (2011), and Egan and Mullin (2012) particularly consider floods, heatwaves, and an unusually warm season. These analyses show that especially personal experiences with heatwaves and floods affect climate change beliefs so that these two extreme weather events can be considered as the major impact from global warming. In line with these results from former empirical studies for high income countries, this leads to the following hypothesis that is examined in our econometric analysis:

Hypothesis 2: *Personal experiences with heatwaves and floods have stronger positive effects on global climate change beliefs in China.*

Furthermore, not only the extreme weather events, but also the consequences of experiences with such events can be very different. Extreme weather events such as heatwaves or floods can lead to great physical or financial damages, but they can also lead to slight limitations in the quality of life during a short time period, or they can even have no consequences at all, for example, if an avalanche is observed during a holiday or if a heatwave is successfully answered by the use of air conditioning. In these latter cases, it can be speculated that the personal experiences with extreme weather have weaker or even no effects on perceptions towards the existence of climate change. In contrast, it can be argued that personal damages due to extreme weather events should lead to stronger impacts on global climate change beliefs.

This argument is supported by psychological studies which emphasize the importance of personally significant experiences with general natural disasters and thus also with extreme weather events. According to the study of Reser et al. (2012) for Australia, such natural disasters that are characterized as being most personally significant are very traumatic for many individuals (see also the traumatic exposure severity scale, TESS, according to Elal and Slade, 2005). Personally significant experiences with general natural disasters such as a physically injured or trapped family member or close acquaintance, damages at the own home, or thoughts at one or more points that one could die are very important indicators for the emotional intensity and psychological impact of such an event (e.g. Norris et al., 2002a, 2002b, McDermott et al., 2005, Mills et al., 2007, Wahlström et al., 2008). In summary, this leads to the following hypothesis that is examined in our econometric analysis:

Hypothesis 3: *Personal physical or financial damages due to extreme weather events have stronger positive effects on global climate change beliefs in China.*

Finally, it has been shown in several studies that socio-demographic and socio-economic factors such as age, gender, or income can also influence perceptions towards the existence of global warming (e.g. Krosnick et al., 2006). With respect to age, some studies cannot identify any effect on global climate change beliefs (e.g. Whitmarsch, 2008, Egan and Mullin, 2012). However, if any impacts of age can be revealed, they are positive, i.e. it can be shown in these cases that older people have stronger climate change beliefs than younger population groups (e.g. Li et al., 2011). With respect to the effects of gender and income, most studies reveal that females and low income groups have stronger climate change beliefs than males and high income groups (e.g. O'Connor et al., 1999, McCright, 2010, McCright and Dunlap, 2011, Whitmarsh, 2011, Li et al., 2011, Egan and Mullin, 2012). In contrast, the impact of education is ambiguous according to former studies. For example, Egan and Mullin (2012) have found that high education has a positive effect on climate change beliefs, whereas Li et al. (2011) could not reveal any impact and O'Connor et al. (1999), Wood and Vedlitz (2007), and Malka et al. (2009) even report negative effects. In line with these results from former empirical studies for high income countries, this leads to the following hypothesis for age, gender, and income that is examined in our econometric analysis:

Hypothesis 4: *Older people, females, and lower income groups have stronger global climate change beliefs in China.*

3. Data

For our empirical analysis we use unique data from a survey among Chinese individuals at the age between 18 and 60 in urban regions. These data are based on face-to-face mall or street interviews that were conducted in December 2012. The survey was designed, translated, and carried out in close collaboration with a professional local survey company, i.e. Horizon Research Consultancy Group, which is one of the leading market research companies in China. It is also one of the few local market research institutions which have the license to construct social surveys in China. In total, 1054 respondents participated in the survey. The questionnaire comprises five parts, namely individual mobility behavior, a stated preferences experiment on the choice between alternative fuel vehicles, experiences with extreme weather events, assessments of global warming, as well as socio-demographic and socio-economic characteristics. The empirical analysis in this paper refers to several variables from the latter three parts of the questionnaire.

According to government figures, China comprises 645 cities, which differ strongly in terms of size, demographic composition, culture, language, level of urbanization, and climate. In order to include economically important cities from several regions across China, two tier 1 and three tier 2 cities, namely Beijing, Guangzhou, Chengdu, Wuhan, and Shenyang, are considered in our study. [6] For each of these five survey cities Table 1 reports the regional belonging, the population figure, the GDP per capita, and the number of respondents in the survey. The table reveals that our empirical analysis refers to big cities that have between 8.1 million inhabitants (Shenyang) and 19.6 million inhabitants (Beijing). It also reveals significant economic differences across the cities. Guangzhou is the wealthiest city with 22164 USD GDP per capita (PPP adjusted) per year, while Chengdu is the least wealthy city with 10454 USD GDP. Although the five survey cities cannot represent China as a whole, the general infor-

[6] The tier designations roughly correspond to the administrative divisions in China. The tier 1 cities are Beijing, Shanghai, and Guangzhou. They were the first to be opened up to competitive economic development by the Chinese government and thus are the most populous and competitive cities in China. Tier 2 cities historically were provincial capitals.

mation from our survey should be generalizable to other Chinese cities experiencing high economic growth and urban modernization.

4. Empirical analysis

4.1 Descriptive statistics

For each of the five survey cities Table 2 reports some descriptive statistics for several socio-demographic and socio-economic characteristics of the 1054 respondents in the empirical analysis, namely age, gender, (household) income, education, and children in the household.[7] For the purpose of comparison, the corresponding census statistics for age, gender, and education are reported in Table 3. With respect to the age groups and gender, the tables reveal that the shares in our sample are very similar to the population shares. In contrast, high education groups are overrepresented in our sample, whereas people with a low education are underrepresented. In this respect, we distinguish between three education groups. Low education comprises respondents who are not educated or who indicate elementary or junior high school as highest education level. Medium education comprises senior and vocational high school, whereas high education comprises college, university (Bachelor, Master, or Doctorate), adult education, and Open University as highest education level.

Table 4 reports the global climate change beliefs of the 1054 interviewees. It reveals that more than three quarters of the respondents believe that global warming is already taking place today. Furthermore, 10.3% of the respondents believe that global climate change is not taking place today, but will take place in the future, whereas only 8.6% do not believe in global climate change at all. These numbers are in line with the statistics summarized by the Center for China Global Climate Change Communication using national survey data collected in July and August of 2012 (in this survey 93% of the respondents indicated global climate change beliefs). However, Table 4 also shows notable differences between the five survey

[7] The percentages for the education groups are based on 1053 instead of 1054 respondents since one interviewee did not reply to the corresponding education question.

cities. For example, more than 18% of the interviewees from Shenyang stated that global climate change would not take place at all, whereas the corresponding share amounts to only 1% in Beijing, although it should be noted that the number of respondents who did not reply to this question is relatively high with 7.3% in this city.

Table 5 reports the percentages of respondents who have personally experienced extreme weather events at the current or former place of residence. In this respect, we consider heatwaves, heavy rainfalls or floods, droughts, sandstorms, windstorms, and avalanches. In contrast to the values in Table 4, these percentages are based on only those interviewees who replied to the corresponding questions.[8] 71.7% of the respondents stated that they have already experienced at least one of these extreme weather events. The respondents have particularly experienced heatwaves (55.8%) and heavy rainfalls or floods (52.4%), whereas only a few respondents have experienced avalanches (4.6%). However, the experiences with single extreme weather events strongly differ across the five survey cities. For example, almost half of the interviewees from Beijing have already experienced sandstorms, whereas the share is very low for respondents from Wuhan (3.9%). Another example refers to windstorms which have been experienced by more than one third of the respondents from Guangzhou, but only a little more than 10% of the interviewees from the other four cities. The differences are obviously due to the unequal climate across the five survey cities. This extent of experiences with extreme weather events is comparable to the extent in the U.S. Leiserowitz et al. (2012a, 2012b) indeed report that 82% of survey respondents stated that they have personally experienced one or more types of extreme weather events, but the number of event types in their studies is higher than in our study (including e.g. tornadoes or hurricanes as discussed above).

Finally, all respondents who have experienced extreme weather events were additionally asked whether these events have led to physical or financial damages in their household. Ta-

[8] These numbers therefore vary between 1038 (in the case of avalanches) and 1048 (in the case of heavy rainfalls or floods). With respect to experiences with at least one of the extreme weather events, some respondents who did not reply to all questions could be considered since they can already be identified in the case of only one of these experiences. As a consequence, the percentages in the last line are based on 1050 interviewees.

ble 6 reports the percentages of interviewees with such damages among all interviewees. In line with the values in Table 5, these percentages are again based on only those respondents who replied to the corresponding questions.[9] Table 6 reveals that more than a quarter of the respondents has suffered such damages. These damages were particularly caused by heavy rainfalls or floods (16.0%) and heatwaves (12.6%). The differences across the five survey cities are again obvious. While only 18.3% of the interviewees from Beijing stated physical or financial damages, the shares are more than one third for the respondents from Guangzhou and Chengdu. In Guangzhou physical or financial damages are particularly caused by heatwaves, whereas in Chengdu damages by droughts and heavy rainfalls or floods play a crucial role.

4.2 Variables in the econometric analysis

For our econometric analysis we initially consider a binary dependent variable that takes the value one if the respondent believes that global climate change is already taking place today or will take place in the future. In this first model specification all interviewees who did not reply to this question on global climate change beliefs are not included. In order to check the robustness of our estimation results, we consider three further indicators for global climate change beliefs and thus dependent variables. The second binary dependent variable again takes the value one if the respondent believes that global warming is already taking place today or will take place in the future, but now takes the value zero if the respondent believes that global warming will not take place at all or answered "don't know", i.e. this model specification also includes those interviewees who did not reply to the question on global climate change beliefs. In contrast, the third model approach again excludes this group of interviewees. Compared to the first model approach, respondents who believe that global climate change will only take place in the future are here treated as global climate change skeptics.

[9] These numbers therefore vary between 1037 (in the case of heatwaves, sandstorms, and avalanches) and 1045 (in the case of heavy rainfalls or floods), whereas the percentages in the last line are based on 1027 interviewees.

The binary dependent variable therefore only takes the value one if the respondent believes that global warming is already taking place today. The fourth model approach is identical to the third, but additionally includes those interviewees who did not reply to the question on global climate change beliefs and treats them as global climate change skeptics, i.e. the binary dependent variable takes the value zero for those interviewees.

As key determinants for global climate change beliefs, we consider several variables for personal experiences with extreme weather events. In order to examine hypothesis 1, we consider the dummy variable "experiences weather events", which takes the value one if the respondent has experienced at least one of the aforementioned extreme weather events, i.e. heatwaves, heavy rainfalls or floods, droughts, sandstorms, windstorms, or avalanches. As an alternative indicator for the strength of personal experiences with extreme weather events, we consider the variable "number experiences weather events", which is the quantity of the overall six different extreme weather event types that have been experienced. In order to examine hypothesis 2 and thus to analyze whether the effects of such experiences differ across the single weather events, we consider the dummy variables "experiences heatwaves", "experiences rainfalls floods", "experiences droughts", "experiences sandstorms", "experiences windstorms", and "experiences avalanches" that take the value one if the respondent has experienced the specific extreme weather event, respectively. In order to examine hypothesis 3, we consider the dummy variable "damages weather events" that takes the value one if the interviewee has suffered physical or financial damages in its household due to at least one of the aforementioned extreme weather events. In addition, the single dummy variables "damages heatwaves", "damages rainfalls floods", "damages droughts, "damages sandstorms", "damages windstorms", and "damages avalanches" take the value one if the interviewee suffered such damages from the specific extreme weather event, respectively.

However, it should be noted that these variables cannot disentangle the effects of personal physical or financial damages due to extreme weather events and experiences with extreme weather events without consequential damages since, for example, the base category of “damages weather events” comprises respondents with both no experiences with extreme weather events as well as experiences without damages. Therefore, we additionally consider the dummy variables “experiences without damages” as well as “experiences heatwaves without damages”, “experiences rainfalls floods without damages”, “experiences droughts without damages”, “experiences sandstorms without damages”, “experiences windstorms without damages”, and “experiences avalanches without damages” that take the value one if the respondent has experienced at least one extreme weather event or the specific extreme weather event, respectively, without any physical or financial damages. By including this group of variables in some model specifications, the effects of experiences with extreme weather events without damages as well as the effects of personal physical or financial damages due to extreme weather events compared with the base group of no experiences with extreme weather events at all, respectively, can be analyzed.

In order to examine hypothesis 4, we finally consider several socio-demographic and socio-economic characteristics. With respect to the age of the respondents, we analyze the two variables “age” and “squared age”, measured in years, respectively, in order to allow for possible nonlinear effects. Furthermore, the dummy variable “female” takes the value one if the respondent is a woman and the dummy variable “high household income” takes the value one if the average monthly household income of the interviewee (after taxes) is 4000 RMB or more. With respect to the income variable, our questionnaire comprises income intervals including the classes 2000 to less than 4000 RMB and 4000 to less than 6000 RMB. The 4000 RMB bound is chosen since in 2010 the median disposable income of Chinese urban households was 3125 RMB (e.g. Gan et al., 2014). Moreover, the dummy variable “high education” takes the value one if the interviewee stated college, university (Bachelor, Master, or Doctorate), adult education, or Open University as highest education level. Finally, we consider the dummy variable “household with children” that takes the value one if at least one child has residence in the household of the respondent as well as the four dummy variables "Beijing", "Guangzhou", "Chengdu", and "Wuhan" in order to control for regional differences so that respondents from Shenyang are the base category.

4.3 Estimation results

Due to the binary structure of the dependent variables, we apply common binary probit models to analyze the determinants of global climate change beliefs. The corresponding parameters are estimated by the maximum likelihood method (ML) (e.g. Greene 2012). In this respect, we consider heteroscedasticity-robust estimates of the standard deviations of the ML estimated parameters according to White (1982) and thus heteroscedasticity-robust z statistics. Table 7 and Table 8 report the corresponding estimation results. Besides the ML parameter estimates, we additionally consider the estimates of average marginal and discrete probability effects. These estimation results (including heteroscedasticity-robust z statistics) are reported in Table 9 and Table 10. The model specifications (1), (2), (3), and (4) are based on the four different binary dependent variables as discussed above. In contrast, the model specifications (1a), (1b), (1c), (1d), (1e), and (1f) refer to the first binary dependent variable that takes the value one if the respondent believes that global climate change is already taking place today or will take place in the future, excluding all respondents who did not reply to the question on global climate change beliefs.

One main estimation result in the first four columns of Table 7 refers to the hypothesized strong positive effect of personal experiences with extreme weather events on global climate change beliefs at the 1% significance level. This impact of "experiences weather events" is very robust across all four model specifications. According to Table 9, such experiences increase the estimated global climate change beliefs between more than eight and almost 13 percentage points on average. In addition, the quantity of single extreme weather event types that have been experienced by the respondent also has a significantly positive effect. The corresponding estimated discrete probability effect according to the fifth column of Table 9 implies an increase of more than 1.5 percentage points for one more extreme weather event type that has been experienced. According to these estimation results, hypothesis 1 can be robustly confirmed.

In contrast, the identification of specific impacts of the single extreme weather events, i.e. heatwaves, heavy rainfalls or floods, droughts, sandstorms, windstorms, and avalanches, on global climate change beliefs, is more difficult. According to the last columns in Table 7 and Table 9, almost all estimated parameters and values of discrete probability effects are only insignificantly different from zero. This result is, for example, widely in line with the study of Whitmarsh (2008) for England. The only exceptions are the positive discrete probability effect for "experiences windstorms" as well as the positive parameter and discrete probability effect for "experiences heatwaves", even when these values are only different from zero at the 10% significance level. The latter result is consistent with other studies in Europe and the U.S. (e.g. Hamilton and Keim, 2009, Joireman et al., 2010, Li et al., 2011, Egan and Mullin, 2012). Compared with experiences with other extreme weather events, our estimation results therefore suggest that experiencing heatwaves is the major driver for decreasing global climate change skepticism. As a consequence, the first part of hypothesis 2 can be weakly confirmed, whereas the second part cannot be confirmed due to the insignificant effect of personal experiences with heavy rainfalls or floods. It should be noted that the predominantly insignificant impacts can also be due to multicollinearity problems since several variables are highly positively correlated, which implies that many respondents have already experienced several extreme weather events. For example, the correlation coefficient between "experiences heatwaves" and "experiences rainfalls floods" amounts to 0.47.[10]

With respect to the effect of personal physical or financial damages due to extreme weather events, the results in the first two columns in Table 8 and Table 10 are very similar to the re-

[10] However, excluding some variables for single extreme weather events can lead to omitted variables biases so that such model specifications are not examined.

sults for the effects of personal experiences with extreme weather events in Table 7 and Table 9. Such damages and particularly damages due to heatwaves thus have a strong positive effect on global climate change beliefs at least at the 5% significance level. These similarities in the estimation results are not surprising since the variables “experiences weather events” and “damages weather events” or “experiences heatwaves” and “damages heatwaves” are strongly related as discussed above. In order to disentangle the effects of personal physical or financial damages due to extreme weather events and experiences with extreme weather events without consequential damages, these two groups of separate variables have to be included jointly as explanatory variables.

According to the penultimate columns in Table 8 and Table 10, personal experiences with extreme weather events without consequential damages indeed have positive effects at the 1% significance level (compared with the base group of no experiences with extreme weather events at all). However, this effect is slightly weaker than the significantly positive impact of personal physical or financial damages due to extreme weather events (and particularly due to heatwaves according to the last columns in Table 8 and Table 10). Such damages increase the estimated global climate change beliefs by more than nine percentage points on average (compared with the base group of no experiences with extreme weather events at all), whereas the corresponding estimated increase for experiences with extreme weather events without consequential damages is only a bit more than seven percentage points. These estimation results indeed suggest that the personal experience with extreme weather events alone is already sufficient to increase global climate change beliefs, but that damages due to these extreme weather events lead to stronger effects. As a consequence, hypothesis 3 can be confirmed.

Finally, our estimation results reveal that several socio-demographic and socio-economic variables matter. According to Table 7 and Table 8, age has a robust significant non-linear U-shaped effect on global climate change beliefs, i.e. an increasing age decreases the probability to believe in global climate change until the age of between 38 and 44 years and from this point increases for older respondents, even when this estimated non-linear effect leads to insignificant average marginal probability effects of age. This is slightly different to the results of Li et al. (2011), which imply that older people have generally stronger climate change beliefs than younger ones. Furthermore, the estimation results for our gender variable reveals that females are (in the amount of between about four and more than six percentage points on average) significantly more skeptical with respect to global climate change compared with males, which is, for example, in contrast to the results of Li et al. (2011) or Egan and Mullin (2012). In addition, household income has a significantly negative effect, which is broadly in line with the results in previous studies (e.g. O'Connor et al., 1999, McCright, 2010, McCright and Dunlap, 2011, Whitmarsh, 2011). As a consequence, the third part of hypothesis 4 can be confirmed, whereas the first two parts must be rejected.

Moreover, a high educational level has a strong positive impact on global climate change beliefs at least at the 5% significance level, whereas a significantly (positive) effect of children in the household only arises in model specifications (3) and (4). The estimation result for the effect of education is, for example, in line with the analysis of Egan and Mullin (2012). One possible explanation for this effect is that people with high educational levels are usually better informed about global climate change issues. Finally, the estimation results for the four city dummies reveal significantly stronger global climate change beliefs in Wuhan and particularly in Beijing or, conversely, significantly more global climate change skepticism in Shenyang. This result is consistent with the descriptive statistics according to Table 4 which shows that Shenyang and Chengdu are most skeptical with respect to global climate change.

5. Conclusions

Beliefs in the existence of global warming are certainly an important precondition for the support of national and international climate policy measures and can also be a stimulus for voluntary climate protection activities. Against this background, this paper has analyzed the extent and particularly the determinants of individual global climate change beliefs. In contrast to former studies for high income countries and especially for the U.S. and Europe, we have focused on China due to its crucial role in global climate policy and its responsibility as the worldwide biggest producer of CO_2 emissions. The empirical analysis is based on unique data from a survey among more than 1000 individuals in five cities in China, namely Beijing, Guangzhou, Chengdu, Wuhan, and Shenyang. Our econometric analysis has identified specific Chinese population groups that are more or less skeptical with respect to global climate change and disentangled the effects of personal physical or financial damages due to extreme weather events and experiences with extreme weather events without consequential damages.

In line with previous studies in other countries, our results suggest that the vast majority of almost 90% of the Chinese respondents believes that global climate change is already taking place or will take place in the future. This seems to be a convenient and sufficient basis for ambitious climate policy goals and measures in China. Furthermore, our econometric analysis of socio-demographic and socio-economic variables has shown that females as well as people in medium ages between 38 und 44 years, with higher household incomes, a lower education, and from Chengdu or Shenyang are more skeptical with respect to global climate change. These sections of the population are therefore important target groups for Chinese policy makers, for example, with respect to public relations or information campaigns, since a support of these population groups for several climate policy measures would certainly require that they become convinced in the existence of global warming.

With respect to experiences with extreme weather events with or without consequential physical or financial damages, our estimation results reveal that the personal experience with extreme weather events alone is already sufficient to increase global climate change beliefs, although physical or financial damages due to these extreme weather events lead to stronger effects. Furthermore, our estimation results show that personal experiences with heatwaves as well as damages due to heatwaves are especially relevant in this respect. An increasing number of extreme weather events and particularly damages due to these extreme weather events in the future might thus further decrease global climate change skepticism and therefore increase the support of climate policy and possibly the extent of voluntary climate protection activities.

However, the exact relationship between climate change beliefs and the support of climate policy or voluntary climate protection activities is ambiguous so far and thus an important direction for further research. Corresponding empirical analyses would not only be interesting for China, but also for other countries in the world. Since international climate policy strongly depends on positions and attitudes on international climate negotiations such as the last UN Climate Change Conference 2013 in Warsaw, another direction for future research is the analysis of the relationship between the positions of negotiators and the extent of global climate change beliefs or skepticism in the home country of the negotiators.

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Appendix: Tables

Table 1: Survey cities

City	Region	Tier designation	Number of inhabitants (in one million)	GDP per capita (in PPP USD)	Number of respondents
Beijing	North (Capital)	Tier 1	19.6	19246	316
Guangzhou	South	Tier 1	12.7	22164	262
Chengdu	Southwest	Tier 2	14.1	10454	170
Wuhan	South Central	Tier 2	9.8	14419	157
Shenyang	Northeast	Tier 2	8.1	15803	149
Total					1054

Note: Sources for population figures and GDP per capita: Tabulation on the 2010 Population Census of the People's Republic of China by County, China Statistical Yearbook 2011, Guangdong Statistical Yearbook 2011, Sichuan Statistical Yearbook 2011, Liaoning Statistical Yearbook 2011, Hubei Statistical Yearbook 2011

Table 2: Descriptive statistics, separately for the five survey cities, overall 1054 respondents

	Beijing	Guangzhou	Chengdu	Wuhan	Shenyang	Total
	Share of age groups (in %)					
18-29 years	35.8	32.8	30.6	39.5	36.2	34.8
30-39 years	23.1	36.3	28.2	21.0	23.5	26.9
40-49 years	27.5	18.7	23.5	24.2	26.8	24.1
50-60 years	13.6	12.2	17.6	15.3	13.4	14.1
	Share of gender (in %)					
Male	49.1	48.9	49.4	49.7	50.3	49.3
Female	50.9	51.1	50.6	50.3	49.7	50.7
	Share of monthly household income groups (in %)					
Less than 1000 RMB	1.0	0.4	0.0	1.3	0.7	0.7
1000 to less than 2000 RMB	0.3	2.3	2.4	1.9	4.0	1.9
2000 to less than 4000 RMB	2.5	5.0	10.6	15.9	15.4	8.3
4000 to less than 6000 RMB	10.4	9.9	20.6	19.1	24.8	15.3
6000 to less than 8000 RMB	13.3	17.9	25.9	20.4	18.8	18.3
8000 to less than 10000 RMB	23.4	19.9	15.9	15.3	12.8	18.6
10000 to less than 15000 RMB	25.0	26.3	10.6	15.3	14.8	20.2
15000 to less than 20000 RMB	11.1	8.8	7.1	3.2	4.0	7.7
20000 to less than 40000 RMB	5.7	3.4	3.5	1.9	2.7	3.8
40000 RMB and more	1.3	0.8	2.9	0.6	1.3	1.3
Don’t know	6.0	5.3	0.6	4.5	0.7	4.0
	Share of education groups (in %)					
Low education	6.7	13.0	13.5	17.8	20.1	12.9
Medium education	21.5	41.8	31.2	36.3	27.5	31.2
High education	71.8	45.2	55.3	45.9	52.4	55.9
	Share of households without or with children (in %)					
Household without children	62.0	45.0	48.2	54.8	65.1	54.9
Household with children	38.0	55.0	51.8	45.2	34.9	45.1

Table 3: Population census statistics, separately for the five survey cities

	Beijing	Guangzhou	Chengdu	Wuhan	Shenyang	Total
	Share of age groups (in %)					
20-29 years	34.8	36.9	28.1	34.0	26.9	32.8
30-39 years	24.6	27.7	26.9	22.2	18.8	24.7
40-49 years	22.8	22.1	27.4	24.9	28.2	24.6
50-59 years	17.7	13.3	17.5	18.8	26.1	17.9
	Share of gender (in %)					
Male	51.6	52.3	50.8	51.4	50.5	51.4
Female	48.4	47.7	49.2	48.6	49.5	48.6
	Share of education groups (in %)					
Low education	41.9	51.3	62.2	47.4	57.0	50.9
Medium education	23.4	26.4	18.9	24.4	20.2	22.7
High education	34.7	22.3	18.9	28.2	22.8	26.4

Table 4: Percentages of assessments of global climate change, separately for the five survey cities, overall 1054 respondents

	Beijing	Guangzhou	Chengdu	Wuhan	Shenyang	Total
Global climate change is already taking place	83.2	72.5	77.7	81.5	63.1	77.1
Global climate change is not taking place today but will take place in the future	6.7	14.5	6.5	8.3	17.5	10.3
Global climate change will not take place at all	1.0	10.7	14.1	5.7	18.1	8.6
Don’t know	7.3	2.3	1.8	4.5	1.3	3.9

Table 5: Percentages of personal experiences with extreme weather events, separately for the five survey cities, 1038-1050 respondents

	Beijing	Guangzhou	Chengdu	Wuhan	Shenyang	Total
Experiences with heatwaves	57.5	53.3	56.2	69.2	42.3	55.8
Experiences with heavy rainfalls or floods	54.9	40.1	61.2	61.8	48.3	52.4
Experiences with droughts	22.0	16.5	43.2	17.3	25.5	23.9
Experiences with sandstorms	49.4	7.1	7.1	3.9	36.2	23.5
Experiences with windstorms	10.5	35.4	13.5	11.6	10.7	17.4
Experiences with avalanches	2.6	4.8	11.2	1.3	4.7	4.6
Experiences with at least one extreme weather event	76.3	64.7	72.9	79.0	65.1	71.7

Table 6: Percentages of financial or physical damages in the household due to extreme weather events, separately for the five survey cities, 1037-1045 respondents

	Beijing	Guangzhou	Chengdu	Wuhan	Shenyang	Total
Damages by heatwaves	8.1	22.7	15.4	10.3	4.0	12.6
Damages by heavy rainfalls or floods	11.2	17.2	23.5	19.7	11.4	16.0
Damages by droughts	3.6	5.5	21.3	9.0	8.7	8.5
Damages by sandstorms	7.1	2.0	2.4	0.0	4.0	3.6
Damages by windstorms	2.2	12.4	5.3	1.3	0.7	4.9
Damages by avalanches	1.0	2.0	3.5	0.0	0.0	1.4
Damages by at least one extreme weather event	18.3	35.1	34.3	25.2	18.8	26.0

Table 7: Maximum likelihood estimates (z statistics) in binary probit models, dependent variables: different indicators for global climate change beliefs, only inclusion of experiences with extreme weather events as explanatory variables

Explanatory variables	(1)	(2)	(3)	(4)	(1a)	(1b)
Experiences weather events	0.5203*** (4.37)	0.4180*** (3.92)	0.4421*** (4.42)	0.4142*** (4.33)	--	--
Number experiences	--	--	--	--	0.1080** (2.46)	--
Experiences heatwaves	--	--	--	--	--	0.2224* (1.71)
Experiences rainfalls floods	--	--	--	--	--	0.1196 (0.90)
Experiences droughts	--	--	--	--	--	0.0497 (0.27)
Experiences sandstorms	--	--	--	--	--	-0.1083 (-0.54)
Experiences windstorms	--	--	--	--	--	0.3051 (1.46)
Experiences avalanches	--	--	--	--	--	-0.2201 (-0.80)
Age	-0.1280*** (-2.99)	-0.1142*** (-3.31)	-0.0765*** (-2.61)	-0.0782*** (-2.86)	-0.1283*** (-2.95)	-0.1215*** (-2.83)
Age squared	0.0016*** (2.95)	0.0013*** (3.10)	0.0009** (2.55)	0.0009*** (2.70)	0.0016*** (2.88)	0.0015*** (2.76)
Female	-0.3055** (-2.45)	-0.2354** (-2.23)	-0.2482** (-2.52)	-0.2353** (-2.56)	-0.2808** (-2.22)	-0.2974** (-2.35)
High household income	-0.4349* (-1.93)	-0.4294** (-2.17)	-0.2943* (-1.77)	-0.3140* (-1.96)	-0.5409** (-2.36)	-0.5549** (-2.41)
High education	0.3257** (2.34)	0.3746*** (3.18)	0.2206** (2.07)	0.2822*** (2.82)	0.2975** (2.11)	0.3187** (2.26)
Household with children	0.1865 (1.37)	0.1742 (1.55)	0.2820*** (2.72)	0.2578*** (2.68)	0.1928 (1.41)	0.1702 (1.25)
Beijing	1.3671*** (5.09)	0.4731** (2.82)	0.9780*** (6.17)	0.6532*** (4.57)	1.3963*** (5.30)	1.4083*** (5.36)
Guangzhou	0.4340** (2.59)	0.3340** (2.03)	0.3303** (2.31)	0.3046** (2.15)	0.3948** (2.34)	0.3141* (1.72)
Chengdu	0.1404 (0.77)	0.1381 (0.79)	0.4112*** (3.27)	0.4064*** (2.63)	0.1635 (0.91)	0.1266 (0.68)
Wuhan	0.5290** (2.38)	0.2891 (1.48)	0.5603*** (3.27)	0.4423*** (2.70)	0.6618*** (2.94)	0.5534** (2.37)
Constant	3.1944*** (4.08)	2.982*** (4.69)	1.5963*** (2.98)	1.6489*** (3.30)	3.4473*** (4.35)	3.3762*** (4.26)
Number of observations	967	1008	967	1008	943	943

Note: * (**, ***) means that the corresponding parameter is different from zero at the 10% (5%, 1%) significance level, respectively

Table 8: Maximum likelihood estimates (z statistics) in binary probit models, dependent variables: global climate change beliefs, additional inclusion of personal physical or financial damages due to extreme weather events as explanatory variables

Explanatory variables	(1c)	(1d)	(1e)	(1f)
Damages weather events	0.3886** (2.36)	--	0.6131*** (3.61)	--
Experiences without damages	--	--	0.4543*** (3.38)	--
Damages heatwaves	--	0.4982** (2.09)	--	0.5709** (2.40)
Experiences heatwaves without damages	--	--	--	0.1163 (0.83)
Damages rainfalls floods	--	-0.1356 (-0.63)	--	-0.0774 (-0.37)
Experiences rainfalls floods without damages	--	--	--	0.2468 (1.54)
Damages droughts	--	0.3005 (1.21)	--	0.2936 (1.17)
Experiences draughts without damages	--	--	--	-0.0272 (-0.12)
Damages sandstorms	--	0.1102 (0.22)	--	0.1308 (0.25)
Experiences sandstorms without damages	--	--	--	-0.1621 (-0.77)
Damages windstorms	--	0.2344 (0.65)	--	0.2503 (0.69)
Experiences windstorms without damages	--	--	--	0.3050 (1.29)
Damages avalanches	--	-0.1461 (-0.25)	--	-0.2148 (-0.36)
Experiences avalanches without damages	--	--	--	-0.3380 (-1.08)
Age	-0.1197*** (-2.75)	-0.1269*** (-2.95)	-0.1224*** (-2.85)	-0.1246*** (-2.94)
Age squared	0.0015*** (2.68)	0.0015*** (2.86)	0.0016*** (2.81)	0.0016*** (2.87)
Female	-0.2842** (-2.24)	-0.2878** (-2.28)	-0.2814** (-2.22)	-0.2917** (-2.30)
High household income	-0.5005** (-2.19)	-0.5214** (-2.24)	-0.5086** (-2.12)	-0.5742** (-2.48)
High education	0.3121** (2.23)	0.3184** (2.26)	0.3221** (2.29)	0.3364** (2.36)
Household with children	0.1689 (1.24)	0.1641 (1.20)	0.1688 (1.24)	0.1602 (1.17)
Beijing	1.4338*** (5.40)	1.4481*** (5.59)	1.3802*** (5.15)	1.4364*** (5.64)
Guangzhou	0.3093* (1.76)	0.2765 (1.54)	0.3967** (2.30)	0.2784 (1.45)
Chengdu	0.1398 (0.78)	0.1413 (0.79)	0.1332 (0.73)	0.1041 (0.55)
Wuhan	0.6697*** (2.98)	0.6647*** (2.94)	0.5994*** (2.63)	0.5580** (2.35)
Constant	3.3677*** (4.24)	3.5612*** (4.49)	3.1540*** (4.00)	3.4453*** (4.37)
Number of observations	948	934	948	934

Note: * (**, ***) means that the corresponding parameter is different from zero at the 10% (5%, 1%) significance level, respectively

Table 9: Estimates (z statistics) of average marginal and discrete probability effects in binary probit models, dependent variables: different indicators for global climate change beliefs, only inclusion of experiences with extreme weather events as explanatory variables

Explanatory variables	(1)	(2)	(3)	(4)	(1a)	(1b)
Experiences weather events	0.0810*** (4.01)	0.0880*** (3.63)	0.1203*** (4.19)	0.1249*** (4.13)	--	--
Number experiences	--	--	--	--	0.0154** (2.50)	--
Experiences heatwaves	--	--	--	--	--	0.0317* (1.72)
Experiences rainfalls floods	--	--	--	--	--	0.0169 (0.91)
Experiences droughts	--	--	--	--	--	0.0069 (0.27)
Experiences sandstorms	--	--	--	--	--	-0.0160 (-0.52)
Experiences windstorms	--	--	--	--	--	0.0385* (1.65)
Experiences avalanches	--	--	--	--	--	-0.0347 (-0.73)
Age	-0.0006 (-1.10)	-0.0013** (-2.02)	-0.0012 (-1.29)	-0.0018* (-1.90)	-0.0008 (-1.33)	-0.0007 (-1.24)
Female	-0.0423** (-2.45)	-0.0450** (-2.24)	-0.0623** (-2.54)	-0.0662** (-2.58)	-0.0399** (-2.22)	-0.0419** (-2.35)
High household income	-0.0501** (-2.39)	-0.0684*** (-2.68)	-0.0673* (-1.96)	-0.0805** (-2.18)	-0.0609*** (-3.09)	-0.0618*** (-3.17)
High education	0.0455** (2.31)	0.0732*** (3.11)	0.0560** (2.05)	0.0806*** (2.79)	0.0427** (2.09)	0.0454** (2.24)
Household with children	0.0259 (1.39)	0.0332 (1.56)	0.0701*** (2.76)	0.0718*** (2.72)	0.0275 (1.43)	0.0241 (1.27)
Beijing	0.1250*** (7.45)	0.0820*** (3.12)	0.2057*** (7.76)	0.1667*** (5.21)	0.1314*** (7.61)	0.1318*** (7.52)
Guangzhou	0.0559*** (2.72)	0.0589** (2.20)	0.0774** (2.48)	0.0804** (2.31)	0.0524** (2.49)	0.0418* (1.82)
Chengdu	0.0187 (0.80)	0.0252 (0.83)	0.0927*** (2.96)	0.1031*** (2.97)	0.0223 (0.96)	0.0173 (0.71)
Wuhan	0.0608*** (2.95)	0.0498* (1.67)	0.1202*** (3.96)	0.1108*** (3.11)	0.0743*** (3.86)	0.0641*** (2.99)
Number of observations	967	1008	967	1008	943	943

Note: * (**, ***) means that the corresponding value is different from zero at the 10% (5%, 1%) significance level, respectively

Table 10: Estimates (z statistics) of average marginal and discrete probability effects in binary probit models, dependent variables: global climate change beliefs, additional inclusion of personal physical or financial damages due to extreme weather events as explanatory variables

Explanatory variables	(1c)	(1d)	(1e)	(1f)
Damages weather events	0.0497*** (2.68)	--	0.0905*** (3.92)	--
Experiences without damages	--	--	0.0728*** (3.35)	--
Damages heatwaves	--	0.0575*** (2.65)	--	0.0668*** (3.01)
Experiences heatwaves without damages	--	--	--	0.0175 (0.84)
Damages rainfalls floods	--	-0.0205 (-0.60)	--	-0.0123 (-0.36)
Experiences rainfalls floods without damages	--	--	--	0.0332 (1.59)
Damages droughts	--	0.0375 (1.40)	--	0.0362 (1.34)
Experiences draughts without damages	--	--	--	-0.0040 (-0.12)
Damages sandstorms	--	0.0149 (0.24)	--	0.0169 (0.27)
Experiences sandstorms without damages	--	--	--	-0.0245 (-0.73)
Damages windstorms	--	0.0299 (0.75)	--	0.0325 (0.79)
Experiences windstorms without damages	--	--	--	0.0384 (1.48)
Damages avalanches	--	-0.0226 (-0.23)	--	-0.0335 (-0.33)
Experiences avalanches without damages	--	--	--	-0.0560 (-0.94)
Age	-0.0006 (-1.11)	-0.0008 (-1.35)	-0.0006 (-0.97)	-0.0007 (-1.18)
Female	-0.0402** (-2.25)	-0.0410** (-2.29)	-0.0391** (-2.22)	-0.0410** (-2.31)
High household income	-0.0571*** (-2.80)	-0.0597*** (-2.90)	-0.0569*** (-2.74)	-0.0636*** (-3.26)
High education	0.0446** (2.21)	0.0458** (2.25)	0.0452** (2.27)	0.0478** (2.34)
Household with children	0.0240 (1.26)	0.0235 (1.22)	0.0236 (1.25)	0.0226 (1.19)
Beijing	0.1335*** (7.69)	0.1349*** (7.80)	0.1278*** (7.45)	0.1330*** (7.68)
Guangzhou	0.0415* (1.85)	0.0376 (1.62)	0.0515** (2.42)	0.0373 (1.52)
Chengdu	0.0191 (0.81)	0.0194 (0.82)	0.0179 (0.75)	0.0143 (0.57)
Wuhan	0.0746*** (3.92)	0.0750*** (3.86)	0.0675*** (3.36)	0.0646*** (2.96)
Number of observations	948	934	948	934

Note: * (**, ***) means that the corresponding value is different from zero at the 10% (5%, 1%) significance level, respectively