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Extreme weather experiences and climate change beliefs in China: An econometric analysis

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1. Introduction

The recently published Assessment Report of the Intergovernmental Panel on Global Climate Change (IPCC) (see IPCC, 2013, i.e. the summary for policymakers of the Working Group I contribution to the IPCC Fifth Assessment Report) considers interferences within the climate system as unequivocal. Many of the predicted changes are without precedent and human activities are very likely to have contributed to climate change. Global warming is therefore considered as one of the crucial environmental and societal challenges in most parts of the world due to its strong impacts on the natural environment and human lives. In order to limit the increase in global temperatures below 2 °C as recognized, for instance, in the Copenhagen Accord 2009 (see UNFCCC, 2010), significant reductions of greenhouse gas and particularly CO_2 emissions are necessary (see also IPCC, 2014, i.e. the summary for policymakers of the Working Group III contribution to the IPCC Fifth Assessment Report). Furthermore, increasing efforts to adapt to the consequences of unavoidable climate change are needed, particularly in the most vulnerable regions.

China plays a dominant role in international climate policy since it is not only the most populous country in the world with more than 1.3 billion inhabitants, but has also overtaken the U.S. as the worldwide biggest producer of CO_2 emissions and even has surpassed the EU in per-capita emissions (e.g. Le Quéré et al., 2014). As many other countries, China has taken a series of specific adaptation and mitigation measures 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 and CO_2 emissions per unit of GDP by 16% and 17% by 2015, both compared to 2010 levels. Against this background, China has implemented emission trading schemes in seven cities and provinces and is planning a national cap-and-trade scheme (e.g. Jotzo and Löschel, 2014). Furthermore, China has recently outlined a national adaptation plan to enhance its capabilities to adapt to climate change. According to the National Development and Reform Commission, The People's Republic of China (2013), the 2013 national adaptation plan includes measures on

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disaster prevention and mitigation, monitoring and early warning, and also policies in the areas of agriculture, water resources, coastal areas and ecosystem, and public health.

While adaptation activities by individuals might be characterized as a private good, which provides private benefit, public adaptation and mitigation activities can be viewed as a national or an international public good, respectively. Therefore, policies to respond to climate change in China and other countries can certainly only be successfully implemented if citizens are willing to support these policies and to accept individual costs for public mitigation or adaptation activities. The necessary condition for the willingness to support different climate policies is that people believe in the existence of global warming and its potential impacts on themselves and/or on other members of the society. General beliefs in the existence of global warming are thus crucial for the acceptability of costly public adaptation and mitigation activities to reduce the negative impacts of climate change (even when the acceptability of mitigation activities additionally requires the specific belief in anthropogenic climate change). Therefore, knowledge about the extent and particularly the determinants of global climate change beliefs is certainly important. Former studies have shown that weather patterns (e.g. Egan and Mullin, 2012; Hamilton and Stampone, 2013) and perceived experiences with extreme weather events such as heatwaves, floods, or droughts (e.g. Spence et al., 2011; Leiserowitz et al., 2012) seem to be important (besides socio-economic variables) since they are positively correlated with climate change beliefs or concerns.

While the direct attribution of an extreme weather event to climate change is not possible and there are still important gaps in knowledge about the impacts of global warming, particularly on a regional scale, it is generally accepted that changes in the mean average surface temperature may lead to a long-run increase of extreme weather events (e.g. Rosenzweig et al., 2001; World Bank, 2010; Howe and Leiserowitz, 2013). While the deaths from extreme weather events have decreased in the last decades, the number of people requiring humanitarian assistance after disasters has strongly increased, especially in lower-middle income countries (e.g. World Bank, 2010). Furthermore, the economic damages due to storms, floods, and droughts have strongly risen from the 1980s to the early 2000s. While the increasing economic damages might rather be affected by a higher exposure of economic value instead by climate change, this development points to the necessity of appropriate adaptation activities to reduce the negative impacts of climate change.

In China the frequency and intensity of short duration heatwaves, droughts, and floods due to intensive daily rainfalls have risen in recent decades. This led, for instance, to 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, 2004; Ding and Pan, 2002; Zhai and Pan, 2003; Zhai, 2004; Parry et al., 2007). These changing weather patterns and extreme weather events are widely discussed in the Chinese and also international media and academia, particularly dealing with the role of global warming for this development and the consequential physical and financial damages for people being affected by these events.

The aim of this paper is to analyze the relationship between perceived extreme weather experiences and climate change beliefs in China. The contribution of our empirical analysis to former studies of the determinants of climate change beliefs and concerns is three-fold: First, we do not focus on single extreme weather events such as floods (e.g. Whitmarsh, 2008; Spence et al., 2011), but consider six different events, which may be related to global climate change. Second, we do not only examine the general perception of extreme weather experiences, but additionally consider perceived personal physical or financial damages. Third, our econometric analysis refers to China due to its crucial role in global climate policy and its likely vulnerability to climate change. This adds important insights to former empirical studies that are particularly referred to the U.S. (e.g. Joireman et al., 2010; McCright and Dunlap, 2011; Hamilton, 2011) and only sporadically to other high-income western countries such as the UK (e.g. Whitmarsh, 2008; Spence et al., 2011) or Australia (e.g. Li et al., 2011).

Our econometric analysis is based on unique survey data 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 believe in global climate change. It should be noted that our analysis of climate change beliefs refers to general beliefs in global warming and not exclusively to beliefs in anthropogenic global warming. We analyze the perceptions of experiences with different extreme weather events with and without physical or financial damages including heatwaves, heavy rainfalls or floods, droughts, sandstorms, windstorms, and avalanches. This analysis of several extreme weather experiences is in line with Leiserowitz et al. (2012), who also consider the relationship between climate change beliefs and experiences with different extreme weather events. However, it should be noted that their study is purely descriptive for U.S. citizens. In addition to the analysis of extreme weather experiences, we control for the relevance of socio-demographic and socio-economic factors (i.e. education, gender, age, income, children in the household) in our econometric analysis.

The remainder of the paper is organized as follows: The next section reviews the relevant literature and develops several hypotheses for our econometric 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 surveys and empirical studies reveal that most people in the world believe in the general existence of global warming and in the specific existence of anthropogenic global warming. For instance, based on an online survey among over 13,000 adults from 13 countries in Europe (Belgium, France, Germany, Italy, Spain, Switzerland, Turkey, UK), North America (U.S., Mexico), and Asia (Hong Kong, Indonesia, Japan), Survey AXA/IPSOS (2012) reports that almost 90% of the respondents believe that the climate has (not necessarily due to human activities) changed significantly in the past 20 years. However, the corresponding shares differ across the countries. While more than 95% of the respondents in Mexico, Hong Kong, Indonesia, and Turkey feel that the climate has changed, only about 72% of the U.S. respondents share this view. This rather low frequency for the U.S. is in line with the results of several polls as discussed in Nisbet and Myers (2007). The result is also confirmed by the study of Carlsson et al. (2012), which compares attitudes toward climate change in the U.S., Sweden, and also China. Although the general existence of global warming is believed by a strong majority in all three countries, the share of climate change skeptics is by far the highest in the U.S. More than 24% of the U.S. respondents state that the temperature has not increased globally. In contrast, these shares are only about 6% in Sweden and even less than 5% in China. Furthermore, almost 27% of the U.S. respondents do not believe in anthropogenic climate change (i.e. state that humans have not affected the temperature increase), whereas the corresponding share is only 4% in China.

With respect to the determinants of climate change beliefs and concerns, a series of empirical studies reveals the high relevance of weather patterns or experiences.[1] Recent studies often use objectively measured weather data at the day of the survey or for different periods before the

[1] Most of the empirical studies that are discussed in the following consider general beliefs, concerns, and views about climate change, which is thus not necessarily affected by human activities. Some of these studies additionally include some aspects of the human contribution in their analyses, while not explicitly focusing on anthropogenic climate change (e.g., Whitmarsh, 2008, 2011, Malka et al., 2009, McCright, 2010, Joireman et al., 2010; McCright and Dunlap, 2011; Spence et al., 2011). In contrast, Hamilton and Stampone (2013) explicitly focus on the determinants of anthropogenic climate change.

survey (e.g. Hamilton and Keim, 2009; Joireman et al., 2010; Egan and Mullin, 2012; Hamilton and Stampone, 2013; Hamilton and Lemcke-Stampone, 2014; Shao et al., 2014; Zaval et al., 2014). Although weather variations provide little to no information about global warming, most studies reveal significant effects of local temperatures or deviations from normal local temperatures on beliefs in climate change or climate change concerns (these temperature effects can be non-linear, e.g. Hamilton and Lemcke-Stampone, 2014, or depend on political orientation, e.g. Hamilton and Stampone, 2013). According to Zaval et al. (2014), citizens obviously use less relevant but available information such as temperatures instead of less available information about global warming patterns for their views on climate change.

Li et al. (2011) argue that the use of this information is due to attribute substitution, in which an easily accessible judgment (e.g. temperatures at the day of the survey) replaces a more complex and less accessible topic (i.e. global long-run temperature trends due to climate change). However, Li et al. (2011) emphasize the role of perceived temperatures instead of actual temperatures. They show that not actual temperature deviations, but perceived deviations from usual temperatures have stronger effects on climate change beliefs and concerns. The main problem of the use of perceived temperatures as explanation for climate change beliefs and concerns is that the causality of the effect is ambiguous since it is also possible that beliefs in climate change affect the perception of temperatures. Li et al. (2011) rule out this possibility of reverse causality by using actual temperatures as instruments for perceived temperatures. The relationship between actual and perceived weather is also analyzed in Goebbert et al. (2012). They show that perceived changes in local temperatures over the past few years are more influenced by ideological and cultural views than by actual temperature changes. This strengthens the view that the causality of the relationship between perceived weather and climate change beliefs remains ambiguous since ideological and political orientation can have a strong effect on climate change views, as discussed below.

However, Goebbert et al. (2012) do not only examine perceived changes in local temperatures, but also perceived changes in local droughts and local flooding over the past few years. They show that ideological and political variables also matter for perceived droughts and floods, but that actual weather changes in this case are much better predictors than in the case of perceived local temperatures. As discussed above, climate change probably leads to a long-run increase of extreme weather events, although the direct attribution of such an event to global warming is not possible. However, it can be argued that experiences with extreme weather events are used as available information for views on climate change, i.e. citizens with extreme weather experiences that may be linked to global warming can be more concerned about this issue (e.g. Spence et al., 2011). In fact, experiences with extreme weather events seem to be more tangible than perceived changes in temperatures so that it can be hypothesized that such experiences are even more relevant.

Whitmarsh (2008) and Spence et al. (2011) analyze the effect of experiences with flooding on climate change concerns. Both studies use data from the UK. However, while Whitmarsh (2008) only considers citizens in two regions in the south of England, the study of Spence et al. (2011) is based on more recent representative data from the whole country, including Wales and Scotland. In contrast to Whitmarsh (2008), Spence et al. (2011) report strong relationships between flooding experiences and climate change concerns. While these two studies only examine experiences with floods, Leiserowitz et al. (2012, 2014) report the extent of experiences with several extreme weather events (i.e. extreme high winds, extreme heatwaves, extreme rainstorms, droughts, extreme cold temperatures, floods, extreme snowstorms, hurricanes, tornados, wildfires) in the U.S. According to these studies, extreme high winds are not only the event type that is experienced by the highest number of U.S. citizens, but they have also led to the highest number of harms.

Leiserowitz et al. (2012) particularly report very strong relationships between perceived personal experiences of extreme weather events and climate change beliefs and concerns. However, their study is purely descriptive, i.e. they only report shares of experiences with these extreme weather events for six groups of citizens with different climate change views including global warming beliefs, issue involvement, policy preferences, and behaviors, but do not conduct econometric analyses. Therefore, it remains ambiguous whether these relationships are possibly influenced by other factors such as socio-demographic variables. This can only be disentangled by econometric analyses. Unfortunately, however, the causality of the relationship between extreme weather experiences and climate change beliefs or concerns cannot be completely clarified with such approaches, either, at least if they are based on cross-sectional instead of panel data. This problem is also discussed in the study of Howe and Leiserowitz (2013) considering perceptions of changes in local climate as dependent variable and beliefs in global warming as explanatory variables and reporting several relationships. In summary, this leads to the following hypothesis being examined in our econometric analysis:

Hypothesis 1. *Perceived experiences with extreme weather events are positively related to global climate change beliefs.*

However, the consequences of extreme weather events can be very different. Events such as heatwaves or floods can result in great physical or financial damages, but they can also lead to only slight limitations in the quality of life during a short time period, or they can even have no consequences at all. It can be hypothesized that extreme weather experiences without harms are much less memorized and personally of importance than experiences with physical or financial damages so that we expect a stronger relationship between damages due to extreme weather events and beliefs in the existence of global warming. This argument is supported by the study of Leiserowitz et al. (2012). They report not only a strong (univariate) relationship between perceived personal experiences of extreme weather events and climate change views as discussed above, but also between experienced harms from extreme weather events and climate change beliefs and concerns.

The relevance of physical or financial damages due to extreme weather events is also supported by psychological studies which emphasize the importance of personally significant experiences with general natural disasters. According to Reser et al. (2012), disasters that are characterized as being most personally significant are very traumatic for many citizens in Australia (see also the traumatic exposure severity scale, TESS, according to Elal and Slade, 2005). Personally significant experiences with natural disasters such as physically injured or trapped family members or close acquaintances, 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. These psychological impacts are confirmed for a series of different natural disasters such as wildfires (e.g. McDermott et al., 2005), the hurricane Katrina (e.g. Mills et al., 2007), the 2004 Indian Ocean Tsunami (e.g. Wahlström et al., 2008) as well as other different kinds of natural disasters including extreme weather events like hurricanes, typhoons, cyclones, tornadoes, floods, or avalanches (e.g. Norris et al., 2002a, 2002b). In summary, this leads to the following hypothesis being examined in our econometric analysis:

Hypothesis 2. *Physical or financial damages due to extreme weather events are stronger positively related to global climate change beliefs than perceived experiences with extreme weather events without damages.*

While most of the discussed econometric analyses of the determinants of climate change beliefs and concerns include several socio-demographic and socio-economic information and/or political and ideological orientation as control variables, some studies even focus on these factors (e.g. Malka et al., 2009; McCright, 2010, 2011; Hamilton, 2011; McCright and Dunlap, 2011; Whitmarsh, 2011). The overwhelming majority of these studies uses data from the U.S. (one exception is the study of Whitmarsh, 2011, for the UK) and shows that conservatives and people with a high identification with the Republican Party have strongly lower climate change beliefs and concerns than liberals and people with a high identification with the Democratic Party (see also e.g. Hamilton and Keim, 2009; Joireman et al., 2010; Egan and Mullin, 2012; Shao et al., 2014). According to McCright and Dunlap (2011), one possible explanation for this result is that conservatives have stronger system justification tendencies, which lead them to defend the status quo and to deny problems such as climate change that threaten system functioning. These views of conservatives and Republican voters seem to significantly contribute to the internationally very high levels of climate change skeptics in the U.S.

It is generally not possible to collect data about political and ideological orientation in China so that we are not able to include such variables in our econometric analysis, i.e. possible effects in this direction must be captured by other socio-demographic and socio-economic variables. However, it can be expected that in China such factors are not as crucial as in the U.S. since the extremely strong polarization between the ideological and political groups on different issues and particularly on the issue of climate change (e.g. McCright, 2011) seems to be particular for the U.S. One indicator for this argument is that the level of beliefs in climate change is by far higher in China than in the U.S. The differences in the U.S. between conservatives and Republicans on the one hand and liberals and Democrats on the other hand are so sharp that political and ideological orientation even influences the effects of education on climate change beliefs and concerns. For instance, Malka et al. (2009), Hamilton and Keim (2009), Hamilton (2011), McCright (2011), Hamilton and Stampone (2013), Shao et al. (2014), and Hamilton and Lemcke-Stampone (2014) show that education or perceived knowledge of climate change only have positive effects among liberals and Democrats, but are insignificant or even have negative effects among conservatives or Republicans.

This pattern often leads to overall insignificant impacts of education. However, there are not only robust positive education effects among liberals and Democrats, but also some slightly positive effects (and hardly significantly negative effects) on climate change beliefs and concerns if no interaction terms between education and political or ideological orientation are included (e.g. McCright and Dunlap, 2011; Egan and Mullin, 2012; Shao et al., 2014, or Whitmarsh, 2011, for the UK). Education is obviously positively correlated with the cognitive ability to evaluate evidence (e.g. Egan and Mullin, 2012) so that education should in general have a positive effect on the belief in evidence- and science-based issues like global warming, at least if not particular political or ideological orientation weakens or even completely overlaps this correlation between education and cognitive ability. As aforementioned, China has overall higher climate change beliefs and seems to be less polarized than the U.S. so that the relevance of different political and ideological orientations on education effects is weak. Therefore, we rather expect positive effects of education on climate change beliefs in China.

In addition, we expect that females have higher beliefs in global warming than males. This expectation is based on the results from most econometric analyses of the determinants of climate change beliefs or concerns (e.g. Hamilton and Keim, 2009; Malka et al., 2009; McCright, 2010; McCright and Dunlap, 2011; Hamilton, 2011; Egan and Mullin, 2012; Hamilton and Stampone, 2013; Shao et al., 2014). One possible explanation for this gender effect is based on the risk perception literature as discussed in McCright and Dunlap (2011). According to this, males (and also whites) have atypically high levels of technological and environmental risk acceptance. This higher risk acceptance can, for instance, be explained by a low feeling of vulnerability to several risks among males due to their dominant position in the social structure that allows them to create, manage, control, and benefit from risks. In contrast, females perceive the world as more dangerous since they are more vulnerable, benefit less from the risks, and have less power and control. This mechanism of different perceptions of technological risks between females and males can be transferred to perceptions of climate change risks and thus to general beliefs in the existence of global warming. Another explanation for this gender effect can be based on simple socialization theories as discussed in McCright (2010). These theories suggest that young females often learn a feminine identity which supports general environmental and specific climate change concerns.

With respect to the effect of age, it can be argued that older people have lower climate change concerns with increasing negative consequences in the future since their personal horizon is much shorter than the horizon of younger people (e.g. Hamilton, 2011) or since they are less likely to be receptive about the impact of global warming (e.g. Shao et al., 2014). This view of negative age effects is supported by several econometric analyses of the determinants of climate change beliefs or concerns (e.g. Hamilton and Keim, 2009; Malka et al., 2009; McCright, 2010; Hamilton, 2011; Whitmarsh, 2011; Hamilton and Stampone, 2013; Shao et al., 2014). In summary, this leads to the following hypotheses being examined in our econometric analysis:

Hypothesis 3a. *People with a higher education have stronger global climate change beliefs.*

Hypothesis 3b. *Females have stronger global climate change beliefs.*

Hypothesis 3c. *Older people have weaker global climate change beliefs.*

We additionally include household income as a proxy for socio-economic status (e.g. Goebbert et al, 2012) and the number of children in the household as control variables in our econometric analysis, for which, however, the direction of the effect is ambiguous according to former studies.

3. Data

For our empirical analysis we use unique data from a survey among Chinese adults at the age between 18 and 60. According to government figures, China comprises 645 cities, which differ strongly in terms of size, demographic composition, culture, language, level of urbanization, and climate. While it is generally not possible to collect data that are representative for all cities or even for whole China including rural regions, the interviews were conducted in five economically important cities in different regions (out of six regions in total) and thus in one more city than in the underlying survey in Carlsson et al. (2012). Specifically, we consider two tier 1 and three tier 2 cities, namely Beijing, Guangzhou, Chengdu, Wuhan, and Shenyang.[2] The information from our survey should be generalizable to other Chinese cities experiencing high economic growth and urban modernization. For each of the 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 22,164 USD GDP per capita (PPP adjusted) per year, while Chengdu is the least wealthy city with 10,454 USD GDP.

Our data are based on face-to-face mall or street interviews in central locations across the five cities. The interviews were conducted in December 2012. In order to reach a high representativeness in each city, the respondents were randomly selected in central locations (Haidian and Chongwen districts in Beijing, Tianhe and Yuexiu districts in Guangzhou, Qingyang district in Chengdu, Shenhe district in Shenyang, Hanyang and Wuchang districts in Wuhan), i.e. every tenth pedestrian was interviewed. The survey was designed, translated, and

[2] 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.

carried out in close collaboration with a professional local survey company, namely 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 conduct 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.

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 education, gender, age, (household) income, and children in the household.[3] For the purpose of comparison, the corresponding census statistics for education, gender, and age 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.[4] We distinguish between three education groups. Low education comprises respondents who did not enjoy any formal education at all or who indicated 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. This small frequency is in line with the even slightly smaller frequency that is reported in Carlsson et al. (2012) as well as 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 cities. For instance, more than 18% of the respondents 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 stated that they have experienced extreme weather events at the current or former place of residence. As discussed above, 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.[5] 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 perceived experiences with single extreme weather events strongly differ across the five survey cities. For instance, 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. The share of respondents with any perceived extreme weather experience is surprisingly very similar to the share in the U.S. According to Leiserowitz et al. (2014), 70% of the respondents stated in 2013 that they have experienced an extreme weather event in the past year.

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. Table 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.[6] Table 6 reveals that 26.0% of the respondents stated that they have 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. Also the frequency of respondents with damages due to any extreme weather event is very similar to the U.S., where 27% of the respondents stated in 2013 that they have suffered harm from extreme weather events in the past year (e.g. Leiserowitz et al., 2014).

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 considered as more skeptical. 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 considers them as more skeptical, i.e. the binary dependent variable takes the value zero for those interviewees.

[3] 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.

[4] This lack of representativeness with respect to education could influence the following descriptive statistics, but should not affect the econometric results since education is included as control variable in our econometric models.

[5] 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.

[6] These numbers thus 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.

As key explanatory variables for global climate change beliefs, we consider several variables for perceived 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 stated that he 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 perceived experiences with extreme weather events, we consider the variable "number experiences", which is the quantity of the overall six different extreme weather event types that have been experienced. In addition, 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 stated that she has experienced the specific extreme weather event, respectively. In order to examine Hypothesis 2, 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 has suffered such damages from the specific extreme weather event, respectively.

However, it should be noted that these variables cannot disentangle the relationships for physical or financial damages due to extreme weather events and the relationships for perceived experiences with extreme weather events without consequential damages since, for instance, the base category of "damages weather events" comprises respondents with both no experiences with extreme weather events at all 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, the correlations between perceived extreme weather experiences without damages and climate change beliefs as well as the correlations between physical or financial damages due to extreme weather events and climate change beliefs compared with the base group of no experiences with extreme weather events at all, respectively, can be isolated.

In order to examine Hypotheses 3a, 3b, and 3c, we finally consider several socio-demographic and socio-economic characteristics. 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. Furthermore, the dummy variable "female" takes the value one if the respondent is a woman. With respect to the age of the respondents, measured in years, we first included it in the common manner. However, the parameter for the corresponding variable was not robustly significantly different from zero so that a linear effect of age could not be confirmed. In order to allow for possible nonlinear effects, we thus consider the two variables "age" and "squared age", measured in years, respectively. 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). 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). We consider heteroscedasticity-robust estimates of the standard deviations of the ML estimated parameters according to White (1982) and thus heteroscedasticity-robust z statistics. Tables 7 and 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 Tables 9 and 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 relationship between perceived personal experiences with extreme weather events and global climate change beliefs at the 1% significance level. This correlation for "experiences weather events" is very robust across all four model specifications. According to Table 9, such experiences are related with estimated global climate change beliefs that are between more than eight and almost 13 percentage points higher on average. In addition, the quantity of single extreme weather event types that have been experienced by the respondent is also significantly positively correlated. The corresponding estimated discrete probability "effect" (in our case correlation) according to the fifth column of Table 9 implies that one more extreme weather event type that has been experienced is associated with climate change beliefs that are more than 1.5 percentage points higher. According to these estimation results, Hypothesis 1 can be robustly confirmed.

In contrast, the identification of separate impacts of perceived experiences with single extreme weather events on global climate change beliefs reveals a more detailed picture. According to the last columns in Tables 7 and 9, almost all estimated parameters and values of discrete probability "effects" are insignificantly different from zero. This result is widely in line with the study of Whitmarsh (2008) for floods in the south of 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. It should be noted that the predominantly insignificant relationships 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 instance, the correlation coefficient between "experiences heatwaves" and "experiences rainfalls floods" amounts to 0.47.[7]

With respect to physical or financial damages due to extreme weather events, the results in the first two columns in Tables 8 and 10 show that such damages and particularly damages due to heatwaves are strongly related to global climate change beliefs at least at the 5% significance level. However, to disentangle the relationships for damages due to extreme weather events and for extreme weather experiences without consequential damages, the two corresponding explanatory variables have to be included jointly. According to the penultimate columns in Tables 8 and 10, perceived experiences with extreme weather events without

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

consequential damages indeed have positive correlations with global climate change beliefs at the 1% significance level. However, this estimated relationship is slightly weaker than the significantly positive correlation between physical or financial damages due to extreme weather events (and particularly due to heatwaves) and global climate change beliefs. Such damages are associated with estimated global climate change beliefs that are more than nine percentage points higher on average (compared with the base group of no extreme weather experiences at all), whereas the corresponding estimated difference for extreme weather experiences without damages is only a bit more than seven percentage points. These estimation results indeed suggest that perceived extreme weather experiences alone are positively correlated with global climate change beliefs, but that damages due to these extreme weather events lead to stronger relationships. As a consequence, Hypothesis 2 can be confirmed.

Finally, our estimation results reveal that socio-demographic and socio-economic variables matter. According to Tables 7 and 8, a high educational level has a strong positive impact on global climate change beliefs at least at the 5% significance level. Therefore, Hypothesis 3a can be confirmed. This result is in line with the studies of McCright and Dunlap (2011), Whitmarsh (2011), or Egan and Mullin (2012) as discussed above. While we are not able to directly examine whether the education effects are influenced by political or ideological orientations as in the U.S., our significant estimation result rather suggests they are not and that the society in China is less polarized than in the U.S. In line with the discussion of different education effects, we have additionally analyzed whether the effect of the education level differs across gender, age, household income, or households with or without children. The separate estimation results with these four interaction terms reveal that both the interaction effects and the education effects become insignificant, while the estimations for the variables that are not interacted with education remain qualitatively nearly identical.[8] This suggests that the education effects are not very different among several population groups in China.

Tables 7 and 8 additionally report a strong and robust gender effect at least at the 5% significance level. However, the tables reveal a reverse effect compared to almost all former econometric analyses in the U.S. (e.g. McCright and Dunlap, 2011; Egan and Mullin, 2012; Hamilton and Stampone, 2013), i.e. males in China have higher estimated global climate change beliefs than females. According to Tables 9 and 10, females have estimated climate change beliefs that are on average between about four and more than six percentage points lower than the beliefs for males. Therefore, Hypothesis 3b must be clearly rejected. While our surprising result strongly contradicts former empirical evidence for the U.S., it is in line with the studies of Cao et al. (2009) and Shields and Zeng (2011) for China, which reveal that males and not females have stronger attitudes toward the environment and show a higher concern about environmental problems and the seriousness of environmental degradation. According to Shields and Zeng (2011), a possible explanation for this result is that Chinese females have on average a lower level of political awareness and participation due to their dominating traditional role in the household. Therefore, they are often less concerned about major public policy issues such as environmental protection or specifically climate change.

With respect to age, some former studies (e.g. Whitmarsh, 2011; Hamilton and Stampone, 2013) show negative effects on climate change beliefs. According to Table 9, the estimation results for "age" in the model specifications (2) and (4) support these former results and thus Hypothesis 3c. As aforementioned, however, in most cases the corresponding parameters are not significantly different from zero so that no robust age effect can be identified. Therefore, we analyze possible nonlinear effects and thus consider the two variables "age" and "squared age". The corresponding results in Tables 7 and 8[9] reveal robust non-linear effects on global climate change beliefs, mostly at the 1% significance level. The estimated parameters suggest a U-shaped effect, i.e. an increasing age decreases the global climate change believes until the age of between 38 and 44 years and from this point increases for older respondents. Therefore, our results are only in line with former studies which report negative age effects when younger adults are considered. However, this non-linear age effect is obviously an interesting new result that has not been considered so far in econometric analyses of the determinants of climate change beliefs and concerns. It can possibly also explain insignificant age effects in former studies which do not include a quadratic term (e.g. Egan and Mullin, 2012; Hamilton and Lemcke-Stampone, 2014). Overall, Hypothesis 3c cannot be confirmed.

Household income has a robust negative effect, although only at the 10% significance level in model specification (1). This result is in line with the studies of Hamilton and Keim (2009), McCright (2010), or Shao et al. (2014), which also report negative income effects on climate change concerns. As for the gender effect in the U.S. (which is, however, rejected in our study), an explanation for this income effect can also be based on the risk perception literature. If people with higher incomes have a higher acceptance of technological and environmental risks and a lower feeling of vulnerability to risks due to their dominant position in the social structure that allows them to create, manage, control, and benefit from risks, their perceptions of climate change risks and thus general beliefs in global warming should be lower than for people with lower incomes.

Furthermore, according to Tables 7 and 8, the variable "household with children" only has significantly positive effects in model specifications (3) and (4), but insignificant effects in all other model specifications. Therefore, no robust conclusions can be drawn from these results. 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 skeptics in Shenyang. This result is consistent with the descriptive statistics according to Table 4 which shows that Shenyang and Chengdu are most skeptical toward the existence of global climate change.

5. Conclusions

Beliefs in the general existence of global warming are certainly crucial for the support of costly adaptation activities by climate policy that aim to reduce the negative impacts of climate change and also a necessary condition for the support of mitigation policy, although the acceptability of public mitigation activities additionally requires the specific belief in anthropogenic climate change. Furthermore, such beliefs can be an important stimulus for voluntary individual climate protection activities. This paper analyzes the extent and particularly the determinants of general global climate change beliefs. In contrast to former studies for the U.S. and sporadically for other high-income western countries such as the UK, we focus on China due to its crucial role in international climate policy in conjunction with its vulnerability to global climate change. The empirical analysis is based on data from a survey among more than 1000 adults in five cities in China, namely Beijing, Guangzhou, Chengdu, Wuhan, and Shenyang. Our econometric analysis particularly disentangles the relationships of global climate change beliefs with physical or financial damages due to extreme weather events and with perceived extreme weather experiences without consequential damages.

In line with former studies, 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. In contrast to the higher extent of climate change skeptics in the U.S., this seems to be a convenient and necessary basis for the support of ambitious public adaptation and possibly also mitigation measures in China, at least by citizens in economically important cities. Furthermore, our econometric analysis of socio-demographic and socio-economic variables shows that

[8] The estimation results are not reported for brevity, but are available upon request.

[9] It should be noted that the estimation of average marginal probability effects cannot be based on a squared term so that the estimation results in Tables 9 and 10 are based on the inclusion of "age" only.

females as well as people with a lower education, in medium ages between 38 and 44 years, with higher household incomes, and from Chengdu or Shenyang are more skeptical toward the existence of climate change. It should be noted that due to this education effect the number of people who believe in climate change is possibly slightly overestimated since high education groups are overrepresented in our sample. With respect to nonlinear age effects, it would be interesting to analyze in future studies whether our estimation results for China can be confirmed in other countries.

While the causality of the relationship between perceived extreme weather experiences and climate change beliefs cannot be fully identified, we show that such experiences with or without consequential physical or financial damages are strongly correlated with global climate change beliefs, although physical or financial damages due to these extreme weather events lead to even stronger relationships. Furthermore, our estimation results reveal that perceived experiences with heatwaves as well as damages due to heatwaves are especially relevant in this respect. This suggests that heatwaves are more associated with climate change than other extreme weather events such as floods or droughts. If perceived extreme weather experiences are not only correlated with climate change beliefs, but also have causal effects, our results suggest that the most appropriate time period to motivate the population in China to support public adaptation and possibly also mitigation activities is after extreme weather events and particularly after heatwaves with strong harms. However, the identification of the causality of the identified relationship has to be left for future research if appropriate (panel) data are available.

A further shortcoming of our study is that only general climate change beliefs are examined. Another direction of further research is therefore the deeper analysis of the determinants of beliefs in anthropogenic global warming in China. Corresponding data were not available for our study. Moreover, our analysis is based on perceived extreme weather experiences, which are necessarily subjective and thus can possibly be influenced by climate change beliefs. Therefore, in line with numerous studies in the U.S., it would be interesting to analyze possible effects of actual weather at the day of the survey or for different periods before the survey that can be objectively measured. Such data are also unavailable so far for China. However, instead of using such weather data, it would perhaps even more interesting to analyze the effects of real extreme weather experiences on climate change beliefs. However, a reliable econometric analysis would require data from natural experiments, i.e. data for the same citizens before and after an extreme weather event.

Appendix A. Tables

Table 1
Survey cities.

City	Region	Tier designation	Number of inhabitants (in one million)	GDP per capita per year (in PPP USD)	Number of respondents
Beijing	North (Capital)	Tier 1	19.6	19,246	316
Guangzhou	South	Tier 1	12.7	22,164	262
Chengdu	Southwest	Tier 2	14.1	10,454	170
Wuhan	South Central	Tier 2	9.8	14,419	157
Shenyang	Northeast	Tier 2	8.1	15,803	149
Total					1054

Note: Sources for population figures and GDP per capita are from 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, and 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 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 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 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 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 10,000 RMB	23.4	19.9	15.9	15.3	12.8	18.6
10,000 to less than 15,000 RMB	25.0	26.3	10.6	15.3	14.8	20.2
15,000 to less than 20,000 RMB	11.1	8.8	7.1	3.2	4.0	7.7
20,000 to less than 40,000 RMB	5.7	3.4	3.5	1.9	2.7	3.8
40,000 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 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 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
	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 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

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

Assessments	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 perceived 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 perceived 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)
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)
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)
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)
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)
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 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)
High education	0.3121** (2.23)	0.3184** (2.26)	0.3221** (2.29)	0.3364** (2.36)
Female	−0.2842** (−2.24)	−0.2878** (−2.28)	−0.2814** (−2.22)	−0.2917** (−2.30)
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)
High household income	−0.5005** (−2.19)	−0.5214** (−2.24)	−0.5086** (−2.12)	−0.5742** (−2.48)
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 perceived 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)
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)
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)
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)
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)
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 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)
High education	0.0446** (2.21)	0.0458** (2.25)	0.0452** (2.27)	0.0478** (2.34)
Female	−0.0402** (−2.25)	−0.0410** (−2.29)	−0.0391** (−2.22)	−0.0410** (−2.31)
Age	−0.0006 (−1.11)	−0.0008 (−1.35)	−0.0006 (−0.97)	−0.0007 (−1.18)
High household income	−0.0571*** (−2.80)	−0.0597*** (−2.90)	−0.0569*** (−2.74)	−0.0636*** (−3.26)
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.

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