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SCHOOL OF BUSINESS, ECONOMICS AND LAW, UNIVERSITY OF GOTHENBURG

*Department of Economics*

*Visiting adress* Vasagatan 1,

*Postal adress* P.O.Box 640, SE 405 30 Göteborg, Sweden

*Phone* + 46 (0)31 786 0000

# Paying for Mitigation: A Multiple Country Study

Fredrik Carlsson, Mitesh Kataria, Alan Krupnick, Elina Lampi, Åsa Löfgren,  
Ping Qin, Susie Chung, and Thomas Sterner\*

## Abstract

Unique survey data from a contingent valuation study conducted in three different countries (China, Sweden, and the United States) were used to investigate the ordinary citizen's willingness to pay (WTP) for reducing CO<sub>2</sub> emissions. We find that a large majority of the respondents in *all three countries* believe that the mean global temperature has increased over the last 100 years and that humans are responsible for the increase. A smaller share of Americans, however, believes these statements, when compared to the Chinese and Swedes. A larger share of Americans is also pessimistic and believes that nothing can be done to stop climate change. We also find that Sweden has the highest WTP for reductions of CO<sub>2</sub>, while China has the lowest. Thus, even though the Swedes and Chinese are similar to each other in their attitudes toward climate change, they differ considerably in their WTP. When WTP is measured as a share of household income, the willingness to pay is the same for Americans and Chinese, while again higher for the Swedes.

**Key words:** Climate change, willingness to pay, multi-country, China, United States, Sweden

**JEL classification:** Q51, Q54

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\* Fredrik Carlsson, Department of Economics, University of Gothenburg, Box 640, SE-40530 Gothenburg, Sweden, (tel) +46 31 7864174, (fax) +46 31 7861043, (email) [fredrik.carlsson@economics.gu.se](mailto:fredrik.carlsson@economics.gu.se); Mitesh Kataria, Max Planck Institute of Economics, Kahlaische Straße 10, D-07745 Jena, Germany, (email) [kataria@econ.mpg.de](mailto:kataria@econ.mpg.de); Alan Krupnick, Resources for the Future, 1616 P St., NW, Washington, DC, 20036, USA, (email) [krupnick@rff.org](mailto:krupnick@rff.org); Elina Lampi, Department of Economics, University of Gothenburg, Box 640, SE-40530, Gothenburg, Sweden, (email) [elina.lampi@economics.gu.se](mailto:elina.lampi@economics.gu.se); Åsa Löfgren, Department of Economics, University of Gothenburg, Box 640, SE-40530, Gothenburg, Sweden, (email) [asa.lofgren@economics.gu.se](mailto:asa.lofgren@economics.gu.se); Ping Qin, Peking University, College of Environmental Sciences and Engineering, 100871 Beijing, China, (email) [qin.ping@economics.gu.se](mailto:qin.ping@economics.gu.se); Susie Chung, Resources for the Future, 1616 P St., NW, Washington, DC, 20036, USA, (email) [chung@rff.org](mailto:chung@rff.org); and Thomas Sterner, Department of Economics, University of Gothenburg, Box 640, SE-40530, Gothenburg, Sweden, (email) [thomas.sterner@economics.gu.se](mailto:thomas.sterner@economics.gu.se).

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## 1. Introduction

At the end of 2009, representatives from governments around the world gathered in Copenhagen to address the threat of climate change. The outcome revealed vast differences among the countries regarding the willingness to commit to reductions of greenhouse gases, and it is clear that future negotiations will ultimately depend on how politically acceptable the proposed reductions are to domestic constituencies. Hence, for policymakers to maintain legitimacy in international negotiations, the costs that a country agrees to pay (implicitly given by the agreement to reduce carbon dioxide (CO<sub>2</sub>) emissions) must be accepted by the citizens who, in the end, will bear the costs of the reduction (Beetham 1991). However, little is known about how the willingness to pay (WTP) to avoid the consequences of climate change differs among and within countries. The aim of this study is to fill this gap by providing some insights from a cross-country comparison.

In a joint multinational effort, our team of researchers from China, Sweden, and the United States administered a nearly identical contingent valuation survey virtually simultaneously in all three countries. It queried ordinary citizens in these countries about their willingness to pay to avoid the consequences of global temperature changes, as forecasted by the Intergovernmental Panel on Climate Change (IPCC 2007). More precisely, we asked for their WTP to reduce the level of CO<sub>2</sub> emissions by 30%, 60%, and 85% by the year 2050.

While there is an existing literature on WTP estimates for reducing greenhouse gas emissions and avoiding the consequences of climate change, the studies are quite diverse and tend to focus on one country, making it difficult to compare the estimates from independent studies across countries. One of the problems with such a comparison is that some of the differences in WTP may be attributable to differences in survey design. In particular, various studies use different underlying scenarios to motivate WTP, such as preventing forest losses caused by climate change (Layton and Brown 2000; Layton and Levine 2003), obtaining green electricity (Nomura and Akai 2004; Hansla et al. 2008), compensating for air travel emissions (Brouwer et al. 2008), taking mitigation actions (Akter and Bennet 2008), reducing dependence on foreign oil and carbon emissions (Li et al. 2009), using more biomass (Solomon and Johnson 2009), and implementing the Kyoto Protocol (Berrens et al. 2004). In a more general attempt, Berk and Fovell (1999) estimate the WTP to prevent “significant” climate change.

In a novel attempt that compares people from different countries, Brouwer et al. (2008) investigated whether air travel passengers are supportive of measures to compensate for the damage caused by their flights. They found that Europeans are the most aware and most willing to pay for carbon offsets whereas North Americans and Asians are less informed and less willing to pay. Hansla et al. (2008) asked Swedish households for their WTP for green electricity and report that a majority of them (80%) have a positive WTP. From both of

these studies, we might expect Swedish respondents to have a higher WTP to reduce carbon emissions than American or Chinese respondents. However, there is little empirical evidence on climate change attitudes and WTP in a climate change setting in China, and it is therefore difficult to predict the outcome of the Chinese survey.<sup>1</sup>

The existing literature also highlights the characteristics and attitudes that are associated with different WTP for mitigating climate change. Cameron (2005) used a convenience sample of college students and found that respondents who are more certain about a given increase in average temperatures have a higher WTP to prevent such an increase. In line with these results, Viscusi and Zeckhauser (2005) and Akter and Bennett (2008) also found that people who find global warming to be more likely also have higher WTP. Hence, as might be expected, one important explanatory factor for how much individuals are willing to pay for mitigating climate change is whether they believe that climate change is a real phenomenon. Therefore, in our study we control for several “climate attitudes” of the respondents.

The paper is organized as follows. Section 1 describes the survey and section 2 presents the sampling framework. Section 3 follows, discussing the respondents’ perception of climate change. In section 4, the WTP results are presented, followed by regression results in section 5 on the effect that attitudes and personal characteristics have on WTP. Section 6 offers a summary and conclusions.

## **2. Description of the Survey**

Our survey had four independent sections. In the first section, we elicited general attitudes about climate change that we later compared with respondents’ WTP values. The questions included whether or not the respondents believe that climate change is occurring and if they believe that actions can be taken to reduce or stop the change. In the second section, the survey provided information on the effects of climate change, which was summarized from IPCC reports. Respondents’ attitudes on reducing global CO<sub>2</sub> emissions were also elicited in this section. After a cheap-talk script,<sup>2</sup> section 2 ended with WTP questions for reducing CO<sub>2</sub> emissions. The third section of the survey was a choice experiment about rules for allocating the responsibilities for CO<sub>2</sub> reductions across countries

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<sup>1</sup> Cai et al. (2010) study how the distributional consequences of climate change policies influence policy preferences. While their survey included only respondents from the United States, it asked the respondents’ opinions on the international costs of climate change mitigation and who should bear the costs. They find that distributional consequences are important to respondents and can significantly affect WTP.

<sup>2</sup> The cheap-talk script reads: “Before making your choices, please consider how an increased cost would affect your possibilities for buying other things. Previous studies of this kind have shown that people claim to be willing to pay more money than they actually would in a real situation. It is important to us that respondents answer these questions as truthfully as possible.”

that is not included in this paper. Finally, section 4 contained questions about the respondents' socioeconomic characteristics.

The climate change information in section 2 provided respondents with stylized and simplified summaries of current understanding, basically that the magnitude of future temperature increases will depend on the amount of future global CO<sub>2</sub> emissions. More specifically, if CO<sub>2</sub> emissions are reduced from current emission levels by 30%, 60%, or 85% in 2050, then the temperature increase will be limited to 4°F, 3°F, or 2°F, respectively. If the world instead does not reduce emissions, but continues with “business as usual,” the temperature is expected to increase by more than 4°F in 2050. The survey explained, again based on information from the IPCC,<sup>3</sup> that this increase in temperature would most likely correspond to large changes in global ecosystems and most countries would be negatively affected. An information screen (table 1) summarized the effects of temperature increases on harvests, increased flooding and storms, and ecosystem effects by the year 2050.

**Table 1 Global Emission Reduction, Temperature Increase, and Its Effects as Presented to Survey Respondents**

<b>Global emissions reduction</b>	<b>85% reduction</b>	<b>60% reduction</b>	<b>30% reduction</b>
<b>Temperature increase</b>	2°F increase	3°F increase	4°F increase
<b>Harvest</b>	Harvests in countries near the equator decrease by 4-6%. Harvests in countries in the northern hemisphere increase by 1-3%.	Harvests in countries near the equator decrease by 10-12%. Harvests in countries in the northern hemisphere are unaffected.	Harvests in countries near the equator decrease by 14-16%. Harvests in the northern hemisphere decrease by 0-2%.
<b>Increased flooding and storms</b>	Small tropical islands and lowland countries (for example, Bangladesh) experience increased flooding and storms.	Additional low-lying areas in the Americas, Asia, and Africa experience increased flooding and storms.	Populous cities face increased flood risks from rivers and ocean storms. Existence of small island countries is threatened.
<b>Threatened ecosystems</b>	Sensitive ecosystems, such as coral reefs and the Arctic ecosystem, are threatened.	Most coral reefs die. Additional sensitive ecosystems and species around the world are threatened.	Sensitive and less-sensitive ecosystems and species around the world are threatened.

WTP values were obtained by using the payment card method, in which respondents choose a number from a matrix, representing their maximum WTP for a certain reduction in global emissions. We used the payment card format because of our experience in China (Krupnick, Hoffmann, and Qin 2009) with this approach and the standard dichotomous choice approach, and the poor performance of the latter relative to the former. In addition, with a

<sup>3</sup> Note that in the survey we gave the following information: “There are a small number of experts who disagree with the IPCC consensus, but because the IPCC represents the large majority of climate researchers, this survey will use information from the IPCC.”

close-ended format with few bids, there was a clear risk of a poor bid-vector design for at least one country, given the uncertainties about the underlying true WTP function. The values in the matrix ranged between \$0 and \$220 per month in the U.S. survey and were adjusted for purchasing power parity (PPP) in the Chinese and Swedish surveys.

Respondents who had a WTP greater than \$220 had the option of stating their maximum WTP in an open-ended payment question. Three WTP questions were asked. The first question asked the WTP for a 30% emissions reduction, compared to business as usual (no reduction). The second WTP question asked for the additional amount the respondent would pay for a 60% reduction instead of a 30% reduction. Finally, the third WTP question asked the additional amount the respondent would pay for an 85% reduction instead of a 60% reduction. The payment was expressed as a monthly cost for the household until 2050 and examples of the typical ways in which this cost would be realized were provided, such as increased energy and gasoline prices.<sup>4</sup> When the respondents chose their WTP value, both the monthly payment and the corresponding annual cost for the household were shown on the screen to ensure that the respondents understood how much they would be paying. They had the opportunity to adjust their WTP after seeing this information.

### **3. Administration of the Surveys**

The surveys were conducted in all three countries in November–December 2009. The questionnaire was designed with the aid of ten focus groups and three pilot studies in the three countries. Careful attention was given to developing a survey that was easily understandable and credible within each country. The survey was also designed to be self-administered on the computer to eliminate interviewer bias and strategic answering to please the interviewer. In China, the survey was conducted on laptops in special rooms with invited respondents. In Sweden and the United States, the respondents took the survey online. The survey yielded 1,230 responses in Sweden, 999 responses in the United States, and 1,264 responses in China.

The Chinese survey was administered in four cities—Shanghai, Nanning, Jiujiang and Chongqing—chosen by the Chinese government’s Ministry of the Environment as being broadly representative of Chinese cities in size, location, and income (Krupnick, Hoffmann and Qin 2009). Respondents were randomly selected to participate in the survey, using neighborhood-based databases that had been used in previous surveys (*ibid.*).

The respondents to the Swedish survey were reached using the panel members of “Panel.se,” Sweden’s largest study panel with around 100,000 members. The panel members were recruited by telephone using random digit dialing, combined with online recruitment.

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<sup>4</sup> Wisner (2007) found that the WTP to support climate change policy depends on the payment vehicle used in the study. For example, with a collective payment mechanism, the elicited WTP was higher compared to when voluntary payment mechanisms was used. In our study, we do not test for different payment vehicles, but rather we make clear how the payments are made and keep this consistent across countries.

The panel is representative of the Swedish population in terms of gender, age, and income. Panel members between 18–74 years old were randomly selected to answer the surveys.

The respondents to the U.S. survey were panel members recruited by a survey company, Knowledge Networks. The panel members were recruited by telephone using random digit dialing and address-based sampling, and representative of the U.S. population in terms of gender, age, race, and income. Panel members aged 18 years and older were randomly selected and invited to take the survey.<sup>5</sup>

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<sup>5</sup> To obtain a more representative panel, if a household did not have a computer and/or internet connection, Knowledge Networks provided a laptop computer and free internet access.

**Table 2 Descriptive Statistics**

Variable	Description	Sweden				United States				China			
		Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.	Mean	Std.	Min.	Max.
Female	= 1, if female	0.483		0	1	0.512	0.500	0	1	0.464	0.499	0	1
Age	Years	49.7	15.4	18	74	47.7	16.8	18	90	54.1	12.6	18	79
Adults	No. of household members 18 and above	1.868	0.677	1	11	2.177	0.987	1	12	2.902	1.139	1	9
Children	No. of household members below 18	0.522	0.911	0	5	0.589	1.025	0	7	0.520	0.667	0	6
Compulsory	= 1, if only compulsory/primary school (ref. category)	0.113		0	1	0.108		0	1	0.160		0	1
High school	= 1, if only high school	0.339		0	1	0.312		0	1	0.134		0	1
Post high school	= 1, if post-high school	0.174		0	1	0.278		0	1	0.277		0	1
University graduate	= 1, if completed university education	0.374		0	1	0.302		0	1	0.428		0	1
Income	Monthly income in US \$000s	3.386	1.526	0.269	6.18	3.407	2.812	0.208	16.67	1.250	0.864	0.123	3.92
Active religious	= 1, if active in an organized religion	0.064		0	1	0.160		0	1	0.011	0.105	0	1
<i>Political affiliation</i>													
Left	= 1, if left wing (Sweden)	0.315		0	1								
Green	= 1, if Green party (Sweden)	0.119		0	1								
Other party	= 1, if other party (Sweden)	0.154		0	1								
Center-right	= 1, if center-right parties (Sweden)	0.412		0	1								
Democrats	= 1, if Democrat (US)					0.368		0	1				
Green party	= 1, if Green party (US)					0.011		0	1				
Other party	= 1, if other party (US)					0.079		0	1				
Independent	= 1, if Independent (US)					0.284		0	1				
Republican	=1, if Republican (US; ref. category)					0.248		0	1				
Communist	= 1, if Communist party (China)									0.313	0.464		



#### **4. Characteristics of Respondents and Attitudes toward Climate Change**

Descriptive statistics are presented in table 2. These statistics are compared, where possible, to population characteristics. There are some important differences between the sample characteristics and population characteristics for the Swedish and Chinese samples; the U.S. sample appears, however, to be representative. In the Swedish sample, the share of subjects with post-high school and university education is significantly higher than the population share.<sup>6</sup> In the Chinese sample, the share of subjects with a university education is also higher than the population shares.<sup>7</sup> We use weighting to address this issue, as described later in the study.

The survey asked several questions regarding attitudes toward climate change and climate policies. The distributions of these responses are reported in table 3.

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<sup>6</sup> The reported share of people (in the age group 18–74 years) with post-high school education is 13.4% and the share of university educated is 18.6% at the national level in Sweden (Statistics of Sweden 2008); the corresponding figures for our sample are 17.4% and 37.4%, respectively.

<sup>7</sup> The share of people (for example, in Beijing) with a university education is around 20% (Beijing Statistical Yearbook 2009), while in our sample, 42.8% have a university education.

**Table 3 Attitudes toward Climate Change: Share of Respondents Agreeing with Each Statement**

Variable	Description of statement	Sweden	United States	China
No temperature increase	The temperature has <i>not</i> increased globally.	0.059	0.243	0.045
Humans affect temperature increase	Humans have affected the temperature increase.	0.939	0.733	0.960
Cannot stop climate change	We cannot do anything to stop climate change.	0.063	0.169	0.096
Can mitigate, but not stop	We can mitigate, but not stop climate change.	0.798	0.599	0.791
Can stop climate change	We can stop climate change.	0.116	0.105	0.092
Own country should reduce	Own country should reduce carbon emissions, even if other countries do not reduce their carbon emissions.	0.820	0.684	0.801
Reduce where it is cheap	Own country should primarily use public funding to reduce carbon emissions wherever it is cheapest, even if it means in another country.	0.446	0.158	0.322
Reduce in own country	Own country should primarily use public funding to reduce carbon emissions in own country.	0.391	0.425	0.563
Primarily mitigate	Countries in the world should deal with climate change primarily by reducing carbon emissions.	0.862	0.590	0.826
Primarily adaptation	Countries in the world should deal with climate change primarily by adaptation.	0.099	0.156	0.152
Trustworthy information	The information given in the survey regarding climate change is trustworthy.	0.817	0.498	0.878
Prioritize environment	We should prioritize environmental improvements, even if we lose jobs.	0.624	0.403	0.767

Note first that a large majority of the respondents in *all three countries* believe that the global mean temperature has increased over the last 100 years, that humans are partly or fully responsible for that increase, that it is possible to mitigate climate change, that their country should mitigate carbon emissions even if other countries do not, and that mitigation is preferable over adaptation. Having said this, Chinese and Swedish respondents tend to be more similar than Americans when it comes to attitudes toward climate change. Americans differ most on the issue of where emissions should be reduced—in the home country or where it is cheapest; a much smaller share of Americans believe that carbon emissions should be reduced where it is cheapest. This is a surprising finding given the large reliance on

international offsets in the greenhouse gas (GHG) cap-and-trade bill passed in June 2009 by the U.S. House of Representatives.<sup>8</sup>

Americans also differ greatly from Sweden and China on the issue of climate change skepticism: 24% do not believe global temperatures have risen, and almost 27% believe that humans have not affected the temperature increase. In comparison, the percentage of skeptics, in the sense that they do not believe that the temperature has increased, is 6% in Sweden and 5% in China. Americans are also much more skeptical about the IPCC information presented on climate change in the survey. Half of the respondents do not believe it to be trustworthy, whereas only 18% of Swedes and 12% of the Chinese think this way. A notable finding is that many more Chinese respondents felt that jobs could be sacrificed in order to improve the environment (77% of Chinese, 62% Swedes, and 40% Americans). In the next section, we explore whether such attitudes translate into differences in WTP.

## 5. Willingness-to-Pay Results

Based on the responses to the three payment-card questions, we estimated a variety of WTP measures. What we report in this paper is the WTP to reduce CO<sub>2</sub> emissions by 30%, 60%, and 85%. Since we used a payment card format, respondent WTP was set to the midpoint of the interval when computing means and conducting regression analysis<sup>9</sup>, except for those respondents who stated a WTP that was outside the range of the bid vector. For these respondents, the WTP was set as the point values given in the open-ended payment question. In order to compare the responses among the three countries, we report WTP in PPP-adjusted U.S. dollars.<sup>10</sup>

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<sup>8</sup> American Clean Energy and Security Act of 2009 (ACES), HR 2454, 111th Congress, 1st sess., June 26, 2009. [http://energycommerce.house.gov/index.php?option=com\\_content&view=article&id=1633&catid=155&Itemid=55](http://energycommerce.house.gov/index.php?option=com_content&view=article&id=1633&catid=155&Itemid=55).

<sup>9</sup> There are many ways to interpret a choice on a payment screen. The midpoint approach may be the most neutral. Furthermore, since the WTP for 60% and 85% reductions depends on the choices made in the preceding question(s), there will be a large number of intervals, which means that it is simpler to treat the data as continuous.

<sup>10</sup> SEK = Swedish kronor; SEK 9.6 = US\$ 1. CNY = Chinese yuan renminbi; CNY 3.4 = US\$ 1.

**Figure 1 Distribution of WTP Responses for 30% Greenhouse Gas Reduction**

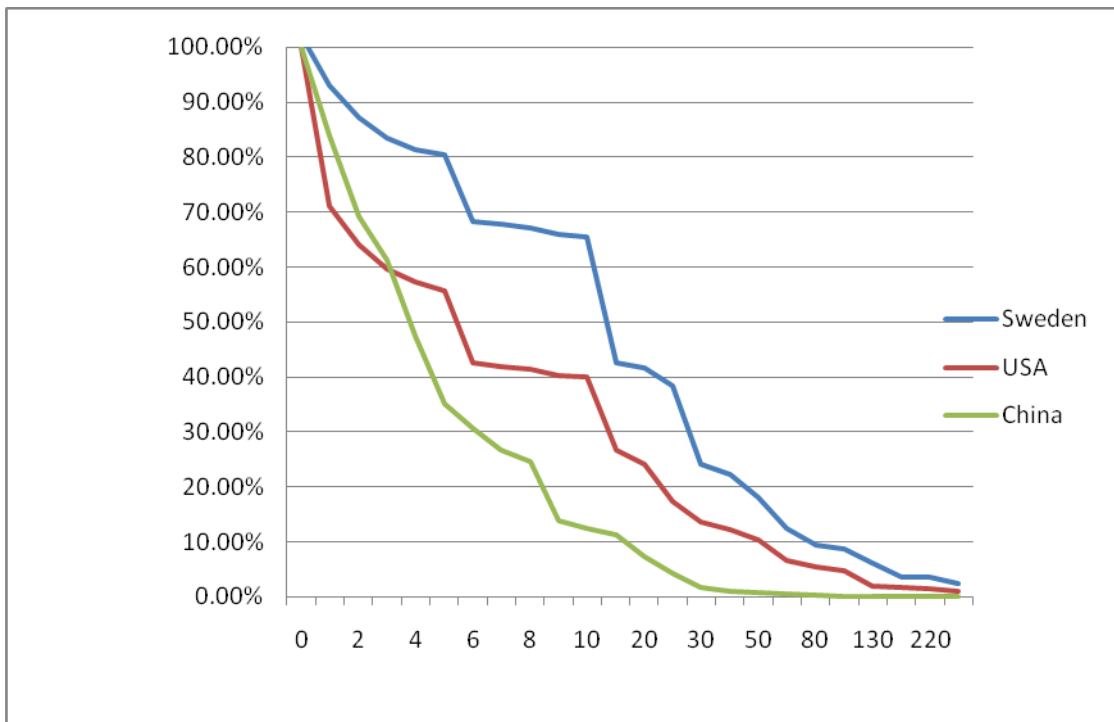


Figure 1 reports the raw household WTP data for each country for the 30% greenhouse gas reduction in a line graph, where the horizontal axis represents the monthly values (in US\$) on the payment card and the vertical axis is the cumulative percent of subjects who are willing to pay an amount equal to or greater than that bid value. We can see a clear difference among the three countries. Swedes are willing to pay more than U.S. and Chinese citizens for every given level of reduction. Furthermore, very few of the Chinese respondents are willing pay more than \$30 per month, in contrast to the U.S. and Swedish respondents. More than 50% of Chinese respondents are willing to pay less than \$4 per month.

However, there is one important caveat to the raw data. As noted above, in both the Swedish and Chinese samples, the shares of highly educated subjects are significantly higher than the population shares. Furthermore, the sample sizes of the four sampled cities in China do not correspond to the relative population size of the cities. Therefore, we weighted the observations from Sweden and China, where the weights are the population share divided by the sample share for each category.<sup>11</sup>

Table 4 reports the monthly WTP values for the three countries, WTPs as a share of income, and the share of respondents with zero WTP for an 85% reduction. (The unweighted WTP values are reported in table A1 in the appendix.) By survey design, the WTP for these respondents is also zero for the 30% and 60% reductions.

<sup>11</sup> For the Swedish sample, we created four weights corresponding to the four education-level categories. For China, we constructed 16 weights corresponding to the four education levels for each of the cities. An alternative approach to using weights is to predict the WTP at population means, using a regression model. These estimated mean WTPs are similar to the weighted ones presented here, so we focus on the weighted ones.

**Table 4 Monthly Household WTP in PPP Dollars, WTP as a Share of Income, and Share of Subjects with Zero WTP**

	Sweden (1230 obs.)			United States (999 obs.)			China (1264 obs.)		
	<i>Mean</i>	<i>Std.dev.</i>	<i>Share of inc.</i>	<i>Mean</i>	<i>Std.dev.</i>	<i>Share of inc.</i>	<i>Mean</i>	<i>Std.dev.</i>	<i>Share of inc.</i>
30% reduction	\$21.70	34.00	0.007	\$17.27	43.69	0.005	\$4.99	10.73	0.004
60% reduction	\$39.54	64.81	0.012	\$27.95	64.13	0.008	\$8.32	18.50	0.007
85% reduction	\$54.24	96.95	0.016	\$36.43	86.69	0.011	\$11.18	24.84	0.009
	<i>Mean</i>	<i>Std.dev.</i>		<i>Mean</i>	<i>Std.dev.</i>		<i>Mean</i>	<i>Std.dev.</i>	
Share subjects with zero WTP	0.080	0.271		0.244	0.430		0.119	0.324	

Notes: PPP = purchasing power parity; obs. = observations; inc. = income.

In all three countries, the mean WTP increases when the emissions reduction increases; using a two-sided t-test, the increase in WTP is significant for all cases and all countries. In all three countries, the mean WTP increases at a decreasing rate, although the increase in WTP is not far from being linear between the 60% and 85% reduction. Furthermore, there are clear differences in the levels of WTP among the countries. Using a two-sided t-test, we can reject the hypothesis of equal WTP among the three countries for a given level of reduction. Sweden has the highest WTP and China has the lowest. The WTP in Sweden is between 4 and 4.5 times higher than the WTP in China. The difference between Sweden and the United States is smaller; the WTP is around 30%–60% higher in Sweden. This difference is to a large extent explained by the larger fraction of respondents with zero WTP in the United States. Among the U.S. subjects, 24% said that they were not willing to pay anything for reducing emissions by 85% (which also means they were not willing to pay anything for the 30% or 60% reductions); in Sweden the share of subjects with a zero WTP was only 8%.

However, there are considerable differences in average income between the countries. Therefore, it is of interest to compute WTP as a share of household income. Table 4 shows that the Swedish respondents were willing to pay 1.6% of their household income to reduce carbon emissions by 85%, while the corresponding figure for the United States is 1.1%, and for China it is 0.9%.

## 6. Econometric Analysis

We now turn to the econometric analysis of the responses. There are two objectives with the econometric analysis. The first is to investigate what determines WTP within a country. The second is to compare the determinants between the countries. In order to focus the analysis, we estimated models only for the 85% reduction (from current emission

levels).<sup>12</sup> In the survey, we told the respondents that this corresponds to an increase in global temperature of 2°F, compared to the temperature today,<sup>13</sup> (IPCC Assessment Report 2007; Warren 2006), which approximately corresponds to the 4°F (above pre-industrial level temperature) target of the Copenhagen Accord.<sup>14</sup> The dependent variable, WTP, is positive, but a non-negligible fraction of the respondents has a zero WTP. Therefore, we could estimate a standard Tobit type 1 model. However, the zero WTP responses are not due to non-observability, but due to a decision of the respondent. We therefore estimated a Tobit type 2 model that contains two equations (see e.g., Carlsson and Johansson-Stenman 1999; Greene 2008). The first one is the probability of a positive response,  $P[WTP > 0]$ , and the second one is the WTP, given a positive response,  $E[WTP|WTP > 0]$ . With the Tobit type 2 model, we took into account the selection problem associated with estimating  $E[WTP|WTP > 0]$  and estimated a correlation coefficient,  $\rho$ , between the error terms of these two equations.

This model is sensitive to how well the first decision, positive WTP, can be explained; and, particularly for a robust identification, it is important to have variables that explain the decision of whether or not to pay anything. However, that does not explain the decision on how much to pay (the so-called exclusion restriction). In our case, we used the attitude variables. The two questions on whether temperature is increasing and whether humans are affecting the temperature increase are only included in the first stage. Furthermore, as a robustness check, we also estimated all the models without the correlation term, in other words, as independent equations.<sup>15</sup> The results in terms of significance and magnitude of the marginal effects are largely the same with the independent specification.

All the models are estimated with the natural logarithm of WTP as the dependent variable. We report three sets of marginal effects for each country: the effect on the probability of a positive WTP, the effect on conditional log WTP, and the effect on unconditional log WTP. We include the natural log of income as an independent variable, making the coefficient of the income variable easy to interpret as the elasticity of WTP. The dummy variables show approximately the estimated percentage impact on WTP.<sup>16</sup> The results are presented in table 5 below.

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<sup>12</sup> The results are similar for the other reduction levels, particularly in terms of coefficient magnitudes, but there are some differences with respect to significance of effects. Note also that technically the responses to this question depend on the responses to the other two reduction levels.

<sup>13</sup> The relationship between temperature increase and greenhouse-gas emission reductions is uncertain. We based the information in figure 1 on the assessment reports of the IPCC.

<sup>14</sup> The Copenhagen Accord can be found at the United Nations Framework Convention on Climate Change (UNFCCC) homepage, [http://unfccc.int/files/meetings/cop\\_15/application/pdf/cop15\\_cph\\_auv.pdf](http://unfccc.int/files/meetings/cop_15/application/pdf/cop15_cph_auv.pdf).

<sup>15</sup> The results are available on request.

<sup>16</sup> As discussed by Kennedy (1981) and Halvorsen and Palmquist (1980), the estimated percentage impact of the dummy variable on WTP is  $\exp(\beta_i) - 0.5V(\beta_i) - 1$ , where  $v(b)$  is the estimated variance of  $\beta_i$ . We report the untransformed coefficients in the tables, but comment in the text when this transformation implies a different percentage impact. Essentially, this transformation will result in a different estimate when the coefficients of the dummy variables are relatively large.

We begin by discussing the results for the probability of a positive WTP response. Remember that the share of subjects with a positive WTP varies between the countries: in Sweden, around 8% have a zero WTP; while in the United States, it is around 25%; and in China, around 12% have a zero WTP. Few socio-economic characteristics have a significant effect on the likelihood of stating a positive WTP. In both Sweden and China, females are more likely to state a positive WTP. Older respondents are less likely to have a positive WTP in both Sweden and the United States, while the opposite is found for China. In addition, religious people are more likely to state a positive WTP in Sweden, and in China, those with a higher income are more likely to state a positive WTP.

In both Sweden and the United States, political preferences have significant effects. For Sweden, the reference case is supporters of the center-right parties, which are currently in power in Sweden. The results show that the supporters of the two left-wing parties and the Green party are more likely to state a positive WTP than the supporters of the center-right parties. For the United States, the reference case for political preference is Republican; and the results shows that Democrats are more likely to state a positive WTP.<sup>17</sup>

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<sup>17</sup> Since political preferences are potentially correlated with socio-economic characteristics, we estimated all the models without the political-preference variables. However, this did not affect the significance of the other variables included in the first equation.

**Table 5 Marginal Effects Tobit Type 2 Model for the 85% Reduction Scenario**

Variable	Sweden			United States			China <sup>a</sup>		
	P(WTP>0)	ln(WTP+1) <sup>b</sup>   WTP>0	ln(WTP+1)	P(WTP>0)	ln(WTP+1)   WTP>0	ln(WTP+1)	P(WTP>0)	ln(WTP+1)   WTP>0	ln(WTP+1)
Female	0.015**	-0.247***	-0.142***	0.042	-0.042	0.098	0.028*	-0.013	0.066
Age	-0.001**	-0.010***	-0.013***	-0.001***	0.001	-0.004	0.002**	0.002	0.006*
Adults	-0.003	0.080***	0.059	0.012	0.102***	0.122*	0.007	-0.041*	-0.018
Children	0.006	-0.060***	-0.018	-0.003	0.013	-0.001	0.018	0.014	0.064
High school	0.007	0.207***	0.242***	-0.069	-0.297	-0.449*	0.002	0.075	0.074
Post-high school	0.003	0.241***	0.247***	-0.056	-0.194	-0.328*	0.012	0.159*	0.181
University education	0.010	0.386***	0.433***	-0.015	-0.084	-0.116	0.030	0.328***	0.388***
ln(Income)	0.001	0.397***	0.380***	0.017	0.140***	0.167***	0.074***	0.638***	0.793***
Religious	0.022**	-0.172**	-0.027	-0.016	-0.163	-0.182	-0.030	-0.333	-0.383
<i>Political affiliation</i>									
Left	0.025***	-0.089*	0.072						
Green	0.052***	0.184***	0.515***						
Other party	-0.076***	-0.325***	-0.762***						
Democrats				0.081**	0.543***	0.707***			
Green party				0.112	0.834**	1.124**			
Other party				-0.143**	0.030	-0.425*			
Independent				0.049	0.346***	0.441***			
Communist party							0.018	-0.066	-0.011
No temperature increase	-0.097***		-0.596***	-0.170***		-0.532***	-0.051		-0.146**
Humans affect temperature increase	0.252***		1.517***	0.380***		1.173***	0.134**		0.391
Own country should reduce		0.519***	0.492***		0.198*	0.161*		0.344***	0.317***
Prioritize environment		0.644***	0.612***		0.624***	0.506***		0.079	0.072
Rho (standard error)		0.352			-0.177			0.469	



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(0.093)

(0.133)

(0.028)

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Note: All models include a constant.

<sup>a</sup> Estimated models for China include dummy variables for the cities of Jiujiang, Nanning, and Chongqing.

<sup>b</sup> By convention, we added 1 to the WTP, so that 1nWTP will equal 0 when WTP = 0.

\*, \*\*, \*\*\* denote that the coefficient is statistically significant at the 10%, 5%, and 1% levels, respectively.

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The coefficients of the two attitude variables included in the first stage are both significant and sizeable for the Swedish and U.S. samples, while only one of them is significant for the Chinese sample. The attitude variable with the largest impact on the probability to state a positive WTP is whether the respondent believes that humans affect climate change. In the Swedish sample, respondent who believes this has a 25% greater probability of stating a positive WTP. For the U.S. sample, the same type of respondent has a 38% greater probability, while for China the probability is 14% greater. Notably, if we compare the effect of this variable to other dummy variables, it becomes apparent that the belief that climate change is caused by humans really is what effectively separates those with a positive WTP from others.

More broadly, when comparing the impacts of the variables on the probability of a positive WTP across the three countries, very few variables have the same impact in the three countries. The exceptions are the attitude variables.

Next we look at the conditional WTP, namely, the effect on WTP conditional upon a positive WTP. In terms of significance, there are large differences between the countries. For the Swedish sample, most of the coefficients are significant, while in both the United States and China fewer coefficients are significant. The only socioeconomic characteristic that is significant and has the same sign in all three countries is income. The corresponding income elasticities, estimated at sample mean, are around 0.4 for Sweden, around 0.65 for China, and 0.15 for the United States. Females have a significantly lower WTP in Sweden, the coefficient of 0.247 corresponds to a 22% percent lower WTP.<sup>18</sup> Age is negatively correlated with WTP in Sweden, while there is no significant effect for the United States or China. The number of adults per household has a positive effect on WTP for the Swedish and U.S. sample, while it has a negative effect in the China sample. The number of children is only significant in the Swedish sample. In both Sweden and China, there is a large difference in WTP between subjects with and without a university education; the university educated respondents have a substantially higher WTP.

We were interested in using religion as a variable in Sweden and China to see if being religious corresponds with heightened ethics, morality, and altruism, which may be tied to being more interested in “saving the planet.” However, while religious respondents were more likely to state a positive WTP in Sweden, they actually stated a lower conditional WTP than non-religious respondents. For the United States, we had the same hypothesis, plus another hypothesis that being very religious may be correlated more with conservatism and the politics of the Republican Party, since religiousness in the population correlates well with the states that tend to vote

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<sup>18</sup> As discussed previously, table 4 reports the untransformed estimates, and they are, therefore, only approximately equal to the percentage impact on WTP.

Republican in the general election.<sup>19</sup> Furthermore, Republicans, as a political party, have been skeptical about climate change.<sup>20</sup> However, in the estimated models, religiousness does not play a significant role for the U.S. sample,<sup>21</sup> while political preferences play a very important role. There is a large difference between Republicans (the reference group) and Democrats; the latter is willing to pay far more, around 54% more for an 85% reduction of carbon emissions. For supporters of the Green party, there is an even stronger effect, but there are very few Green party members in the United States. In the Swedish sample, supporters of the Green party have a WTP that is substantially higher than the WTP of supporters of the center-right parties (the reference group).

Finally, the coefficients for the two variables reflecting attitudes towards environmental policies—preferring that their own country decrease emissions regardless of what other countries do and wanting to prioritize the environment even if it means lost jobs—are positive, large, and significant for all three countries, except for the second variable in China.

We are not commenting in this paper on the last set of results in detail. The effect on unconditional WTP depends on the two marginal effects that have been discussed. There are some cases where there are opposite effects on the probability of stating a positive WTP and on the conditional WTP. In those cases, the effect on unconditional WTP depends on the size of these two effects. For example, in Sweden, religious people were more likely to state a positive WTP, but had a lower conditional WTP. In this particular case, this resulted in an insignificant difference between religious and non-religious respondents for unconditional WTP.

## 7. Conclusions

By administering a contingent valuation survey to a sample of ordinary citizens (living in China, Sweden, and the United States), we investigated the willingness to pay (WTP) for reducing CO<sub>2</sub> emissions by 30%, 60%, and 85%. We found that a large majority of the respondents in *all three countries* believed that the mean temperature has increased globally over the last 100 years and that humans are partly or fully responsible for that increase. When it

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<sup>19</sup> For instance, compare state by state results of the 2008 presidential election (<http://www.cnn.com/ELECTION/2008/results/president/>) to responses to a Pew Center poll on the percentage of the population by state who attends religious services at least once per week (at <http://religions.pewforum.org/maps/>)

<sup>20</sup> See this interesting speech (March 2, 2010) by Senator Lindsey Graham (R-SC) at <http://climateprogress.org/2010/03/02/graham-says-gop-should-stop-demonizing-climate-change-you%E2%80%99re-risking-your-party%E2%80%99s-future-with-younger-people-by-calling-it-a-hoax/>

<sup>21</sup> Since religion and political preferences can be correlated, we also estimated all the models without religion and political preferences, respectively. The only important effect was that if we removed the political preference variables in the U.S. sample, the religiousness variable becomes almost significant (p-value = 0.104), which is a weak support of our hypothesis regarding religion and WTP.

comes to the differences between the countries, Americans generally seemed to believe less in climate change and that humans are responsible for the changes, compared to Chinese and Swedes. Americans were also more pessimistic in the sense that a larger share of them (around 17%, compared to 10% in China and 6% in Sweden) believed that climate change is inevitable, and that we can do nothing to stop it.

We also found clear differences in the WTP between the countries, rejecting the hypothesis of equal WTP (for a given level of CO<sub>2</sub> reduction) among all the countries. Sweden had the highest WTP and China the lowest. The WTP in Sweden was between 4 and 4.5 times higher than the WTP in China for a 30% reduction. The difference between Sweden and the United States was smaller; the WTP was around 30–60% higher in Sweden. This is largely explained by the larger fraction of U.S. respondents with zero WTP. In the United States, 24% of the subjects said that they were not willing to pay anything for reducing emissions by 85%, while in Sweden the share of subjects was 8%. On the other hand, controlling for income differences between the countries by comparing WTP as a share of household income, we found that respondents in the United States and China were willing to give up about the same percentage of their income for all levels of reduction. The Swedes' willingness to pay as a fraction of income was higher. In comparing WTP for even greater CO<sub>2</sub> reductions, we noted that marginal WTP fell, as expected from theory.

Even if the attitudes of Swedish and Chinese respondents are more similar than the U.S. respondents' attitudes, there are striking similarities between the countries when it comes to the correlation between climate attitudes and WTP. For example, respondents who believed that humans are affecting the climate were 13%–38% more likely to have a positive WTP, irrespective of country of residence. On the other hand, there were large differences between the countries with respect to the relationship between characteristics of the respondents and the willingness to pay for reducing greenhouse gas emissions.

These findings have important policy implications. This study provides insight into how costs could be distributed so that countries—with different attitudes toward climate change and sociodemographic characteristics—contribute the share that they are willing to pay. The results of this study show that Swedes, Americans, and Chinese are willing to pay 1.6%, 1.1%, and 0.9%, respectively, of their income to prevent a warming of more than 2°F. A policy interpretation is that this is an estimate of the cost burden, as a percent of gross domestic product (GDP), of climate change mitigation that each country is willing to bear. Since the American respondents are more suspicious about climate change in general and more pessimistic about possibilities to reduce CO<sub>2</sub> emissions, changing attitudes about the legitimacy of climate change and the threats it imposes may be key to unlocking public willingness to support major

expenditures for mitigation. Perhaps the biggest surprise in our study was the willingness of the Chinese people to pay for CO<sub>2</sub> mitigation as a fraction of income that was very similar to that in the United States.

Comparing our estimates to other estimates of costs or benefits is difficult. One of the few global studies that gives comparable figures is *The Stern Review* (2007). It suggests that the annual cost of cutting total greenhouse gases to about 25% of current levels by 2050, consistent with a 550 ppm CO<sub>2</sub> stabilization level, will be in the range of -1.0 to +3.5% of GDP, with an average estimate of approximately 1%. At the same time, *The Stern Review* claims that the expected benefits of avoiding climate change are several times larger (at least on the order of 5% of global GDP). Our estimates show that the willingness to pay, stated in China, United States, and Sweden, is near the lower end of this cost estimate and considerably lower than its benefit estimates.

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## Appendix

**Table A1 Monthly Household WTP in PPP Dollars (Unweighted Averages)**

	Sweden (1230 obs.)			United States (999 obs.)			China (1264 obs.)		
	<i>Mean</i>	<i>Std.dev.</i>	<i>Share of inc.</i>	<i>Mean</i>	<i>Std.dev.</i>	<i>Share of inc.</i>	<i>Mean</i>	<i>Std.dev.</i>	<i>Share of inc.</i>
30% reduction	\$23.08	40.68	0.007	\$17.27	43.69	0.005	\$5.81	9.01	0.005
60% reduction	\$43.87	83.15	0.013	\$27.95	64.13	0.008	\$9.81	16.49	0.008
85% reduction	\$61.01	133.23	0.018	\$36.43	86.69	0.011	\$13.52	24.97	0.011

Note: PPP = purchasing power parity; obs. = observations; inc. = income.