

Institute *for* Policy Integrity
New York University School of Law



Economists and Climate Change

Consensus and Open Questions

J. Scott Holladay
Jonathan Horne
Jason A Schwartz

Policy Brief No. 5
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Contents

Foreword	v
Executive Summary	vii
Why Survey Economists?	1
Survey Design	7
Results	11
Conclusion	23
Notes	25
Appendix	33

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Foreword

There is considerable agreement among scientists who study the climate that human actions, primarily the burning of fossil fuels, are contributing to climate change on a global scale. After decades of research, collaboration through the Intergovernmental Panel on Climate Change, and efforts to communicate complex research findings to the general public, the scientific consensus on the need for action to reduce greenhouse gases is widely accepted.

Less well known is whether a similar consensus exists among the economists who study climate change regarding the likely impacts of greenhouse gases on the economy. Widespread media reports about the costs of climate change legislation may lead a casual observer to suppose that many economists would be opposed to climate change policy, or would attribute relatively little economic risk to greenhouse gas emissions. This important Policy Brief by J. Scott Holladay, Jonathan Horne, and Jason A Schwartz begins to investigate that intuition. By surveying top experts in the field, they seek to find out if there is widespread agreement among economists on some of the key questions raised by climate change policy.

The results are striking. There is a strong consensus among the top economic experts that, in fact, climate change represents a real danger to important sectors of the U.S. and global economies. Moreover, most believe that the significant benefits from curbing greenhouse gas emissions would justify the costs of action. The majority of top economists surveyed feel that the United States should reduce domestic emissions regardless of the actions of other countries. They strongly support market-based schemes for reducing emissions, such as a carbon tax or a cap-and-trade approach. There

is also agreement that if a cap-and-trade system is established, the emissions allowances should be auctioned rather than distributed for free. There is near unanimity among respondents that pricing carbon—whether done through a tax or cap-and-trade program—will create incentives to invest more in energy efficiency and cleaner energy production.

There are also areas of disagreement. In particular, how to account for the responsibility of current generations for future generations remains a difficult question, with respondents nearly evenly split between approaches; a significant amount would prefer to address the question through moral inquires rather than the exclusive use of economic models. Similarly, when it came to assigning specific numbers—such as quantifying the extent of the harm or domestic versus global impacts—there was wide variation.

But overall, a clear picture emerges from the results: There is broad consensus among top economists with expertise in climate change that greenhouse gas emissions pose a real economic threat, and that steps taken to reduce emissions, if done right, can produce net benefits. While there will always be room for debate on specific questions, this Policy Brief can help us focus on the right questions to ask.

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Executive Summary

The Institute for Policy Integrity surveyed a group of the top economic experts on climate change to solicit their views on several key questions that affect climate change policy. The pool of economists was selected by searching the top twenty-five economics journals over the past fifteen years and identifying all articles related to climate change. The roughly 300 authors of those articles were contacted and sent a survey, and more than half replied. The results showed surprising consensus on some questions, but continued debate on others.

The results were:

- 84% of respondents agreed or strongly agreed that “the environmental effects of greenhouse gas emissions, as described by leading scientific experts, create significant risks to important sectors of the United States and global economies.”
- 75% agreed or strongly agreed that “uncertainty associated with the environmental and economic effects of greenhouse gas emissions increases the value of emission controls, assuming some level of risk-aversion.”
- Agriculture was the domestic economic sector most identified as “likely to be negatively affected by climate change,” with 86% of respondents selecting this sector.
- 91.6% preferred or strongly preferred “market-based mechanisms, such as a carbon tax or cap-and-trade system” over command-and-control regulation to reduce greenhouse gas emissions.
- 80.6% preferred auctioning carbon allowances rather than freely distributing allowances.
- 97.9% agreed or strongly agreed that “placing a ‘price on carbon’ through a tax or cap-and-trade system will increase incentives for energy efficiency and the development of lower-carbon energy production.”

- 57% agreed that the U.S. government should commit to greenhouse gas reductions “regardless of the actions of other countries,” while an additional 15.5% agreed that it should do so “if it can enter a multilateral emissions reduction treaty with some countries,” and 21.8% agreed the U.S. should move forward “if other major emitters commit to reducing emissions through a global treaty.” Only 0.7% would wait until all countries commit to action, and 2.1% thought the U.S. should not act regardless of the actions of other countries.
- 92.3% agreed or strongly agreed that “most of the environmental and economic effects of greenhouse gas emissions will be felt by future generations.”
- 37.5% responded that “benefits to future generations” should be evaluated “by discounting them at a constant discount rate,” while 36.8% stated that they should be evaluated “by using alternative discounting methodologies (such as hyperbolic discounting),” and 16.7% stated that they should be evaluated “by reference to moral inquiries unrelated to discounting.”
- The median value for a discount rate used to evaluate impacts on future generations, if discounting was to be used, was 2.4%, but there was wide variation, suggesting that there is no clear consensus.
- The median social cost of carbon estimate was \$50, but there was very wide variation, suggesting that there is no clear consensus on the exact extent of the harm created by each unit of greenhouse gas emissions.

Why Survey Economists?

Choosing to survey expert economists on climate change raises the questions: Do economists have a useful perspective to add on climate change; is the consensus view of expert economists valuable; and has anyone ever surveyed economists on climate change before?

The Role of Economics on Climate Change

More often than not, when economics enters the U.S. debate on climate change, it is in the context of analyzing only the potential costs—and not the benefits—of various policy options.¹ For example, when Congress asked the Environmental Protection Agency, the Department of Energy, and its own Congressional Budget Office to investigate the economic impacts of legislative proposals, none of the resulting reports included any significant discussion of the benefits of implementing policies to reduce greenhouse gas emissions, much less quantified estimates.²

But in fact, economics offers a crucial perspective not only on the most cost-effective and efficient responses to climate change, but also on the need to respond in the first place. Economists have built sophisticated “integrated assessment models” that combine complex data on the global economy and climate, in order to estimate the economic consequences of a particular policy. A necessary first step in that process is to project what would happen if no policy were enacted (called a “baseline” or “business-as-usual” scenario). In other words, economists have devoted considerable effort to identifying and quantifying the dangers of unabated climate change.

As a result, many economists have become experts on key issues such as:

- The speed, severity, and global distribution of climate change's myriad potential effects on the economy, public health, the environment, and national security;
- The nature of low-probability climate risks with catastrophic, irreversible consequences;
- The interaction of potential international responses to climate change; and
- The costs and benefits to future generations, as weighed alongside the costs and benefits to current generations.

These issues are all central to the debate on climate change that continues in the halls of Congress and across the United States. Yet economists are seldom consulted by Congress or the media on the overall need for action, or on how aggressively the United States should act. Even on the questions more frequently asked of economists—like the lowest-cost strategy for cutting emissions—the consensus answer of economists is not well understood.³ This Policy Brief tries to reassert economics as a valuable tool for analyzing all aspects of climate policy: the benefits as well as the costs.

The Value of Expert Consensus

The consensus view of experts has tremendous influence on both public opinion and policymakers. The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations to provide the world with a clear, consensus-based, scientific view on the current understanding of climate change and its consequences.⁴ Through a deliberative review process, thousands of climate experts from across the globe assess the most recent scientific, technical, and socio-economic information, and then synthesize their findings.⁵ IPCC's 2007 Synthesis Report was "unequivocal" in declaring that the globe has warmed; that observed climate change is largely anthropogenic; and that twenty-first century climate change will be considerably more pronounced than what we have seen so far.⁶ IPCC's findings have been repeatedly cited by Congress in recent legislative proposals as a chief reason to take action,⁷ and some

evidence suggests the work of IPCC has also moved public opinion on climate change.⁸

IPCC does review the research of economists and also solicits their expertise to help develop the consensus viewpoint. In particular, economists participate in the Working Group on “Impacts, Adaptation, and Vulnerability,”⁹ which has explored the consensus view on such economic topics as “the social cost of carbon” (a figure that quantifies the marginal damage from each additional ton of greenhouse gas emissions).¹⁰

However, there are drawbacks to the deliberative process used by IPCC to identify consensus. Group deliberations can lead to “groupthink,” which can cause the results of deliberation to suffer from censorship and uniformity.¹¹ Indeed, IPCC has been criticized for being *too* consensual: some argue that it moves too slowly and adopts only the “lowest-common denominator” conclusions, leading to overly conservative results that ignore more up-to-date viewpoints.¹² In fact, actual temperature increases in recent years have tracked the high end of IPCC’s projections.¹³ In other words, IPCC has tended to underestimate the rate of climate change, and the results of its deliberative process perhaps only indicate the minimal consensus in the scientific community—the *least* we can expect.¹⁴

Besides deliberation, an alternate method for identifying the consensus opinion of experts is to use surveys and find a group’s “statistical” or average answer.¹⁵ Well-developed theories on “the wisdom of crowds” explain why the average answer from a group is likely to be more accurate than most individuals in that group, and why large groups do better than small groups.¹⁶ For example, statistical groups of experts have been shown to significantly outperform individual experts on predicting such uncertain (and climate change-related) quantities as the annual peak rainfall runoff of various countries or changes in the U.S. economy.¹⁷ By comparison, deliberating groups only tend to do about as well as their average members on making accurate predictions, and not as well as their best members.¹⁸

Surveys and statistics are also better at revealing the full range of opinions in a group. Deliberation tends to reduce variance, since deliberations can amplify cognitive errors and overemphasize common knowledge, causing a group to converge on a common—

though not necessarily accurate—answer.¹⁹ By showing the diversity of opinion, surveys can indicate where debate still exists on an issue and where a consensus might emerge in the future.

Surveys and statistics have been used successfully to confirm that a consensus on climate change exists among earth scientists. For example, in 2008, Peter Doran and Maggie Kendall Zimmerman polled 3,146 earth scientists on their beliefs about climate change: 90% stated that temperatures had risen since the 1800s, and 82% felt anthropogenic emissions were a significant factor; respondents with specific expertise on the climate were even more adamant, showing nearly unanimous support for both propositions.²⁰

A survey of economists with expertise on climate change could similarly confirm that a consensus exists on certain key issues, and could also help define the nature and significance of any remaining areas of disagreement or uncertainty. All that information could be extremely valuable as the United States continues to craft its climate policies.

The Need for a Comprehensive Survey

Three general types of economist surveys have been conducted on climate change, but none sufficiently or definitively describe areas of consensus or disagreement.

First, “surveys” of the economics literature on climate change are completed both when bodies like IPCC review the latest research and when meta-analyses are conducted on specific questions. For example, economists like Richard Tol have “surveyed” the literature on the social cost of carbon through meta-analysis, averaging out a collection of individual estimates to generate a value that could be thought to represent a consensus.²¹ Such studies make an incredibly important contribution to our understanding of what economists are thinking, but because they are time intensive, they often are infrequently updated and typically cover only one of many important economic issues.

Second, some short, informal polls have been conducted, typically via the internet. For example, John Whitehead and Tim Habb have hosted opinion polls on their *Environmental Economics* weblog.²² In a survey conducted June-July 2009, Whitehead and Habb asked whether respondents would prefer a carbon tax or a cap-and-trade

method (of 203 results, 55% preferred a tax, and 35% preferred cap-and-trade). Their survey was e-mailed out to 1,133 economists, and was also posted online (respondents were asked to identify themselves as economists). Such open, web-based surveys are interesting, but they are subject to respondent bias. Economists with strong opinions on climate change may be more likely to respond, potentially skewing the results. Moreover, by tending to focus on only one issue at a time, such surveys cannot reveal interesting correlations between answers on a series of questions.

Finally, and most importantly, the U.S. Government Accountability Office (GAO) conducted a thorough and formal survey of 18 leading economists in 2007-2008.²³ Some of GAO's key findings include:

- 100% of GAO's panelists thought Congress should implement a market-based mechanism to control emissions and place a price on carbon; a majority preferred at least partial auctioning of allowances under a cap-and-trade system.
- 89% of GAO's panelists felt the United States should act as soon as possible, regardless of actions taken by other countries.
- 78% of GAO's panelists felt moderately certain that the benefits of action would outweigh costs.
- 78% of GAO's panelists felt the price set on carbon dioxide emissions (which, ideally, should be equal to the damages imposed by emissions) should be under \$20 per ton; only 17% felt the price should be over \$20.²⁴
- GAO's panelists felt that avoiding damages like flooding, species loss, and health effects would be the most important benefit of action; reducing the risk of extreme, irreversible events was the second-most important benefit of action.
- GAO's panelists said the choice of a discount rate was the most important assumption underlying their economic models; panelists identified ideal discount rates in the range of 0-5%.

These are notable results, and this Policy Brief attempts to build on them, improving accuracy and credibility. To begin, GAO's survey

was conducted principally from July to November of 2007, making its results over two years old.²⁵ Our scientific understanding of climate change continues to improve at a rapid pace,²⁶ and two-year-old data is certainly already in need of an update.

A more significant shortcoming was that GAO chose to survey only 18 experts (25 were initially contacted), all selected in part for their affiliation with U.S.-based institutions.²⁷ The statistical answers of small groups are not as robust as those of larger groups.²⁸ Similarly, by focusing on a few, U.S.-affiliated economists, GAO's survey was not representative of the wide variety of opinions that may exist among expert economists worldwide. Also, despite the application and disclosure of some general selection criteria,²⁹ ultimately it is unclear why these economists and not others were chosen, which reduces the transparency and repeatability of the survey.

The small sample size could be especially important where—as in this case—respondents are known to each other and often work closely together. The theory of statistical answers assumes that the chance any one group member is wrong is statistically unrelated to the chance that other group members are wrong; but where respondents know each other, work together, and may think alike, this assumption may no longer hold true.³⁰

Finally, the particular survey method utilized by GAO replicates some of the problematic features of a deliberative model. GAO used a modified “Delphi method,” consisting of two rounds of online questionnaires.³¹ This methodology generally represents an improvement on typical deliberative approaches.³² But, as GAO readily admits, “this approach allowed for the panelists to reevaluate their original responses in light of the responses of the whole group.”³³ Such a methodology could increase the potential for error-producing effects like “anchors” or other symptoms of deliberative group dynamics.

In short, GAO demonstrated the value that an economist survey can add to the climate change debate. This Policy Brief tries to take the next step toward uncovering the consensus view of economists on climate change.

Survey Design

We surveyed 289 of the world's expert economists with expertise on climate change. We sent them a focused survey of 12 questions designed both to elicit consensus findings and to identify areas of disagreement. We received 144 completed surveys, for a response rate of nearly 50%.

Designing a Focused Survey

The questions were designed to accomplish three purposes. First, they were designed to elicit consensus findings: questions falling within economists' competence on which there is widespread agreement. Second, they were designed to identify areas where economists do not agree. In these areas, debate is ongoing, and the economic profession as a whole cannot yet give a consensus answer. Third, the survey was designed to elicit a range of economically "acceptable" answers for certain values: that is, while the survey cannot give a single answer, it can lay out ranges of answers.

We surveyed economists on the following topics:

- the qualitative and quantitative risks of climate change to the U.S. and global economies (questions 1-2, 8-9);
- the distribution of the burden of climate change on future generations versus current generations, and how best to account for that difference (questions 3, 10, and 11);
- the effect of uncertainty about climate change on the valuation of mitigation efforts (question 4);
- the design of emissions control mechanisms (questions 5-7);
and

- whether the United States’s commitment to emissions reductions should depend on other countries’ actions (question 12).

The full text of the survey is included as an appendix to this document.

Prior to distributing the survey, we conducted a series of internal and external tests, to help ensure the questions were unambiguous, and we made several changes to both content and format to improve the questions’ clarity.

Nevertheless, several respondents expressed concerns about the survey. The first concern was that the questions were too focused on the United States. As one economist who refused to participate put it, “you are not picking up the bigger picture” of the impacts of climate change on other economies. Several respondents argued that the questions were too simple to accurately capture the complexity of climate change or that specific questions could not be answered. When asked about the social cost of carbon, one respondent replied: “No one knows, including me.” These responses reflect the great deal of uncertainty regarding some of the issues considered in this survey. There was also concern that the wording of our questions was too conservative and would lead us to the false conclusion—based purely on “the way the questions are written”—that “economists say climate change is not a problem.” While we appreciate and acknowledge such concerns, we believe the results of our survey are valid and useful.

Selection of Respondents

We were careful to identify a pool of potential respondents broad enough to produce robust results that represented the full range of viewpoints, but also focused enough to include only true experts on the economics of climate change. We started by compiling a list of economists who had published an article relating to climate change, broadly defined,³⁴ in a leading economics publication in the last fifteen years. We defined leading publications as publications ranking in the top twenty-five economics journals.³⁵ We conducted a thorough search of each journal for articles that, as evident from their titles and abstracts, significantly discussed the benefits, costs, or uncertainties of climate policies; applied or criticized a climate

model; or explored the costs of climate change as relevant to the economics of energy, natural resources, agriculture, and other disciplines. The papers published by the economists in our sample tended to be extremely academic and concerned with details of economic theory or statistical models; they were not political pieces, and they cannot be easily classified as advocating either for or against climate change legislation.

Our literature review initially revealed 312 authors who fit our selection criteria. Some of the experts we identified were later removed from our list of potential respondents, as some authors had died since publication of their work, and some could not be located. In addition, we excluded respondents who affirmatively rejected identification as economists, or who stated that they no longer worked in the area. With these authors removed, the total pool of experts was 289.³⁶

We feel confident that the authors identified are experts in economics related to climate change, and also are representative of a range of opinions. For example, economists receiving the survey included both authors who proposed an economic model that predicted a potentially positive effect on global agriculture from climate change, as well as authors who subsequently criticized that model and approach.³⁷ In other words, our pool of potential respondents included experts on both sides of important debates.

Nearly half of the experts we identified (131 authors out of 289 total) had been published only in the 25th-ranked economics journal, the *Journal of Environmental Economic Management* ("JEEM"), which is a specialist environmental publication. In order to ensure the large number of authors published in a single journal would not skew results, we separated respondents into those who qualified because of a publication in the top 24 journals ("Category 1") and those who qualified because of a publication in JEEM ("Category 2"). Economists who had published in multiple journals including JEEM were placed in Category 1. When we later compared the results from the two groups, we found that the two populations did not differ markedly.³⁸

Survey Administration

We administered the survey online using Google Forms, soliciting responses from Category 1 and Category 2 separately; responses from the two categories were segregated. Respondents were initially contacted by e-mail, informing them of the reason for their selection and purpose of the survey, and asking them to complete the survey. The survey included twelve questions and took about five minutes to complete. Respondents were assured that individual answers would remain confidential, and the survey did not include any identifying information that would allow us to track which respondents left a particular answer, or even if a given economist in the sample responded to the survey. Thus, all follow-up communications (such as calls and reminder e-mails) were sent to everyone in the sample, even those who might have already responded.

Because the survey concentrated on a carefully targeted, high-quality population, we were able to take advantage of the small sample size and boost our response rate. We expended a great deal of effort to find the individuals in our target population, share the questionnaire with them, and encourage them to complete the survey. After the survey had been in the field one week, we contacted everyone in the sample by phone and also sent a reminder e-mail.

The survey was sent to 289 economists in total, of which 144 responded, generating a 49.8% response rate. (The response rate for Category 1 was 56.5%, and the response rate for Category 2 was 44.3%.) This strong response rate is likely a function of our efforts to identify and target a select sample of experts, as well as our use of follow-up communications. The margin of error was relatively small, with no margin of error greater than .5%.³⁹ In addition, the high response rate helps reduce concerns about respondent bias.⁴⁰

Results

The survey found consensus on several key questions:

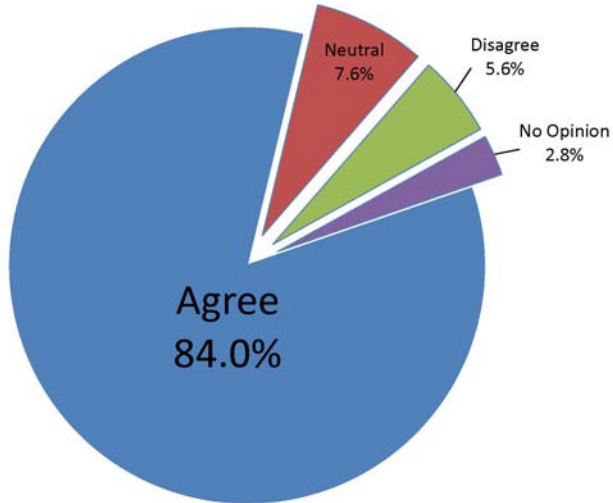
- Climate change poses risks to the U.S. and global economies;
- Several domestic economic sectors, most notably agriculture, will be negatively affected;
- Uncertainty about climate change increases the value of action;
- The United States should adopt market-based mechanisms for reducing emissions, those mechanisms will create incentives for efficiency and clean energy, and allowances should be auctioned rather than given away; and
- The United States should join a global regime to reduce emissions, with a majority of economists saying the United States should commit to emissions reductions regardless of other countries' actions.

The survey also found that there is no consensus that the future costs and benefits of climate change policy should be discounted at a constant rate, with an equal number saying that alternative discount methodologies should be used, and a significant percentage stating that alternative moral inquires were the most appropriate way to approach intergenerational questions.

Economic Risks and Uncertainties

Economists overwhelmingly agreed that, based on the most recent scientific opinion, climate change presents “significant risks to important sectors in the U.S. and global economy.”⁴¹ These results

show that most expert economists believe that climate change presents a clear danger, despite lingering uncertainties regarding the exact speed and severity of global warming.



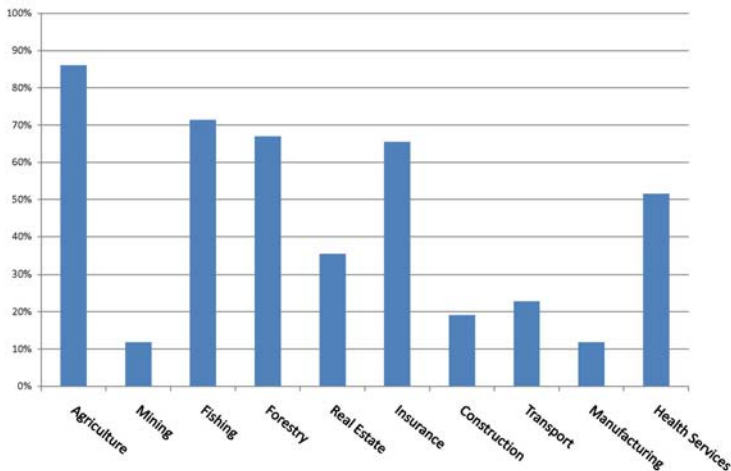
The environmental effects of greenhouse gas emissions, as described by leading scientific experts, create significant risks to important sectors of the United States and global economy.

Three quarters of respondents also felt that the uncertainty regarding climate change *increases* the value of taking action to control emissions.⁴² Many scientists and economists believe that climate change carries the risk of certain events that—even though they have a low probability of occurring—would impose catastrophic costs if they come to pass. For example, there may be certain temperature “tipping points,” when the environmental consequences of global warming will themselves begin to reinforce climate change. Polar ice currently reflects heat away from the planet’s surface; if that ice melts as temperature rises, more heat will be absorbed by newly exposed land and water, thereby dramatically speeding up global warming.⁴³ Such consequences would be irreversible over relevant time scales. When consequences are irreversible, there is a value to preserving options in the face of uncertainty, and theory predicts rational actors will be willing to pay a premium to preserve the option to avoid an irreversible, catastrophic mistake.⁴⁴ Our survey confirms that most expert

economists do believe that uncertainty about the speed and severity of climate change increases the value of precautionary actions.

Even respondents who did not agree that climate change presented economic risks felt the uncertainty increased the value of regulation. 43% of respondents who agree, disagreed, or were neutral about the risks of climate change all agreed that uncertainty increased the value of controls. However, while 34% of those who thought climate change was a threat *strongly* agreed that uncertainty increased the value of controls, only 22% of those who did not believe climate change posed a risk *strongly* agreed that uncertainty increased the value of controls.

Impact on Economic Sectors



The following domestic economic sectors are likely to be negatively affected by climate change.

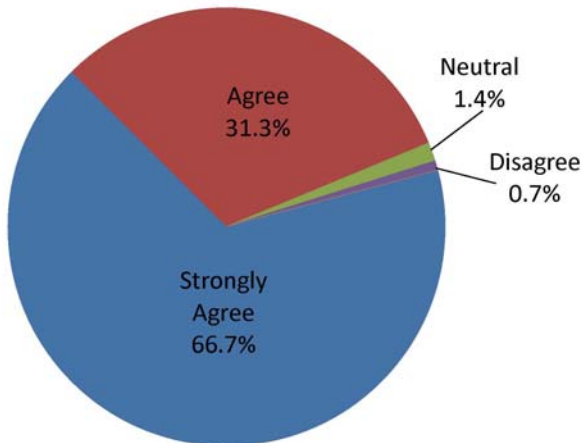
With regard to the effects of climate change on specific economic sectors, questions about agriculture have been of particular interest to decisionmakers. Some have argued that climate change will help—or at least not hurt—the U.S. agricultural sector,⁴⁵ and several Senators have criticized legislative proposals on climate change because they feel U.S. agriculture might have more to gain under climate change than under cap-and-trade legislation.⁴⁶ However, when asked, 86% of respondent economists thought agriculture is at risk from climate change.

The responses indicate that expert economists believe that the damages from climate change could be concentrated in a few economic sectors, but those sectors make up a significant fraction of the total U.S. economy.⁴⁷

U.S. Policy Design and International Coordination

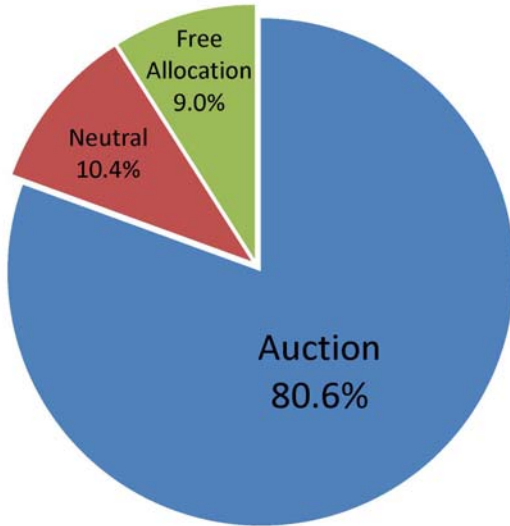
Expert economists nearly unanimously agreed that placing a tax on greenhouse gas emissions or capping them will encourage energy efficiency and clean energy development. 98% of respondent economists believed that pricing carbon will lead to increased incentives for “energy efficiency and the development of lower-carbon energy production,” with 67% strongly agreeing. That illustrates the strong consensus around the “textbook” intuition that an efficient tool to combat damages from pollution is to price the damages into the market.

Placing a “price on carbon” through a tax or cap-and-trade system will increase incentives for energy efficiency and the development of lower-carbon energy production.



Nearly all respondents—92%—also agreed or strongly agreed that market-based mechanisms, as opposed to command-and-control approaches, are the preferred way to cut greenhouse gas emissions and place a price on carbon. As such, most economists would support the cap-and-trade structure proposed by the main legislative options now pending before Congress.

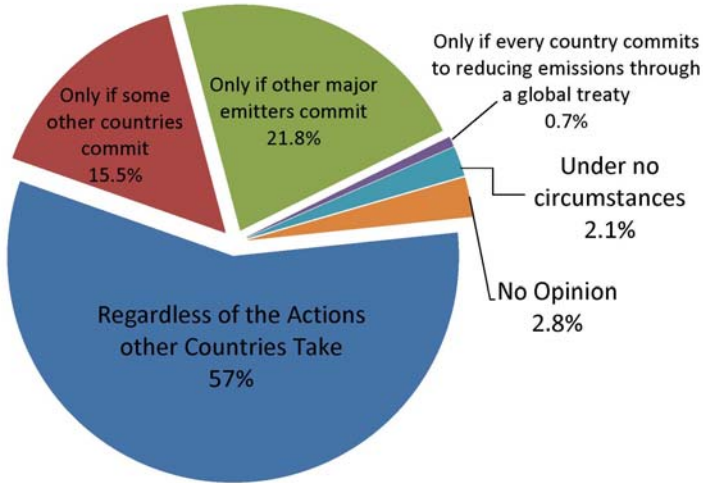
However, such legislative proposals plan to distribute the vast majority of emissions allowances for free, rather than through a system of auctioning. 81% of top economists disagreed with this choice; only 9% preferred or strongly preferred free allocation of permits. An auction is more efficient and more equitable than free allocations, since an auction can raise revenue, allowing Congress to distribute profits back to low- and middle-income consumers, to help offset increased energy costs.⁴⁸



Under a cap-and-trade system, is it preferable to auction permits and use the revenue to reduce inefficient taxes or compensate consumers, or to distribute allowances for free to regulated emitters?

Many leading U.S. decisionmakers, especially top Republicans, have suggested the United States should not take any decisive actions on climate change until all other countries are committed to similar actions.⁴⁹ 94.4% of economists would disagree. They believe that the United States should engage in emissions reductions at least if most other major emitting countries do as well. Only 1 respondent felt that the United States should wait for every emitter to sign on to a climate change treaty before reducing emissions. A strong majority agreed that that the United States should reduce reductions even if it must act alone.

The U.S. government should commit to reducing greenhouse gas emissions:



Cross-results correlations⁵⁰ further illustrate the beliefs on international coordination. Of those respondents who believed climate change represents a threat to the economy, 63.9% also felt that the United States should reduce emissions regardless of the actions of other countries. By comparison, of those who were not certain that climate change represented a threat to the economy, only 21.7% felt the United States should reduce emissions unilaterally. But even within that second group, a plurality (47.8%) felt the United States should reduce emissions if it could be done in concert with other major emitters.

The Social Cost of Carbon

The survey asked economists to estimate the monetary valuation of incremental damage from each ton of greenhouse gas emissions (also known as the social cost of carbon). Policymakers have spent considerable efforts lately trying to generate a uniform estimate for the social cost of carbon to use in rulemakings. Recently, a federal interagency panel suggested a preliminary range of estimates from \$5 to \$56 per ton of carbon dioxide, with a preferred value of \$20 (for year 2007 emissions).⁵¹

Our survey does not indicate a strong consensus on any single numerical estimate; instead, we can report on the “interquartile range” of responses. The interquartile range is the range from the first to third quartiles—in other words, from the 25th percentile to the 75th percentile. The interquartile range thus accounts for the middle half of answers. Such figures demonstrate not only the current diversity of opinions among experts, but also where consensus might possibly emerge in the future. Many economists expressed their uncertainty over this number by entering a range for the social cost of carbon. We chose the low end of the range given in each of those cases,⁵² meaning our statistics are conservative and can be treated as a lower bound for these economists’ opinions on the social cost of carbon.

The median response for the expert economists we surveyed was \$50. Fifty dollars was also the most common response (the “mode”) to the question. That value falls at the high end of the government’s interagency suggestions, and is more than twice the value preferred in recent federal rulemakings. In fact, 71.2% of respondents submitted estimates *greater than* the \$20 figure adopted by the Environmental Protection Agency, the Department of Energy, and the Department of Transportation in rulemakings this year. A recent Policy Integrity report estimated that the House climate legislation would be benefit-cost justified provided that the social cost of carbon is at least \$8.97.⁵³ More than 88% of respondents felt that the true social cost of carbon was greater than this breakeven point for congressional action.

The social cost of carbon is a controversial issue that economists continue to struggle with.⁵⁴ As such, it is not surprising that there was considerable dispersion among the responses to this question. The interquartile range is \$20 to \$100. A reasonable conclusion to draw from this information is that while there is some convergence around \$50 (which was the most common response and median response), the true social costs of carbon is more likely to be higher than lower. The social cost of carbon is an active area of research for economists and should be watched very closely, especially since economists might be expected to move their estimates in the direction of the high end of the range.⁵⁵

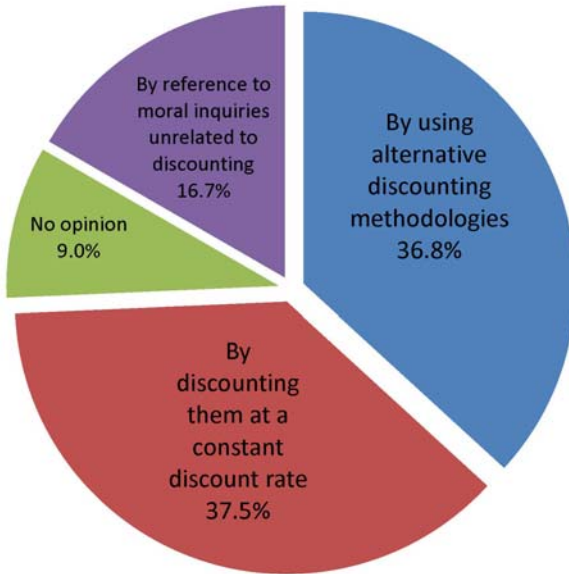
The average estimated social cost of carbon was over \$120,000, but that is highly sensitive to two outlier responses. One respondent answered \$10,000, and another submitted \$10,000,000. Those values are significantly larger than the next highest estimates. It is possible that the respondents mistyped their entries, that they misunderstood the question, or that these answers represent protest responses. We also calculate the statistics for this question after “trimming” those responses. This represents a conservative (downward) approach to compiling these responses. The average estimated social cost of carbon using only “trimmed” responses falls to \$107 (with a standard deviation of \$339). This still represents a tremendous range of responses and suggests a great deal of uncertainty regarding the exact level of damages generated by greenhouse gas emissions. Perhaps the response that best captures the uncertainty regarding the damages generated by greenhouse gas emission was: “No one knows, including me.”

Estimates on the social cost of carbon were also highly sensitive to beliefs about the likely economic effects of global warming. Among respondents who felt that climate change represented a threat to the U.S. economy, the median social cost of carbon response was \$50; the median estimate was only \$20 among those who did not believe climate change threatened the U.S. economy. (The median for the first group is the same as for the total sample because far more respondents found climate change to be a threat, and \$50 was a common answer). The range of responses was much wider for the first group than for the second.

All of the above estimates on the social cost of carbon represent global values. Greenhouse gases are global pollutants, meaning that damages are independent of where pollutants are emitted. Each ton of emissions abated generates benefits not just in the United States, but around the world. The survey asked what percentage of benefits from emissions reduction would accrue to the United States. The average response was 7.7%, and the median was 4%. These estimates are roughly consistent with numbers used by the interagency review on the social cost of carbon, which calculated a potential range of 2-11%, with a preferred value of around 6%.⁵⁶ Numbers in this range suggest that the United States will reap significant benefits from taking action on climate change, but that

international coordination is crucial. Given the global extent of the problem, each individual country has an incentive to “free ride” on the efforts of others—it is important for all countries to act to overcome this incentive or else appropriate controls will not be put in place.

Discounting and Future Generations



How should the benefits to future generations be evaluated?

Respondents strongly felt that most of the burdens of climate change will fall on future generations (92.3% agreed or strongly agreed). This suggests that the costs of reducing emissions will be faced today, but the benefits will largely accrue to future generations (i.e., the benefit of not suffering severe climate change). Economists are less sure how to deal with the cross-generational aspect of the climate change problem. The respondents were almost evenly divided between discounting methodologies, with some suggesting that discounting was not appropriate at all.

The group that believed discounting in some form was appropriate was split between traditional constant rate discounting and

alternative mechanisms, such as hyperbolic discounting. It was somewhat surprising that a sizeable minority of economists recommended using moral inquires rather than economic techniques to evaluate benefits and costs for future generations.⁵⁷ These results are at odds with the approach taken by several federal agencies in recent rulemakings, where constant rate discounting was given the most attention, and alternative means of accounting for obligations to future generations were not adequately discussed.⁵⁸

The survey also asked economists to assume that benefits accruing to future generations will be discounted at a constant rate, and then estimate the appropriate discount rate. The question was phrased to elicit answers even from the 17% of respondents who felt that any discount rate at all was inappropriate. Despite the question's phrasing, six economists still answered that the discount rate should be zero. The interquartile range of answers was 1.0% to 3.9%. Notably, this range (which is likely a conservative estimate of economists' true opinions) falls well below the 5% and 7% rates that federal agencies continue to use on policies relating to climate change—often, agencies make calculations using rates at 3%, 5%, and 7%, and present the multiple estimates alongside each other with equal weight.⁵⁹

There is still great uncertainty over what discount rate to use. The total range for the 102 respondents who answered the question was 0-12%, with a standard deviation of 2.5. This relatively large dispersion suggests consensus on discount rates has yet to emerge.

It is interesting to compare the discount rate responses by the type of discounting that respondents felt was appropriate.⁶⁰ The respondents who felt that discounting a constant rate was the correct way to evaluate benefits to future generations had an average discount rate of 3.8%. Those who responded that alternative discounting methodologies were more appropriate had an average discount rate of just 2.7%. The difference between these responses is statistically significant at the 5% level, suggesting there are real differences between these groups' opinions on the correct discount rate for evaluating future benefits. Of those who felt that the most reasonable way to evaluate future benefits was through moral inquiries the average discount rate was 1.1%.

Several economists refused to answer the discount rate question. The response rate varied somewhat by the response to the related question about the appropriate way to discount future benefits. Those who felt that discounting at a constant rate was most appropriate responded at an 82% rate, while those who felt that alternative techniques were more appropriate responded at a 68% rate. That difference may arise because of the difficulty of describing the alternative discount methodology the respondent had in mind. Because the group with a lower average discount rate also responded at a lower rate, the survey's estimate of the discount rate is likely an upper bound for the opinions of our respondents.

Category 1 versus Category 2

The results of the responses from economists who published their research in a general economics journal (Category 1) were calculated separately from those who published in an environmental economic journal (Category 2) to test for differences of opinions across these two groups. The results show that there is no statistical difference in the pattern of responses between the two groups. 81% of Category 1 respondents felt that climate change was likely to cause significant damages to sectors of the U.S. economy. Among Category 2 respondents, the corresponding figure was 87%. That difference is not statistically significant. Similarly the median estimate of the social cost of carbon is \$50 for the Category 1 economists and \$40 for the Category 2 economists. This \$10 difference is extremely small compared to the differences in estimates within the categories and is not statistically significant.⁶¹ The responses to the questions on the correct discount rate and the fraction of benefits from emissions abatement that accrue to the United States are similar. In no case is there a statistically significant difference in the responses of the two groups.

These cumulative results hide some differences between the groups. The authors who published in an environmental economics journal have stronger feelings about the dangers that climate change poses to the United State economy. 42% of the Category 1 economists agree with those concerns and 39% strongly agree. The pattern is reversed in Category 2: 36% of Category 2 economists agree with the statement and 52% strong agree. The pattern of Category 2 economists reporting stronger opinions holds for the question on the

impact of uncertainty on the need to address greenhouse gas emissions. Similarly, 62% of Category 2 economists believe that the United States should reduce emissions regardless of the actions of other countries. This percentage falls to 52% for Category 1 respondents.

The Category 2 respondents also hold stronger feelings regarding the energy efficiency benefits of placing a price on carbon. 63% of Category 1 respondents strongly agree that placing a price on carbon will generate incentives for energy efficiency, while 70% of Category 2 respondents strongly agreed with that sentiment. Category 2 respondents were somewhat less strongly in favor of using market-based incentives rather than command-and-control to reduce emissions. 57% of Category 1 economists strongly preferred market-based incentives while only 47% of Category 2 responded that way.

In summary, while there are no significant differences in the general answers provided by Category 1 and Category 2 respondents, Category 2 economists tended to hold stronger beliefs on climate change.

Conclusions

It often can take a surprising amount of time for expert opinion to be recognized by the media, and for it to filter through to influence decisionmakers and the public. For years after an overwhelming majority of climate scientists agreed that global warming was a real and dangerous phenomenon, news reports continued to present the issue as an ongoing, unresolved debate. In fact, in September 2009, the United Nations hosted a conference to discuss how the media has failed to translate scientific consensus into public awareness on climate change.⁶²

A similar communications breakdown also threatens to prevent the media, decisionmakers, and the public from understanding the economic consensus on climate change. For example:

- Even in an article reporting that most Americans support a cap-and-trade solution, the market-based design—favored by 92% of expert economists—was called “controversial.”⁶³
- Senators continue to debate whether climate change threatens the U.S. economy and U.S. agriculture,⁶⁴ even while over 80% of expert economists believe that global warming will have negative impacts on each.
- Congress has moved towards giving away most emissions allowances for free,⁶⁵ despite that over 80% of experts believe auctioning is the economically better choice.
- The American public still wonders whether we need more research before taking action,⁶⁶ perhaps unaware that three-fourths of expert economists believe the lingering

uncertainty about global warming's effects just increases the value of taking action now.

- Congress continues to fret about the economic consequences of acting without having the entire international community onboard,⁶⁷ while a strong majority of experts believe unilateral action is justified, and nearly all would support U.S. action in the context of some international agreement.
- Federal regulators utilize damage estimates on the low end of the range generated by expert opinion, and are out of step with the majority of economists who would either use alternatives to constant discounting or would not use discounting at all.⁶⁸

Economists certainly do not agree on everything when it comes to evaluating climate change and policy options. But even where areas of debate persist, a more accurate reporting of the range of opinions would benefit decisionmakers.

With time, the expert view will likely solidify and become more widely accepted. But on climate change, we might not have the luxury of time to let expert consensus slowly seep down and influence decisionmakers. The window for cost-effective options to mitigate global warming may be rapidly closing.⁶⁹ This Policy Brief demonstrates that economists have a lot to say about the costs and benefits of taking action on climate change; on many issues, experts are already speaking with one, clear voice. We hope the media, the government, and the public are listening.

Notes

¹ Even economists themselves sometimes do not see the value of their own work on estimating benefits. For example, in a recent report from the U.S. Government Accountability Office, a majority of economists said that “estimates of benefits [of reducing greenhouse gas emissions] [a]re only somewhat or moderately useful,” due to considerable uncertainties associated with potential future impacts of climate change. U.S. GOV’T ACCOUNTABILITY OFFICE, CLIMATE CHANGE: EXPERT OPINION ON THE ECONOMICS OF POLICY OPTIONS TO ADDRESS CLIMATE CHANGE 30 (2008). However, as this Policy Brief demonstrates, despite that uncertainty, economists do have a lot to contribute to discussions of the benefits of reducing greenhouse gas emissions.

² EPA, ANALYSIS OF THE AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009: APPENDIX 12 (2009), available at http://www.epa.gov/climatechange/economics/pdfs/HR2454_Analysis_Appendix.pdf (“None of the models used in this analysis currently represent the benefits of [climate change] abatement.”); ENERGY INFO. ADMIN., DEP’T OF ENERGY, ENERGY MARKET AND ECONOMIC IMPACTS OF H.R. 2454 (2009), available at [http://www.eia.doe.gov/oiaf/servicerpt/hr2454/pdf/sroiaf\(2009\)05.pdf](http://www.eia.doe.gov/oiaf/servicerpt/hr2454/pdf/sroiaf(2009)05.pdf); CONG. BUDGET OFFICE, COST ESTIMATE—H.R. 2454: AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009 (2009), available at <http://www.cbo.gov/ftpdocs/102xx/doc10262/hr2454.pdf>.

³ For example, a 2008 poll conducted by ABC News/Planet Green/Stanford University asked “If the United States does more than other countries to address global warming, do you think that would help the U.S. economy, hurt the U.S. economy, or have no effect?” About a third of respondents each thought the U.S. economy would be helped, hurt, and unaffected (33%, 32%, and 29%, respectively). See Polling Report, Environment Polls, <http://www.pollingreport.com/enviro.htm> (last visited Nov. 2, 2009). Similarly, a 2007 Newsweek/Princeton Survey poll asked whether the economic costs of taking action on climate change would be unacceptably high, not high, or high but worth the sacrifice: 17% thought the economic costs would be too high; 27% answered the costs would not be high; 42% thought the high costs would be justified; and 14% were unsure. *Id.*

⁴ See Intergovernmental Panel on Climate Change, Organization, <http://www.ipcc.ch/organization/organization.htm> (last visited Nov. 2, 2009).

⁵ See IPCC, PROCEDURES FOR THE PREPARATION, REVIEW, ACCEPTANCE, ADOPTION, APPROVAL AND PUBLICATION OF IPCC REPORTS (2003), *available at* <http://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles-appendix-a.pdf> (describing the review process); IPCC, Procedures, http://www.ipcc.ch/organization/organization_procedures.htm (last visited Nov. 2, 2009) (“Authors, contributors, reviewers and other experts are selected by the Bureau of the Working Group from a list of nominations received from governments and participating organizations. They can also be identified directly by the Bureau because of their special expertise reflected in their publications and works. The composition of lead author teams shall reflect a range of views, expertise and geographical representation.”).

⁶ IPCC, FOURTH ASSESSMENT REPORT: SUMMARY FOR POLICYMAKERS 2, *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

⁷ *E.g.*, H.R. 2454, 111th Cong., § 311 (2009); S. 2191, 110th Cong., § 2 (2007).

⁸ For example, according to a 2007 Newsweek/Princeton Survey poll, only 52% of respondents thought most climate scientists agreed that the earth has been warming, and only 47% thought most climate scientists agreed that human activities were a major cause of global warming; the rest thought there was a lot of disagreement, or were unsure. *See* Polling Report, *supra* note 3. But two months later, in October 2007, IPCC was awarded the Nobel Prize (with Al Gore). *See* Press Release, The Nobel Foundation, *The Nobel Peace Prize for 2007*, Oct. 12, 2007 (*available at* http://nobelprize.org/nobel_prizes/peace/laureates/2007/press.html). And in November 2007, IPCC released its latest synthesis report, declaring anthropogenic climate change was “unequivocal.” *See* IPCC, FOURTH ASSESSMENT REPORT, *supra* note 6. Though the coincidence of timing does not prove causation, more recent polls do indicate that while Americans remain uncertain about whether actions and regulations are warranted, fewer than 25% of Americans still believe global warming is a scientifically unproven theory. *See*, Polling Report, *supra* note 3 (reporting on a 2008 CNN/Opinion Research poll).

⁹ IPCC Working Group II, Invited Experts, <http://www.ipcc-wg2.gov/AR5/AR5%20documents/complet-1st%20venise%2016.7.09.pdf> (last visited Nov. 2, 2009) (listing participants in preparation for the Fifth Assessment Report, including over a dozen leading economists).

¹⁰ Gary Yohe et al., IPCC Working Group II, Climate Change 2007: Impacts, Adaptation, and Vulnerability 813, 821-24 (2007), *available at* <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter20.pdf> (discussing 100 estimates of the SCC).

¹¹ Cass R. Sunstein, *Group Judgments: Deliberations, Statistical Means, and Information Markets* 2 (John M. Olin Law & Economics Working Paper No. 219, 2004).

¹² *See* Bill McKibben, *Warning on Warming*, N.Y. REV. BOOKS, Mar. 15, 2007, *available at* <http://www.nybooks.com/articles/19981> (reviewing the IPCC Fourth Assessment Report).

¹³ *See, e.g.*, Stefan Rahmstorf et al., *Recent Climate Observations Compared to Projections*, 316 *Sci.* 709 (2007), *abstract available at* <http://www.sciencemag.org/cgi/content/abstract/sci;316/5825/709>.

¹⁴ Recently, the International Alliance of Research Universities (IARU), a prestigious body of research universities, convened to supplement IPCC's report with more up-to-date data. The conference had over 2,500 attendees, most of whom were researchers. The body's conclusions were grimmer than IPCC's: the best scientific evidence indicates that emissions and temperature rises are near the upper boundary of IPCC's models; and that temperature rises will have societal effects near the top of IPCC's estimates. In other words, as a predictive matter, IPCC's 2007 report was too conservative in its climate change estimates and in its estimates of climate change's impacts. IARU, *SYNTHESIS REPORT: CLIMATE CHANGE—GLOBAL RISKS, CHALLENGES & DECISIONS 5* (2009), available at <http://climatecongress.ku.dk/pdf/synthesisreport>.

¹⁵ Sunstein, *supra* note 11. Another promising approach, information markets, would be hard to implement for many of the economic questions we are interested in on climate change.

¹⁶ See *id.* at 7 (citing JAMES SUROWIECKI, *THE WISDOM OF CROWDS* (2004)). In particular, the Condorcet Jury Theorem states that the probability of a correct answer, by a majority of the group, increases toward certainty as the size of the group increases, if each individual person is more likely than not to be correct. "The theorem is based on some simple arithmetic. Suppose, for example, that there is a three person group, in which each member has a 67% probability of being right. The probability that a majority vote will produce the correct answer is 74%." *Id.* at 7 n.35. The theorem assumes that people will be unaffected by whether their votes will be decisive; that people will not be affected by one another's votes; and that the chance any one group member is wrong is statistically unrelated to the chance that other group members are wrong. This last assumption may be violated when members of groups have similar training and so think alike; but the theorem "has been shown to be robust to violations of the third assumption." *Id.* at 8.

¹⁷ See J. Scott Armstrong, *Combining Forecasts*, in *PRINCIPLES OF FORECASTING* 416, 428-31 (2001); but cf. Sunstein, *supra* note 11, at 11 n.44 (reporting that a group of law professors "did fairly well in estimating the weight of the horse who won the Kentucky Derby, fairly badly in estimating the number of lines in *Antigone*—and horrendously with the number of Supreme Court invalidations of state and federal law!").

¹⁸ *Id.* at 14 (citing Daniel Gigone & Reid Hastie, *Proper Analysis of the Accuracy of Group Judgments*, 121 *PSYCH. BULLETIN* 149 (1997)).

¹⁹ See generally *id.*

²⁰ Peter T. Doran & Maggie Kendall Zimmerman, *Examining the Scientific Consensus on Climate Change*, 90 *Eos* 22 (2009) (76 of 79 climate scientists answered that temperatures had risen, and 75 of 77 said anthropogenic emissions were a significant factor).

²¹ Richard Tol, *The Social Cost of Carbon: Trends, Outliers and Catastrophes*, *ECONOMICS* (2008), available at <http://www.economics-ejournal.org/economics/journalarticles/2008-25>.

²² John Whitehead, Environmental Economics, <http://www.env-econ.net/2009/07/all-environmental-economists-dont-strongly-favor-a-carbon-tax.html> (last visited Nov. 2, 2009).

²³ GAO, *supra* note 1.

²⁴ One panelist preferred pricing each greenhouse gas separately, as opposed to setting one collective price.

²⁵ GAO, *supra* note 1, at 45.

²⁶ See Energy Conservation Program: Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines, 74 Fed. Reg. 44913, 44947 (Aug. 31, 2009) (to be codified at 10 C.F.R. pt. 431) (discussing, in the context of a Department of Energy rulemaking that uses a new interagency estimate of the social cost of carbon, how “scientific and economic knowledge about the impacts of climate change continues to grow”).

²⁷ GAO, *supra* note 1, at 44.

²⁸ Sunstein, *supra* note 11, at 11 (“[I]f experts are available, it would make sense to obtain a statistical answer from them, rather than to select one *or a few*.”) (emphasis added).

²⁹ GAO, *supra* note 1, at 6, 44.

³⁰ See discussion and citations at *supra* note 16 (but note that the theorem has proven robust to violations of the third assumption).

³¹ GAO, *supra* note 1, at 6-7, 44-45.

³² See Sunstein, *supra* note 11, at 37-38.

³³ GAO, *supra* note 1, at 45.

³⁴ We defined climate change broadly to include any papers that had implications for the climate change debate, even if that was not their main focus.

³⁵ Kalaitzidakis et al., *Rankings of Academic Journals and Institutions in Economics*, 1 J. EURO. ECON. ASSOC. 1346 (2003).

³⁶ A full list of the final authors and articles is available by request.

³⁷ Specifically, the authors of the following articles were in our sample pool: Robert Mendelsohn, William D. Nordhaus, & Daigee Shaw, *The Impact of Global Warming on Agriculture: A Ricardian Analysis*, AM. ECON. REV., Sept. 1994, at 754; William R. Cline, *The Impact of Global Warming on Agriculture: Reply*, AM. ECON. REV., Dec. 1996, at 1309; John Quiggin & John K. Horowitz, *The Impact of Global Warming on Agriculture: A Ricardian Analysis: Comment*, AM. ECON. REV., Sept. 1999, at 1044.

³⁸ We conducted t-tests for difference in means for each of the questions (scoring categorical responses on a -2 to 2 scale). The differences were not statistically significant for any question. Question-by-question results for the two groups are available from the authors.

³⁹ The table below includes the margin of error for certain sets of responses included in this Policy Brief. All confidence intervals are available from the authors upon request. The confidence interval at the 95% level for a finite population was calculated using the formula in L. KISH, SURVEY SAMPLING (1965). The formula for

margin of error is: $1.960 * \sqrt{(p(1-p)/n)} * \sqrt{((N-n)/(N-1))}$. N=289, n varied between 142 and 144 depending on the question, p is the percent of people who fit in the response group described in the second column. The confidence interval is calculated by adding and subtracting the margin of error from the response percentage. Confidence intervals were:

Question	Response Group	Response Percentage	Margin of Error	Confidence Interval
Q1	(Agree + Strongly Agree)	84%	0.35%	83.6% - 84.4%
Q3	(Agree + Strongly Agree)	92.3%	0.26%	92.0% - 92.6%
Q4	(Agree + Strongly Agree)	75.0%	0.42%	74.6% - 75.4%
Q5	(Prefer + Strongly Prefer Market Based)	91.6%	0.27%	91.3% - 91.9%
Q6	(Prefer + Strongly Prefer Auctioning)	80.6%	0.38%	80.2% - 81.0%
Q7	(Agree + Strongly Agree)	98.0%	0.14%	97.9% - 98.1%
Q10	(By discounting them at a constant discount rate)	37.5%	0.47%	37.0% - 38.0%
Q12	(Regardless of the actions other countries take)	57.0%	0.49%	56.5%-57.5%

Question 2 allowed multiple responses and the results are tabulated separately:

Sector	Response Percentage	Margin of Error	Confidence Interval
Agriculture	86.0%	0.34%	85.7%-86.3%
Mining	11.8%	0.31%	11.5% - 12.1%
Fishing	71.3%	0.45%	70.9% - 71.7%
Forestry	66.9%	0.45%	66.4% - 67.4%
Real Estate	35.3%	0.47%	34.8% - 35.8%
Insurance	65.4%	0.46%	64.9% - 65.9%

Construction	19.1%	0.38%	18.7% - 19.5%
Transport	22.8%	0.41%	22.4% - 23.2%
Manufacturing	11.8%	0.31%	11.5% - 12.1%
Health Services	51.5%	0.48%	51.0% - 52.0%

These confidence intervals are not corrected for respondent bias. Because we did not keep identifying information, it was not possible to perform some traditional checks on respondent bias, such as screening for geological biases in response rates. However, we were able to compare “earlier responders” with “later responders” to determine if there were systematic differences between these two groups. We conducted t-tests for difference in means across each question. In no case were those differences statistically significant. We also tested for the differences in the intensity of feeling between early and late responders by comparing the number of respondents who answered “strongly” with their opinions. Early respondents had slightly stronger feelings, but again the differences were not statistically significant.

⁴⁰ Our response rate of nearly 50% was significantly above average for other web-based surveys. See Colleen Cook et al., *A Meta-Analysis of Response Rates in Web- or Internet-Based Surveys*, 60 EDUC. & PSYCH. MEASUREMENT 821, 829 (2000), available at <http://epm.sagepub.com/cgi/reprint/60/6/821> (reporting that the mean response rate of a meta-analysis of web surveys was 39.6%); see also *id.* at 821 (explaining that while “it is not necessarily true that representativeness increases monotonically with increasing response rate’ ...[n]evertheless, we remain concerned about our response rates if we are uncertain with regard to sample representativeness. We know that ultimately, if we capture all or almost all of the population, our samples must be representative.”).

⁴¹ Due to rounding, the numbers reported throughout this section may not sum to 100%. See the complete results summary for more detailed results.

⁴² The question asked respondents to assume some level of “risk aversion.” Risk aversion is a common behavioral phenomenon in which people faced with a choice select a lower average payout to avoid the risk of a particularly bad outcome. Because policymakers have shown a tendency to exhibit risk aversion, we asked the respondents to include it in their considerations.

⁴³ See Timothy M. Lenton et al., *Tipping Elements in the Earth’s Climate System*, 105 PROC. OF THE NAT’L ACAD. OF SCI. 1786 (2008).

⁴⁴ See Nicholas Stern, *The Economics of Climate Change*, AM. ECON. REV., May 2008, at 1, 17, available at <http://www.atypon-link.com/AEAP/doi/pdf/10.1257/aer.98.2.1> (explaining attitudes to risk); Letter from Michael Livermore, Executive Director of IPI, to Minerals Management Service, U.S. Dep’t of Interior (Apr. 6, 2009) (discussing the problems of irreversibility and uncertainty with respect to valuing offshore natural resources, and the need to incorporate an options value framework into the federal oil and gas leasing program).

⁴⁵ See, e.g., Ronald A. Fleming et al., *A Reassessment of the Economic Effects of Global Climate Change on U.S. Agriculture*, 30 *CLIMATIC CHANGE* 147, 167 (1995). Note that the authors' results depended on climate change increasing incomes for American farms by decreasing worldwide farm production and thereby raising food prices.

⁴⁶ See Jessica Leber, *Administration Officials Tout Cap-and-Trade's Benefits for Farmers*, *CLIMATEWIRE*, July 23, 2009 (noting Senators Saxby Chambliss, Mike Johanns, Blanche Lincoln, and Pat Roberts all criticized the Department of Agriculture's analysis that farmers would benefit under climate legislation).

⁴⁷ The sectors that over half of the respondents felt were in danger of being affected by climate change (agriculture, forestry, fishing, insurance, and health services) add up to over 10% of the U.S. economy, according to 2007 data from the U.S. Bureau of Economic Analysis (the most recent data available).

⁴⁸ See *Protecting Lower-Income Families While Fighting Global Warming: Hearing Before H. Subcomm. on Income Security and Family Support*, 111th Cong. (2009) (statement of Terry M. Dinan, Senior Advisor, Congressional Budget Office); *Policy Options to Prevent Climate Change: Hearing Before H. Comm. on Ways and Means*, 110th Cong., 8 (2008) (testimony of Dallas Burtraw, Senior Fellow, Resources for the Future); Dallas Burtraw et al., *The Incidence of U.S. Climate Policy: Where You Stand Depends on Where You Sit* 36 (Res. for the Future Discussion Paper No. 08-28, 2008), available at <http://www.rff.org/RFF/Documents/RFF-DP-08-28.pdf>.

⁴⁹ See, e.g., 155 Cong. Rec. S. 9649 (daily ed. Sept. 22, 2009) (statement of Sen. Inhofe) (asserting that the Senate will not accept any international agreement unless "China and other developing countries agree to mandatory emission cuts comparable to those required in America") (emphasis added); Senator George Voinovich, Speech at the CQ-Roll Call Climate Change Conference (Oct. 20, 2009) (opposing action by the United States on climate change until the "international community come[s] to the table...I am very concerned with the go-it-alone approach").

⁵⁰ It should be noted that some cross-correlations rely on generalizing from relatively small sets of data. In this case, only 11 respondents felt that climate change did not believe that climate change was a threat. The sample size should be kept in mind when analyzing these results.

⁵¹ See Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 74 Fed. Reg. 49454, 49680 (Sept. 28, 2009) (to be codified at 40 C.F.R. pts. 86, 600); Energy Conservation Program: Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines, 74 Fed. Reg. 44913, 44947 (Aug. 31, 2009) (to be codified at 10 C.F.R. pt. 431).

⁵² For each of the numerical questions we chose the most conservative end of the scale whenever a respondent entered a range. This means we chose the low end of the range for the social cost of carbon and percent of benefits to the United States questions, and the high end for the discount rate question. This ensures that our results are extremely conservative.

⁵³ J. SCOTT HOLLADAY & JASON A SCHWARTZ, *THE OTHER SIDE OF THE COIN: THE ECONOMIC BENEFITS OF CLIMATE CHANGE LEGISLATION 2* (2009), *available at* <http://www.policyintegrity.org/publications/documents/OtherSideoftheCoin.pdf>.

⁵⁴ *See* Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 74 Fed. Reg. 49454, 49680 (Sept. 28, 2009) (discussing “at least four caveats” on estimating the social cost of carbon).

⁵⁵ *See id.* at 49676 (citing IPCC’s conclusion that “It is *very likely* that globally aggregated figures underestimate the damage costs because they cannot include many non-quantifiable impacts”).

⁵⁶ *Id.* at 49612; Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines, 74 Fed. Reg. 44913, 44947 (Aug. 31, 2009) (to be codified at 10 C.F.R. pt. 431).

⁵⁷ There is a lively debate in the economic literature about discounting; the Stern Review spurred a new round of sparring. For a summary of the debate, with citations of various positions, see John Quiggin, *Stern and His Critics on Discounting and Climate Change*, 89 CLIMATE CHANGE 195 (2007).

⁵⁸ *See* Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 74 Fed. Reg. 49454, 49612-13 (Sept. 28, 2009) (acknowledging that “[t]he choice of a discount rate...raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law,” and exploring the use of hyperbolic discounting, but not seriously discussing the application of moral inquiries rather than economic techniques).

⁵⁹ *See generally id.* (using 3% and 5% rates for the calculation of the social cost of carbon, and using 3% and 7% rates for general discounting of costs and benefits relating to the climate policy); *id.* at 49477 n.57 (“The 3% and 5% estimates have independent appeal and at this time a clear preference for one over the other is not warranted.”).

⁶⁰ Another cross-results correlation suggests that those who do not think most of the burdens of climate change will fall on future generations tend to recommend a higher discount rate.

⁶¹ Using a t-test for difference in means, the hypothesis that these two groups have the same mean cannot be rejected at the ten percent level.

⁶² Press Release, United Nations Educational, Scientific, and Cultural Organization, Declaration for an Increased Public Awareness of Climate Change (Sept. 9, 2009), *available at* http://portal.unesco.org/ci/en/ev.php-URL_ID=29099&URL_DO=DO_TOPIC&URL_SECTION=201.html (discussing the International Conference on Broadcast Media and Climate Change).

⁶³ *Poll: Most Americans Back Obama’s Energy Policy*, ASSOC. PRESS, Aug. 28, 2009.

⁶⁴ *See supra* note 46.

⁶⁵ The House-passed climate legislation includes a significant number of free allowances, as does the current legislative proposal pending in the Senate.

⁶⁶ An October 2009 poll conducted by NBC News/Wall Street Journal found that 29% of the American public believes “[w]e don’t know enough about global climate change, and more research is necessary before we take any actions.” An additional 13% felt concern about global warming was unwarranted, and only 29% believed that research had established global warming as a serious problem demanding immediate action. *See* Polling Report, *supra* note 3.

⁶⁷ *See supra* note 49; *see also supra* note 3 (discussing public opinion on economic costs of unilateral action).

⁶⁸ *See supra* note 51-59 and accompanying text.

⁶⁹ *See* INIMAI M. CHETTIAR & JASON A SCHWARTZ, *THE ROAD AHEAD: EPA’S OPTIONS AND OBLIGATIONS FOR REGULATING GREENHOUSE GAS EMISSIONS 2* (2009).

