The Public Face of Science Across the World

Optimism and Innovation in an Era of Reservations and Inequality

Matthew C. Nisbet and Erik C. Nisbet

AMERICAN ACADEMY OF ARTS & SCIENCES

The Public Face of Science Across the World

Optimism and Innovation in an Era of Reservations and Inequality

Matthew C. Nisbet and Erik C. Nisbet

ISBN: 0-87724-127-9

This publication is available online at www.amacad.org/project/public-face-science.

Suggested citation: Matthew C. Nisbet and Erik C. Nisbet, *The Public Face of Science Across the World: Optimism and Innovation in an Era of Reservations and Inequality* (Cambridge, Mass.: American Academy of Arts and Sciences, 2019).

Cover image: A lab technician for the Kuwait Institute of Scientific Research holds up positive and negative tests for sulfate-reducing bacteria in water samples. Photograph by Dean Calma/ IAEA. Image used under Creative Commons Attribution 2.0 Generic (CC BY 2.0).

This paper is produced with support from the Rita Allen Foundation as part of the American Academy's project on The Public Face of Science. The statements made and views expressed in this publication are those held by the authors and do not necessarily represent the views of the Officers and Members of the American Academy of Arts and Sciences.

Please direct inquiries to:
American Academy of Arts & Sciences
136 Irving Street
Cambridge, MA 02138
Telephone: 617-576-5000
Fax: 617-576-5050
Email: aaas@amacad.org
Web: www.amacad.org

Contents

Tables

Figures

Introduction

In recent years, scientists and civil society leaders have grown increasingly worried about a pervasive “antiscientific” culture in the United States. Despite such fears, several long-standing public opinion trends offer reassurance to those alarmed about the cultural status of science and technology today. Since the 1970s, polls have indicated that the great majority of Americans voice confidence in the leadership of the scientific community, believing optimistically that the societal benefits of their work outweigh any harms or potential moral trade-offs. In contrast, during the same period, public confidence in almost every other major institution has plummeted. Americans have expressed similarly strong support for government funding of scientific research, recognizing the value of scientific activity to society.[1]

Yet fissures in public sentiment have always existed, as various opinion studies over the past twenty years have revealed, with new points of contention emerging recently. Both religious and secular Americans, for example, express reservations about the perceived conflict between scientific advances such as gene editing and moral values.[2] The Americans most optimistic about science and technology, according to other studies, come from wealthier and better educated backgrounds. For these optimists, scientific and technological innovation is likely to enhance their careers, fuel gains in their stock portfolios, and provide benefits that they can afford. In contrast, Americans of lower educational status and income levels tend to express greater reservations and ambivalence about science and technology. These Americans may be justifiably concerned that innovations may

1. John C. Besley, “The National Science Foundation’s Science and Technology Survey and Support for Science Funding, 2006–2014,” *Public Understanding of Science* 27 (1) (2018): 94–109; National Science Board, “Chapter 7. Science and Technology: Public Attitudes and Understanding,” in *Science & Engineering Indicators 2018* (Washington, D.C.: National Science Foundation, 2018), https://www.nsf.gov/statistics/2018/nsb20181/report/sections/science-and-technology-public-attitudes-and-understanding/highlights; and Matthew C. Nisbet, *Scientists in Civic Life: Facilitating Dialogue-Based Communication* (Washington, D.C.: American Association for the Advancement of Science, 2018), https://www.aaas.org/programs/dialogue-science-ethics-and-religion/resources-engaging-scientists-project.

2. Cary Funk, Brian Kennedy and Elizabeth Sciupac, *U.S. Public Wary of Biomedical Technologies to “Enhance” Human Abilities* (Washington, D.C.: Pew Research Center, 2016); Matthew C. Nisbet, “The Gene-Editing Conversation,” *American Scientist* 106 (1) (2018): 15–19; and Dietram A. Scheufele, Michael A. Xenos, Emily L. Howell, et al., “U.S. Attitudes on Human Genome Editing,” *Science* 357 (6351) (2017): 553–554.

displace their jobs, negatively impact their way of life, or remain beyond their ability to afford. Similar disparities by socioeconomic status are reflected in public consumption of science news, viewing of documentaries, and attendance at science museums and festivals.[3]

These fissures are by no means unique to the United States but are reflective of a rapidly changing world order in which scientific advances and technological innovations are intricately connected to debates over progress, inequality, democratic decision-making, authority, and respect for traditional values.[4] Only by systematically exploring commonalities and differences across nations can we begin to understand the unique processes by which globalization, cultural modernization, secularization, and inequality may be combining to influence public attitudes about science, technology, and society.

Summary of Main Findings

To address this gap in our current understanding, drawing on previously published research and survey findings, we reviewed the types of cross-national survey trends available for assessing beliefs about science and technology, including the major intellectual schools of thought about the factors that may account for differences between and within countries. Despite the attention that survey measures of science literacy receive, studies suggest that more consequential to opinion formation are individuals' mental models about science and society. These include beliefs about the promise of science and technology to improve society ("scientific optimism") and reservations about the impact of science and technology on traditional values and the speed of change ("scientific reservations"). Among the main observations put forward by scholars to explain differences in

3. John C. Besley, "Audiences for Science Communication in the United States," *Environmental Communication* 12 (8) (2018): 1005–1022; Funk et al., *Public Wary of Biomedical Technologies to "Enhance" Human Abilities*; Matthew Nisbet and Ezra M. Markowitz, "Understanding Public Opinion in Debates over Biomedical Research: Looking Beyond Political Partisanship to Focus on Beliefs about Science and Society," *PLOS One* 9 (2) (2014): e88473; Kristin K. Runge, Dominique Brossard, and Michael A. Xenos, "Protective Progressives to Distrustful Traditionalists: A Post Hoc Segmentation Method for Science Communication," *Environmental Communication* 12 (8) (2018): 1023–1045; Amy Mitchell, Jeffrey Gottfried, and Cary Funk, "Sciences News and Information Today," Pew Research Center Journalism and Media, September 20, 2017, https://www.journalism.org/2017/09/20/science-news-and-information-today; and Matthew Nisbet, "Ending the Crisis of Complacency in Science," *American Scientist* 105 (1) (2017): 18–22.

4. Julia Metag, Michaela Maier, Tobias Füchslin, et al., "Between Active Seekers and Non-Users: Segments of Science-Related Media Usage in Switzerland and Germany," *Environmental Communication* 12 (8) (2018): 1077–1094.

beliefs across countries is the "postindustrial paradox." In contrast to less-developed countries, citizens in more-advanced economies may no longer idealize science and technology as necessary to economic growth. These populations are still likely to expect benefits from science, but they may also be more sensitized to the moral trade-offs and risks posed by research.

A second, related line of scholarship does not focus on science and technology attitudes specifically, but rather on how such opinions are embedded within a broader process of cultural modernization that is taking place at different rates and in different ways across the world. Countries tend to differ by secular versus traditional values. For those countries with more-traditional values, it is likely that populations will express stronger scientific reservations. Countries also differ in terms of survival versus self-expression values. In developing countries with less security, populations may view scientific advances and technological innovation as necessary to survival, well-being, and prosperity, therefore expressing more optimism and fewer reservations. Specific to self-expression, populations living in advanced democracies not only may feel more conflicted about the benefits and trade-offs of science and technology, but their personal freedoms may make them more likely to express their reservations.

Building on these past insights, we present results from our analysis of the 2010–2014 World Values Survey, which comprises the most recently available data for assessing global science and society beliefs.[5] We evaluated the country-level and individual-level factors that shape public attitudes across fifty-four countries and eighty-one thousand survey respondents.

Consistent with the postindustrial paradox, our findings indicate that people living in post-Soviet and Eastern Bloc countries, Muslim-majority countries, and less-developed countries expressed comparatively greater levels of optimism and fewer reservations about science and technology. In contrast, those enjoying higher standards of living and greater political freedoms in more-developed countries tended to be less optimistic. Residents of wealthier countries also expressed greater reservations. But interestingly, after controlling for human, economic, and democratic development, people living in countries with greater scientific and technological development, as measured in terms of scientific publications, patents, and citations, tended to be more optimistic about science and technology. Whether such optimism creates a culture that drives scientific ambition and productivity or whether such outputs boost optimism is not a question we can answer with our data.

In terms of individual-level factors across countries, those who shared classical liberal values oriented toward the market, openness, free

5. Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

enterprise, free inquiry, and the pursuit of knowledge, networks, and information expressed higher levels of scientific optimism and fewer reservations. These scientific optimists tended to believe in economic competition and the importance of democracy; they were more likely to use and seek out information and connections via digital media; and they were more likely to express economic satisfaction, along with confidence in universities, business, and civil society groups like environmental nonprofits. In contrast, those who had greater confidence in religious institutions and who were more religiously devout scored lower on scientific optimism and higher on reservations. A similar pattern appeared among those who were more distrustful of various forms of societal authority, such as the state, nation, or family, and who were morally relativistic.

There were, however, important caveats and contingencies to these relationships based on the country-context in which individuals lived. For example, the least educated living in the richest countries tended to express much higher levels of scientific reservations than the least educated living in poorer countries. The former respondents may justifiably believe that they cannot afford or do not have access to medical advances or technological innovations; or they may fear that such innovations in areas like robotics or automation will disrupt their jobs and weaken their communities. Similarly, the religiously devout living in richer countries tended to express stronger reservations than their counterparts living in poorer countries. In this case, the religiously devout lucky enough to reside in a country that has achieved a high material standard of living were more sensitive to the normative trade-offs relative to new scientific advances than were their religious counterparts living in countries where science may still be seen as an essential vehicle for escaping material deprivation.

In wealthier countries, those expressing greater skepticism of traditional forms of authority such as the family, nation, and state were also less optimistic and held stronger reservations about science and technology than their counterparts in poorer countries. In wealthy countries, individuals skeptical of traditional authority may be more prone to view the close association between scientific research, technological innovation, militarization, and surveillance as operating in the service of social control rather than economic growth, as their counterparts in developing countries might primarily view science.

To conclude, we discuss our main findings in the context of concerns voiced today by scientists and civil society leaders about the cultural status of scientific authority, informing decisions about communication initiatives and policies intended to address rising public anxiety in an era of startling advances and disruptive innovations.

Global Views of Science and Technology

Civic Science Literacy

In a first line of research assessing cross-national differences in how publics relate to science and technology, some scholars have focused on measuring "civic science literacy," comparing scores on quiz-like questions among representative samples of adults surveyed in the United States, Europe, and Asia. Knowledge of basic scientific ideas and concepts is essential, argue these scholars, if individuals are to participate in politics and public affairs, compete in the workplace, and succeed at practical aspects of daily life. Given this importance, tracking and comparing science knowledge across countries provides an important indicator of a nation's civic health and capacity.[6]

Civic science literacy has been measured in national surveys by way of two separate but related knowledge constructs. First is the understanding of factual terms and concepts. These questions are intended to represent a vocabulary of basic scientific constructs sufficient to read opposing views in a newspaper. Examples of questions tapping factual knowledge include true-or-false questions—assessing statements such as "lasers work by focusing sound waves," "electrons are smaller than atoms," and "antibiotics kill viruses as well as bacteria"—as well as multiple-choice questions—"does the Earth go around the Sun, or does the Sun go around the Earth?" or "which travels faster: light or sound?"

In the United States, the biannual National Science Board surveys have for decades asked a consistent set of nine such questions. Since 2001, the average number of correct answers to the nine questions has ranged from 5.6 to 5.8. Better-educated Americans score higher than their less-educated counterparts. For example, those with a graduate degree tend to answer about 80 percent of the questions correctly, compared with 60 percent among those with a high school education. Overall, for several decades,

6. For overviews, see Jon D. Miller, "The Measurement of Civic Scientific Literacy," *Public Understanding of Science* 7 (3) (1998): 203–223; Jon D. Miller, "Public Understanding of, and Attitudes Toward, Scientific Research: What We Know and What We Need to Know," *Public Understanding of Science* 13 (3): 273–294; and Jon D. Miller, "The Sources and Impact of Civic Scientific Literacy," in *The Culture of Science: How the Public Relates to Science Across the Globe*, ed. Martin W. Bauer, Rajesh Shukla, and Nick Allum (New York: Routledge, 2011), 213–236.

Table 1: Conceptual Understanding, Factual Science Knowledge, and Understanding of Probability among Individuals Living in the United States and Ten European Countries, 2011

Self-Reported Understanding of Scientific Concepts in the News		Factual Science Knowledge		Understanding of Probability	
Country	Score (0–12)	Country	Score (0–20)	Country	%
Denmark	7.5	Denmark	15.6	Denmark	81.4
Germany	7.1	Netherlands	15.3	Netherlands	79.3
Netherlands	7.0	Germany	14.8	**United States**	**60.6**
France	6.4	Czech Republic	14.6	United Kingdom	59.8
Poland	5.7	**United States**	**14.3**	France	50.7
United Kingdom	5.3	Austria	14.2	Germany	48.4
Austria	5.2	United Kingdom	14.1	Spain	45.7
Spain	5.0	France	13.8	Czech Republic	41.9
United States	**4.9**	Poland	12.4	Italy	39.8
Italy	4.4	Italy	12.0	Austria	33.5
Czech Republic	4.1	Spain	11.2	Poland	32.7

Face-to-face interviews were conducted with approximately 1,500 respondents living in each of the eleven countries from October–November 2011. **Source:** Fundación BBVA, *BBVA Foundational International Study on Scientific Culture: Understanding of Science* (Madrid: Fundación BBVA, Department of Social Studies and Public Opinion, 2012).

scores on these questions have remained relatively stable and are mostly a function of formal education levels, particularly the number of college-level science courses completed.[7]

A second dimension of civic science literacy has been defined as knowledge of science as a process or mode of inquiry, measured by way of three types of questions assessing understanding of probability, experimental

7. For discussion and analysis, see National Science Board, "Chapter 7. Science and Technology"; and Matthew C. Nisbet and Ezra Markowitz, *Americans' Attitudes about Science and Technology: The Social Context for Public Communication* (Washington, D.C.: AAAS Leshner Leadership Institute, 2016). Notably, in the United States, questions specific to evolution and the Big Bang are not included in the nine-item index used by the NSB to measure basic factual literacy. Rather than measuring scientific knowledge, these questions tend to measure a commitment to a specific religious tradition or outlook. Many members of the public are aware of the scientifically correct answer to these topics, but if not otherwise prompted to consider the scientific context for the question, they are inclined to answer in terms of their religious views. For more, see J. Micah Roos, "Measuring Science or Religion? A Measurement Analysis of the National Science Foundation Sponsored Science Literacy Scale 2006–2010," *Public Understanding of Science* 23 (7) (2014): 797–813.

designs, and what it means to study something scientifically.[8] The percentage of Americans answering these questions correctly have remained relatively stable going back to the 1990s, with the number of science courses completed by an individual strongly predictive of knowledge.

The most recently available surveys comparing civic science literacy between the United States and other countries was commissioned in 2011 by the BBVA Foundation of Spain.[9] The project included face-to-face interviews with a nationally representative sample of 1,500 people living in the United States and in each of ten European countries. Three dimensions of knowledge were measured using similar question wording across all of the countries:

- ***Understanding of scientific concepts in the news:*** Respondents were asked if they understood completely, partly, or not at all specific specialist terms or expressions mentioned in the news media such as "the power of gravity," "DNA," "the greenhouse effect," "atom," and "ecosystem."
- ***Factual science knowledge:*** Respondents were asked true-or-false–style questions such as "hot air rises," "Earth's gravity pulls objects toward it without them being touched," and "the earliest humans lived at the time of dinosaurs."
- ***Understanding of probability:*** Respondents were asked a question about the probability of a couple's likelihood of having a child with a hereditary disease.

As Table 1 indicates, Americans score comparatively lower on self-reported understanding of specific concepts in the news, rank fifth among eleven countries in terms of factual science knowledge (though country differences are not substantial), and rank third specific to understanding of probability. The top scoring countries across all three dimensions were the Northern European countries Denmark, the Netherlands, and Germany. Scholars have previously surmised that Americans on average score better

8. Jon D. Miller, Rafael Pardo, and Fujio Niwa, *Public Perceptions of Science and Technology: A Comparative Study of the European Union, the United States, Japan, and Canada* (Madrid: Fundación BBVA, 1997). For an alternative conceptualization and measurement of science literacy, see Dan Kahan, "On the Sources of Ordinary Science Knowledge and Extraordinary Science Ignorance," in *The Oxford Handbook of the Science of Science Communication*, ed. Kathleen Hall Jamieson, Dietram A. Scheufele, and Dan Kahan (New York: Oxford University Press, 2017), 35–50.

9. Fundación BBVA, *BBVA Foundational International Study on Scientific Culture: Understanding of Science* (Madrid: Fundación BBVA, Department of Social Studies and Public Opinion, 2012).

on science literacy measures than the average European because of the unique nature of the U.S. education system, which exposes students at the high school and college levels to a broad base of course work that includes science classes. In contrast, many EU students start to narrowly specialize early on during their high school years and through college. As a consequence, nonscience majors in the European Union may miss out on the valuable "civic science" education that U.S. students receive.[10]

In terms of other available cross-national comparisons, the authors of the 2017 National Academies of Sciences, Engineering, and Medicine report *Science Literacy: Concepts, Contexts, and Consequences* summarized the most recently available country-specific data from a variety of independent surveys for which consistent question wording was used (see Table 2). As the authors observe, "scores for individual items vary from country to country, and no country seems to outperform the others on every question." In conclusion, they write that countries "with similar measures of economic development and educational attainment tend to have similar average scores on measures of science knowledge." They recommend that more research should focus on how social structural and country-level differences may either enable or limit access by individuals to opportunities for science-learning and participation. Similarly, they emphasize that a focus on average national scores obscures what are likely to be wide variations in science literacy within a country based on socioeconomic background or other factors.[11]

Beliefs about Science, Technology, and Society

Despite the attention that survey measures of science literacy receive, the authors of a 2008 meta-analysis of 1,930 public opinion surveys conducted across forty countries concluded that there is only a weak relationship between science literacy and public attitudes about science. In the years since, authors of other studies have observed that attitudes about food biotechnology, climate change, or biomedical research are more likely to vary

10. Miller et al., *Public Perceptions of Science and Technology*.

11. National Academies of Sciences, Engineering, and Medicine, *Science Literacy: Concepts, Contexts, and Consequences* (Washington, D.C.: National Academies Press, 2016); and Nick Allum, John Besley, Louis Gomez, and Ian Brunton-Smith, "Disparities in Science Literacy," *Science* 360 (6391) (2018): 861–862.

Table 2: Correct Responses to Factual Science Knowledge Questions by Country/Region

	United States 2014 %	Canada 2013 %	China 2010 %	European Union 2005 %	India 2004 %	Japan 2011 %	Malaysia 2014 %	Russia 2003 %	South Korea 2004 %
The center of the Earth is very hot. **(True)**	84	93	56	86	57	84	75	—	87
The continents have been moving their location for millions of years and will continue to move. **(True)**	82	91	50	87	32	89	62	40	87
Does the Earth go around the Sun, or does the Sun go around the Earth? **(Earth around Sun)**	76	87	—	66	70	—	85	—	86
All radioactivity is man-made. **(False)**	72	72	48	59	—	64	20	35	48
Electrons are smaller than atoms. **(True)**	51	58	27	46	30	28	35	44	46
Lasers work by focusing sound waves. **(False)**	50	53	23	47	—	26	30	24	31
The universe began with a huge explosion. **(True)**	42	68	—	—	34	—	—	35	67
It is the father's gene that decides whether the baby is a boy or a girl. **(True)**	59	—	58	64	38	26	45	22	59
Antibiotics kill viruses as well as bacteria. **(False)**	55	53	28	46	39	28	16	18	30
Human beings, as we know them today, developed from earlier species of animals. **(True)**	49	74	66	70	56	78	—	44	64
N	**2,130**	**2,004**	**68,416**	**26,403**	**30,255**	**812–984**	**2,653**	**2,207**	**1,000**

Source: National Academies of Sciences, Engineering, and Medicine, *Science Literacy: Concepts, Contexts, and Consequences* (Washington, D.C.: National Academies Press, 2016); and National Science Board, "Chapter 7. Science and Technology: Public Attitudes and Understanding," in *Science & Engineering Indicators 2018* (Washington, D.C.: National Science Foundation, 2018), https://www.nsf.gov/statistics/2018/nsb20181/report/sections/science-and-technology-public-attitudes-and-understanding/highlights.

in relation to social background, identity, mental models, and information sources than to knowledge.[12]

Reviewing this evidence, the members of a National Academies of Sciences, Engineering, and Medicine committee on science literacy concluded in 2016 that "available research does not support the claim that increasing science literacy will lead to appreciably greater support for science in general."[13] Once factors such as individual background, values, and information sources are accounted for, concluded the authors of a separate National Academies report published the following year, the "relationship between knowledge and attitudes across studies is either weakly positive, nonexistent, or even negative."[14]

Though science literacy likely plays only a minor role in shaping public attitudes, past research has identified two major mental models about science, technology, and society that people across countries tend to rely on to draw inferences, retrieve information from memory, form judgments, and generate opinions. Once activated by events, experiences, conversations, or messages, these mental models likely serve as shortcuts for evaluating a topic such as stem cell research, gene editing, or genetically modified food, and for estimating the trustworthiness of scientists and their institutions as sources of information.[15]

The first mental model, *scientific optimism*, is an attitude construct representing respect for the intentions of scientists, a sense that science and technology provide useful results and products for society, and the assumption that future benefits from science and technology are likely. Questions typically used to measure this construct ask respondents to agree or disagree with statements such as "scientific research is essential for improving the quality of human lives" and "new technology used in medicine allows people to live longer and better." The second schema, *scientific reservations*, is an attitude construct reflecting public concerns about the

12. Nick Allum, Patrick Sturgis, Dimitra Tabourazi, and Ian Brunton-Smith, "Science Knowledge and Attitudes across Cultures: A Meta-Analysis," *Public Understanding of Science* 17 (1) (2008): 35–54; and Caitlin Drummond and Baruch Fischhoff, "Individuals with Greater Science Literacy and Education Have More Polarized Beliefs on Controversial Science Topics," *Proceedings of the National Academy of Sciences* 114 (36) (2017): 9587–9592.

13. National Academies of Sciences, Engineering, and Medicine, *Science Literacy*, 102.

14. National Academies of Sciences, Engineering, and Medicine, *Communicating Science Effectively: A Research Agenda* (Washington, D.C.: National Academies Press, 2017), 31.

15. Jon D. Miller, *Biomedical Communications: Purpose, Audience, and Strategies* (Amsterdam: Elsevier, 2001); Matthew C. Nisbet, Dietram A. Scheufele, James Shanahan, et al., "Knowledge, Reservations, or Promise? A Media Effects Model for Public Perceptions of Science and Technology," *Communication Research* 29 (5) (2002): 584–608; and Nisbet and Markowitz, "Understanding Public Opinion in Debates Over Biomedical Research."

speed of change in modern life and a sense that science and technology pose conflicts with traditional values or belief systems. Questions measuring this mental model ask respondents to agree or disagree with statements such as "scientific research these days doesn't pay enough attention to the moral values of society" and "it is not important for me to know about science in my life." In the U.S. context, the two schema tend to be negatively correlated with one another. Thus, individuals who strongly believe in the promise of science and technology are generally less likely to have concerns about negative impacts.[16]

In previous studies examining public opinion about biomedical research, for example, even after controlling for partisanship and ideology, those scoring high on scientific reservations were on average more likely to oppose human genetic engineering and embryonic stem cell research. In contrast, those scoring high on scientific optimism were more likely to support such advances. Overall, these two mental models were the strongest predictors of attitudes, outweighing the influence of social demographics, religiosity, and ideology.[17]

The 2011 BBVA Foundation survey of public attitudes across ten European countries and the United States included a comprehensive battery of questions measuring beliefs about science, technology, and society. Scientific optimism was evaluated using a composite index of answers to questions asking respondents to agree or disagree with the following statements:

- Science is the motor of progress.
- Thanks to science, people's health is improving all the time.
- Science is central to a society's culture.
- Science has reduced the fears and the superstitions of the past.
- Science is the best way to understand the world.
- Science promotes a freer society.
- Science has an answer for all the major problems in the world.

Similarly, scientific reservations were evaluated using a composite index of questions asking respondents to agree or disagree with the following questions:

- Science makes our way of life change too fast.
- Science has made everything more complex and hard to understand.
- People would be better off if they lived a simpler life, without so much science and technology.

16. Nisbet and Markowitz, "Understanding Public Opinion in Debates Over Biomedical Research."

17. Ibid.

- Technological progress creates an artificial and inhuman way of life.
- Science increases the risk of war.
- Science has created a world that is full of risks for people in their daily life.
- Technological advances are among the main reasons for today's high unemployment.
- Scientists should not change the workings of nature.
- Science harms rather than helps the environment.
- Sciences drive out religion.
- Science destroys people's moral values.

As Table 3 indicates, the authors found "no marked inter-country differences" in scores on scientific optimism and scientific reservations, only slight variations.[18] All of the countries scored relatively higher on scientific optimism than scientific reservations. Overall, however, scientific reservations tended to be lower in countries where scientific activity and technological development were the most intense and productive, such as the United Kingdom, the Netherlands, the United States, Germany, and Denmark.

Table 3: Comparison of Ten European Countries and the United States on Scientific Optimism and Scientific Reservations, 2011

Scientific Optimism		**Scientific Reservations**	
Country	Score (0–60)	Country	Score (0–60)
Italy	39.8	Poland	31.5
Germany	39.4	Spain	30.6
Poland	38.9	Italy	29.7
Austria	38.7	France	29.3
Spain	37.8	Czech Republic	29.2
Czech Republic	37.7	Austria	28.0
Denmark	37.1	United Kingdom	26.4
France	36.6	Netherlands	26.1
United States	**36.2**	**United States**	**25.4**
Netherlands	35.6	Germany	25.2
United Kingdom	34.1	Denmark	23.4

The report authors found "no marked inter-country differences" in scores on scientific optimism and scientific reservations, only slight variations. **Source:** Fundación BBVA, *BBVA Foundational International Study on Scientific Culture: Understanding of Science* (Madrid: Fundación BBVA, Department of Social Studies and Public Opinion, 2012).

18. Fundación BBVA, *BBVA Foundational International Study on Scientific Culture*.

Modernization, Cultural Values, and Inequality

Among the main observations put forward by scholars to explain differences in beliefs about science, technology, and society across countries is the postindustrial paradox: as societies transition from industrial to postindustrial economies, public attitudes about science and technology evolve. In contrast to less-developed countries, in more-advanced economies like the United States and those of Northern Europe, science and technology may no longer be idealized as necessary to economic growth or national identity. The populations of these countries are still likely to expect benefits from scientific advances, but they are also likely to be more sensitive to the potential risks of innovations such as food biotechnology or gene editing. The public may also be less willing to fund science given other societal priorities like addressing inequality.[19]

Researchers testing these assumptions via survey studies observed that among European countries in the 1990s, interest in science was greatest among nations with low- to mid-levels of development but dropped off among European countries that had achieved the highest levels of modernization and standards of living. Similar patterns related to public attitudes about science were observed by researchers analyzing survey data collected during the 2000s in India, China, and Europe. Among Chinese and Indians, science and technology were viewed with strong levels of optimism, but Europeans living in richer, more-modernized countries tended to be more ambivalent about the benefits and costs of scientific advancement.[20]

A second related line of scholarship does not focus specifically on science and technology attitudes but rather on how such opinions are embedded within a broader process of cultural modernization taking place at different rates and in different ways around the world. This process of modernization in turn can be explained by the philosophical, political, religious, geographical, and economic history of a country and its people. Analyzing several decades of findings from cumulative World Values Surveys, these scholars argue that populations of countries vary in terms of traditional values versus secular-rational values. Populations in countries with more-traditional values may express stronger reservations about the

19. See the collected chapters in Bauer et al., *The Culture of Science*; and John C. Besley, "The State of Public Opinion Research on Attitudes and Understanding of Science and Technology," *Bulletin of Science, Technology & Society* 33 (1–2) (2013): 12–20.

20. Bauer et al., *The Culture of Science*.

impact of science and technology on religious faith or the speed of change than those living in nations scoring higher on secular-rational values.[21]

Countries also differ in terms of survival versus self-expression values. In developing countries, populations are likely to feel less secure about their economic status, their personal well-being, and the place of their nation in the world. Scientific advances and innovations are therefore more likely to be viewed as necessary to survival, well-being, and prosperity, with populations in less-developed countries expressing more optimism and fewer reservations than their counterparts living in more-developed nations. Specific to self-expression, those countries that have achieved economic growth and development, according to this line of research, tend to score higher in terms of democratic freedoms. In contrast to more-authoritarian, less-developed countries, populations living in advanced democracies not only may feel more ambivalent about the benefits and impacts of science and technology, but the personal freedoms they enjoy may make them more likely to express their reservations.[22]

Notably, in studies conducted by authors analyzing the World Values Survey, the United States scores higher in traditional values than other advanced Western economies, but also higher in terms of self-expression values compared with most other nations. This unique combination of a population holding more-traditional values but also enjoying the personal freedom to express opinions based on those values may have unique influences on beliefs about science, technology, and society.

21. See Ronald Inglehart and Christian Welzel, *Modernization, Cultural Change, and Democracy: The Human Development Sequence* (Cambridge: Cambridge University Press, 2005); Russell J. Dalton and Christian Welzel, eds., *The Civic Culture Transformed: From Allegiant to Assertive Citizens* (Cambridge: Cambridge University Press, 2014); Christian Welzel, *Freedom Rising* (Cambridge: Cambridge University Press, 2013); and Ronald Inglehart, *Cultural Evolution: People's Motivations Are Changing, and Reshaping the World* (Cambridge: Cambridge University Press, 2018).

22. Ibid.

Analyzing the World Values Survey

In order to better understand the factors influencing public views of science, technology, and society across countries, we analyzed the sixth wave of the World Values Survey (WVS), conducted in sixty countries between 2010 and 2014. Every decade since the 1970s, the WVS project has conducted nationally representative surveys using a common questionnaire assessing global differences in behaviors, values, motivations, and social, political, and cultural beliefs. The 2010–2014 iteration of the WVS included items that tapped respondents' beliefs about science, technology, and society.

The sixth wave of the WVS provides the most recent available data specific to how people across the globe perceive the societal promise of science and technology and the reservations that they might hold. In our analysis, after accounting for missing individual-level survey data and available country-level data, we eliminated six countries from our analysis: Haiti, Hong Kong, Iraq, Libya, Palestine, and Taiwan. Our final analysis therefore includes an assessment of public attitudes across fifty-four countries and eighty-one thousand survey respondents.

Measuring Science, Technology, and Society Beliefs

To evaluate beliefs about science, technology, and society, we analyzed three questions from the WVS that measured scientific optimism and three questions that measured scientific reservations. These questions are similar to those used by other researchers in previous studies separate from those carried out by the WVS team.[23] Using a ten-point scale, with 10 representing the strongest agreement and 1 representing the least agreement, respondents were asked to agree or disagree with the following statements:

23. Fundación BBVA, *BBVA Foundational International Study on Scientific Culture*; Miller, *Biomedical Communications*; Nisbet et al., "Knowledge, Reservations, or Promise?"; and Nisbet and Markowitz, "Understanding Public Opinion in Debates Over Biomedical Research."

Scientific Optimism (Cronsbach alpha α = 0.74)

- Science and technology are making our lives healthier, easier, and more comfortable.
- Because of science and technology, there will be more opportunities for the next generation.
- All things considered, would you say that the world is better off, or worse off, because of science and technology? Please tell me which comes closest to your view on this scale: 1 means that "the world is a lot worse off," and 10 means that "the world is a lot better off."

Scientific Reservations (Cronsbach alpha α = 0.55)[24]

- One of the bad effects of science is that it breaks down people's ideas of right and wrong.
- We depend too much on science and not enough on faith.
- It is not important for me to know about science in my daily life.

To limit missing responses to these questions, the "no answer" and "don't know" responses from all six survey questions were recoded to the middle point (5.5) of the ten-point scale for each item. The two dependent measures, which are weakly correlated, were constructed by combining the average of the respective three survey items into a single index with final scores ranging from 1 to 10.

In Table 4, we detail how the populations of the fifty-four countries compare relative to sample mean scores on scientific optimism and scientific reservations. Each nation rates relatively high on scientific optimism, with the combined mean score at least 6 or higher on the ten-point scale. Most of the top-ranking countries are developing economies, with their populations likely viewing scientific achievement as vital to economic growth and improving living standards. Interestingly, seventeen of the nineteen countries that scored highest in terms of scientific optimism are post-Soviet or Muslim-majority countries. The exceptions are Rwanda and China, the latter sharing a history of communist ideological influence with post-Soviet/Eastern Bloc countries.

Scientific and technological progress was an integral part of Soviet ideology and identity; thus, we would expect the populations of countries with Soviet or Eastern Bloc heritage to stand out in their beliefs about science,

24. The less than optimal reliability for the three reservations items may suggest that they are not as translatable across non-Western countries and non-Christian cultures than the items specific to scientific optimism. More research is needed on this possibility, improving the reliability of the reservations items if used in a future World Values Survey.

Table 4: Comparison of Fifty-Four Countries by Sample Mean Scores on Scientific Optimism and Scientific Reservations

Scientific Optimism			Scientific Reservations		
Country	Mean Score	Standard Deviation	Country	Mean Score	Standard Deviation
Uzbekistan*#	8.8	1.5	South Africa	6.5	1.7
Qatar*	8.6	1.6	Ecuador	6.4	1.7
Rwanda	8.4	1.0	Mexico	6.3	2.1
Kazakhstan*#	8.3	1.7	Chile	6.1	1.8
Azerbaijan*#	8.3	1.7	Colombia	6.0	1.8
Egypt*	8.2	1.5	Thailand	6.0	1.8
Pakistan*	8.0	1.8	Trinidad and Tobago	5.9	1.9
Belarus#	8.0	1.7	Nigeria	5.9	1.7
Yemen*	8.0	1.8	Pakistan*	5.9	2.3
Kuwait*	7.9	1.8	Armenia*#	5.9	1.6
Estonia#	7.9	1.5	Ghana	5.8	1.5
Ukraine#	7.9	1.7	Turkey*	5.8	2.2
Poland#	7.9	1.9	India	5.8	1.7
Kyrgyzstan*#	7.8	1.8	Philippines	5.8	2.1
Georgia*#	7.8	1.7	Argentina	5.7	1.9
Armenia*#	7.8	1.9	Uruguay	5.7	2.0
Turkey*	7.8	1.6	Jordan*	5.6	1.9
Russia#	7.8	1.8	Romania#	5.6	2.2
China	7.7	1.6	Peru	5.6	1.6
Malaysia*	7.7	1.6	Kuwait*	5.6	2.4
Sweden	7.6	1.7	Singapore	5.4	1.6
Germany	7.6	1.7	Russia#	5.4	2.0
Australia	7.5	1.9	Ukraine#	5.3	2.0
Ghana	7.4	1.6	Lebanon*	5.3	1.8
South Korea	7.4	1.7	South Korea	5.3	1.6
Singapore	7.4	1.5	Cyprus	5.2	1.9
Romania#	7.4	2.0	Zimbabwe	5.1	1.9
Nigeria	7.3	1.5	Egypt*	5.1	1.9
Jordan*	7.3	1.9	Georgia*#	5.1	1.7
Tunisia*	7.3	1.9	Algeria*	5.1	1.8
Morocco*	7.3	1.9	Morocco*	5.0	1.5
Netherlands	7.3	1.5	**United States**	**5.0**	**2.1**
Cyprus	7.3	1.8	Estonia#	5.0	2.1
Mexico	7.3	2.1	Malaysia*	5.0	1.7
India	7.3	1.8	Belarus#	5.0	1.8
South Africa	7.2	1.6	Spain	5.0	1.6
Slovenia#	7.2	1.8	China	4.9	1.6
Zimbabwe	7.2	1.8	Kyrgyzstan*#	4.9	2.2
United States	**7.2**	**1.7**	Azerbaijan*#	4.8	2.2
Algeria*	7.2	2.1	Kazakhstan*#	4.8	2.1
Trinidad and Tobago	7.1	1.9	Tunisia*	4.8	1.8
Ecuador	7.1	1.8	Brazil	4.7	1.9
Uruguay	7.1	1.8	New Zealand	4.7	2.0
Japan	7.0	1.5	Poland#	4.7	2.0
Argentina	7.0	1.7	Uzbekistan*#	4.7	1.9
New Zealand	7.0	1.7	Slovenia#	4.6	1.8
Philippines	6.9	2.1	Germany	4.6	1.8
Brazil	6.9	2.0	Japan	4.5	1.6
Spain	6.9	1.7	Qatar*	4.4	2.1
Thailand	6.8	1.7	Yemen*	4.2	1.7
Chile	6.8	1.8	Australia	4.1	2.1
Peru	6.7	1.9	Sweden	4.1	1.8
Colombia	6.7	2.0	Rwanda	4.1	1.0
Lebanon*	6.5	2.0	Netherlands	4.0	1.8

* indicates Muslim-majority country; # indicates former Soviet Republic or Eastern Bloc country. **Source:** Data from Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

technology, and society.[25] The relationship between science and Islamic faith is more complex and has been the topic of considerable discussion in recent years. Although the gap in scientific advancement between Muslim countries and the rest of the world has widened, surveys also suggest that their citizens may hold a strong sense of optimism about science and technology.[26] Analyzing cross-national surveys, the Pew Forum on Religion and Public Life, for example, has found that most people living in Muslim-majority countries do not see any conflict between science and their religion.[27] In contrast to their negative feelings about U.S. foreign policy, people living in several Muslim-majority countries, including Malaysia, Indonesia, Jordan, Tunisia, Kuwait, and Lebanon, also express strong levels of admiration for U.S. science and technology, indicating a sense of hopeful aspiration about what science and technology can contribute to their own society.[28]

Specific to mean scores on scientific reservations, the fifty-four countries score relatively low in comparison with scores on scientific optimism. Per country, sample means range from 4 to 6.5 on a ten-point scale. Four of the top five countries relative to reservations are strong majority–Roman Catholic countries. Of the fifty-four countries surveyed, most of the post-Soviet/Eastern Bloc and Muslim-majority countries rank toward the bottom third in terms of reservations. Scoring at the bottom of the range are several of the most economically advanced countries, including Japan, Germany, Australia, and the Netherlands. The United States in comparison ranks about mid-tier among the fifty-four countries. Importantly, however, the U.S. mean score of 5.0 on reservations is considerably lower than its national mean score of 7.2 on scientific optimism.

25. Loren R. Graham, *Science in Russia and the Soviet Union: A Short History* (Cambridge: Cambridge University Press, 2004).

26. For further discussion, see Nidhal Guessoum, *Islam's Quantum Question: Reconciling Muslim Tradition and Modern Science* (London: I.B. Tauris, 2010); Steve Paulson, "Does Islam Stand Against Science?" *The Chronicle of Higher Education*, June 19, 2011; and Jim Al-Khalili, *Pathfinders: The Golden Age of Arabic Science* (London: Penguin Books, 2010).

27. The Pew Forum on Religion and Public Life, *The World's Muslims: Religion, Politics and Society* (Washington, D.C.: Pew Research Center, 2013), http://www.pewforum.org/2013/04/30/the-worlds-muslims-religion-politics-society-overview/

28. Pew Research Center, Global Indicators Database (Washington, D.C.: Pew Research Center, last updated April 2019), http://www.pewglobal.org/database/indicator/46/survey/all/.

Evaluating Country-Level and Individual-Level Factors

To be more confident about the country-level factors associated with beliefs about science, technology, and society, we ran a series of multilevel model (MLM) regressions predicting individual scores on scientific optimism and scientific reservations. These statistical models allow us to control for country-level factors such as the degree of human development, democratic development, scientific development, and the cultural history of a country, while also examining individual-level factors such as those related to socioeconomic status, personal beliefs and values, religiosity, and forms of institutional trust.

We examined in our statistical analysis the relationship between beliefs about science, technology, and society, as well as five country-level variables. These included:

1. ***Human Development:*** This broad composite measure compiled by the United Nations Development Programme includes multiple indicators assessing country-level health, education, and standards of living. Measures specific to these three dimensions are averaged together into a "Human Development Index" between 0 and 1 for each country, with higher scores indicating greater levels of human development. For each country, we used in our MLM analysis the HDI score corresponding with the year that the WVS survey was conducted in that country.[29] See Table 5 for the Human Development Index for each country.

2. ***Democratic Development:*** We also include a composite measure of a country's democratic development as indicated by protection for civil liberties, access and freedom to information, and press freedom. This composite measure comprises two annual indices created by Freedom House, a nonpartisan, nonprofit organization that annually assesses civil and political liberties along with press freedom in 195 countries. Freedom House assesses political and civil liberties by way of two seven-point scales, which we combined and reverse-coded into one scale ranging from 2 (lowest liberty) to 14 (highest liberty), and then standardized into a one-hundred-point score. Freedom House also assesses the amount of political, legal, and economic restrictions of press freedom on a one-hundred-point

29. United Nations Development Programme, *The Real Wealth of Nations: Pathways to Human Development*, Human Development Report 2010 (New York: United Nations Development Programme, 2010), http://hdr.undp.org/sites/default/files/reports/270/hdr_2010_en_complete_reprint.pdf and http://hdr.undp.org/en/statistics/.

scale, which we reverse coded to reflect 1 (no press freedom) to 100 (high press freedom). We then averaged these two one-hundred-point measures to create an overall combined index of "Democratic Development." For each country, we used the Freedom House scores corresponding with the year that the WVS survey was conducted in that country.[30] See Table 5 for the Democratic Development score for each country.

3. ***Science and Technology Development:*** To account for the level of scientific and technological development, we used each country's score on the 2013 Knowledge Creation Index (KCI).[31] Published by the Global Innovation Index project, the KCI is a one-hundred-point composite measure assessing the knowledge and technology outputs of a country, standardized per purchasing power parity U.S. dollar (PPP$) across countries (see Table 5). The KCI is based on five metrics:

   i. Number of patent applications filed by country residents at the national patent office (per billion PPP$ GDP).

   ii. Number of international patent applications filed by country residents at the Patent Cooperation Treaty (per billion PPP$ GDP).

   iii. Number of utility model applications filed by residents at the national patent office (per billion PPP$ GDP).

   iv. Number of scientific and technical journal articles (per billion PPP$ GDP)

   v. The country's H-index: the number of published articles (H) that have received at least H citations from the Scopus citation index in the period from 1996 to 2011.

Not surprisingly, scores on human development (HDI) are strongly related to national scientific and technological output (KCI). In a simple regression, HDI explains 71 percent of the variance in national-level KCI, though there are important outliers to this trend. Four types of countries significantly outperform, relative to science and technology output, what would be predicted by their HDI scores. These include 1) less- to moderately developed Asian countries, such as China, India,

30. Freedom House, *Freedom in the World 2015* (Washington, D.C.: Freedom House, 2015); and Freedom House, *Freedom of the Press 2015* (Washington, D.C.: Freedom House, 2015).

31. Cornell University, INSEAD, and World Intellectual Property Organization, *The Global Innovation Index 2013: The Local Dynamics of Innovation* (Geneva: World Intellectual Property Organization, 2013).

Table 5: Scores on Human Development, Democratic Development, and Science and Technology Development among the Fifty-Four Countries Included in Analysis

Human Development (HDI)		Democratic Development (composite)		Science and Technology Development (KCI)	
Country	Score	Country	Score	Country	Score
Australia	0.94	Sweden	94.5	Sweden	61.4
United States	**0.94**	Netherlands	94.0	Netherlands	61.1
Netherlands	0.92	New Zealand	92.5	**United States**	**60.3**
Germany	0.92	Germany	91.5	Singapore	59.4
New Zealand	0.92	**United States**	**91.5**	Germany	55.8
Sweden	0.92	Estonia#	91.0	New Zealand	54.5
Japan	0.91	Australia	89.5	South Korea	53.3
South Korea	0.91	Cyprus	89.0	Australia	53.1
Singapore	0.90	Spain	88.5	Japan	52.2
Slovenia#	0.89	Poland#	87.5	Estonia#	50.6
Spain	0.89	Slovenia#	87.5	Spain	49.4
Cyprus	0.85	Uruguay	87.5	Cyprus	49.3
Estonia#	0.84	Japan	85.9	Slovenia#	47.3
Qatar*	0.83	Chile	84.5	Malaysia*	46.9
Poland#	0.82	Ghana	82.4	China	44.7
Chile	0.82	South Korea	81.4	Qatar*	41.0
Argentina	0.81	Trinidad and Tobago	81.4	Chile	40.6
Kuwait*	0.81	South Africa	76.4	Romania#	40.3
Belarus#	0.79	Romania#	72.4	Poland#	40.1
Uruguay	0.79	India	70.8	Kuwait*	40.0
Romania#	0.79	Brazil	70.4	Uruguay	38.1
Russia#	0.78	Argentina	67.4	Argentina	37.7
Mexico	0.78	Peru	67.3	Armenia#	37.6
Malaysia*	0.77	Philippines	64.7	South Africa	37.6
Trinidad and Tobago	0.76	Georgia#	62.2	Thailand	37.6
Kazakhstan*#	0.75	Turkey*	58.2	Colombia	37.4
Lebanon*	0.75	Ukraine#	57.7	Jordan*	37.3
Peru	0.74	Tunisia*	56.1	Russia#	37.2
Brazil	0.74	Ecuador	55.2	Mexico	36.8
Georgia#	0.74	Mexico	54.7	Brazil	36.3
Ukraine#	0.74	Colombia	54.6	India	36.2
Azerbaijan*#	0.73	Nigeria	53.6	Peru	36.0
Armenia#	0.73	Lebanon*	48.5	Turkey*	36.0
Ecuador	0.72	Malaysia*	47.1	Tunisia*	35.8
Turkey*	0.72	Thailand	46.6	Ukraine#	35.8
Thailand	0.72	Singapore	45.1	Georgia#	35.6
Colombia	0.72	Pakistan*	43.5	Lebanon*	35.5
Algeria*	0.71	Kuwait*	41.9	Belarus#	34.6
Tunisia*	0.71	Morocco*	41.0	Trinidad and Tobago	33.2
Jordan*	0.70	Egypt*	39.4	Ecuador	32.8
China	0.70	Armenia#	38.9	Kazakhstan*#	32.7
Egypt*	0.66	Algeria*	36.9	Philippines	31.2
South Africa	0.66	Kyrgyzstan#*	36.4	Morocco*	30.9
Philippines	0.65	Qatar*	34.9	Ghana	30.6
Uzbekistan*#	0.65	Jordan*	33.9	Azerbaijan*#	29.0
Kyrgyzstan*#	0.62	Azerbaijan*#	28.4	Egypt*	28.5
Morocco*	0.59	Kazakhstan*#	27.9	Rwanda	27.6
Ghana	0.56	Russia#	27.4	Kyrgyzstan*#	27.0
India	0.55	Rwanda	26.9	Nigeria	26.6
Pakistan*	0.52	Yemen*	26.3	Zimbabwe	24.0
Nigeria	0.47	Zimbabwe	24.3	Uzbekistan*#	23.9
Yemen*	0.46	China	18.2	Pakistan*	23.3
Rwanda	0.43	Belarus#	14.2	Algeria*	23.1
Zimbabwe	0.40	Uzbekistan*#	10.1	Yemen*	19.3

* indicates Muslim-majority country; # indicates former Soviet Republic or Eastern Bloc country. **Source:** Data from United Nations Development Programme, Freedom House, and Cornell University, INSEAD, and World Intellectual Property Organization. See footnotes 29, 30, and 31 for full source information.

Malaysia, and Singapore, that invest heavily in science and technology; 2) smaller, highly developed Northern European countries, such as the Netherlands, Sweden, and Estonia, that have unusually strong science and technology sectors; 3) larger highly developed countries, such as the United States and Germany, that account for a disproportionate amount of global scientific and technological output; and 4) African countries, such as Rwanda, Nigeria, and Zimbabwe, that have prioritized science and technology development.

4. ***Post-Soviet/Eastern Bloc Country:*** We included a binary variable (0 versus 1) that indicates whether a country was previously a Soviet or Eastern Bloc country. Of the fifty-four countries, thirteen were coded as post-Soviet/Eastern Bloc (see Table 5).

5. ***Muslim-Majority Country:*** We included a binary variable (0 versus 1) that indicates whether a country was Muslim-majority. Of the fifty-four countries, sixteen were coded as Muslim-majority (see Table 5).

In our MLM regression model we also included individual-level factors related to sociodemographic background, religious affiliation, secular values, interest in politics and economic beliefs, forms of media use, forms of institutional confidence/trust, and democratic values.

- ***Sociodemographics (six variables):*** We used six variables related to sociodemographic background, including age, gender (with male coded high), and educational attainment measured on a nine-point scale ranging from "no formal education" to "university level education with degree." We also included a measure asking respondents to self-report their socioeconomic class ranging on a five-point scale from "lower class" (1) to "upper class" (5) and a dichotomous indicator of whether an individual was employed or not. The sixth variable measured an individual's sense of economic security, calculated by averaging three survey items asking how often they had gone without food, gone without needed medicine, and gone without cash income ($\alpha = 0.81$).

- ***Religious Affiliation (three variables):*** For respondents to surveys conducted across the fifty-four countries, the most popular religious affiliations were Muslim (24.2 percent; Sunni and Shia),[32] Roman Catholic (18.3 percent), Protestant Christian (11.9 percent), Orthodox Christian (10.1 percent), and Hindu (4.8 percent). In addition, 18.3 percent of respondents cited “none” for their religious affiliation. For our analysis, we created dichotomous dummy variables for Roman Catholic, Protestant, and Orthodox Christian affiliations, with all other religious denominations serving as the reference category.

- ***Secular Values (four variables):*** From the WVS survey, we included four measures of secular values originally developed by the political scientist Christian Welzel.[33] These four variables include defiance of traditional authority, moral relativism, skepticism of state authority, and degree of religiosity. As conceptualized by Welzel, each variable measures a unique dimension of individual detachment “from external sources of quasi-sacred authority, like religion, the nation, the state, and group norms.”[34]
  - Defiance of traditional authority was measured by three questions that asked whether respondents’ main goal in life was to make their parents proud; whether greater respect for authority was good or bad; and how proud respondents were to identify with the nation in which they lived (for example, to be an “American” or “Chinese”). Responses to each question were averaged and combined, resulting in a multipoint index from 0 to 1, with greater defiance scored high.
  - Moral relativism was measured by three questions asking respondents if they thought it could always be justified, never be justified, or something in between to avoid a fare on public transport, cheat on taxes if provided the chance, and accept a bribe in

32. Given that an estimated 10–13 percent of all Muslims are Shia, compared with the 87–90 percent who are Sunni, for analysis purposes, the two items from the World Values Survey were combined into a single Muslim measure. There is also no theoretical work or past research indicating that the two Muslim traditions differ in general views about science, technology, and society. In the analysis, Muslim is also a reference category, rather than a predictor variable as is used in the HLM models. See The Pew Forum on Religion and Public Life, *Mapping the Global Muslim Population: A Report on the Size and Distribution of the World’s Muslim Population* (Washington, D.C.: Pew Research Center, 2009), https://www.pewresearch.org/wp-content/uploads/sites/7/2009/10/Muslimpopulation.pdf.

33. Christian Welzel, *Freedom Rising: Human Empowerment and the Quest for Emancipation* (Cambridge: Cambridge University Press, 2013); see online appendix for methodology, https://www.cambridge.org/files/8613/8054/8416/FreedomRising_OA.pdf.

34. Ibid, 12.

the course of professional duties. Responses were recoded into a dummy variable for each item, with 0 as "never justifiable" and all other responses as 1. The scores were then averaged over the three dummies, yielding a four-point index from 0 to 1.

- Degree of religiosity was measured using three questions asking respondents how important religion was in their life, how often they attended religious services, and whether or not they considered themselves to be a religious person, not a religious person, or an atheist. Responses to these questions were averaged and recoded into an multipoint index from 0 to 1, with higher scores reflecting greater religious devotion.
- Skepticism of state authority was measured by three questions asking respondents how much confidence they had in the armed forces, the police, and the courts. Responses were recoded as 0 for a "great deal" of confidence, 0.33 for "quite a lot" of confidence, 0.66 for "not very much" confidence, and 1 for "none at all." The three items were then averaged and combined into a multipoint index from 0 to 1.

- ***Interest in Politics and Economic Beliefs (four variables):***
  - Political interest was assessed by averaging two variables tapping the importance respondents placed on politics and their expressed interest in politics (items correlated at $r = 0.54$).
  - Belief in economic competition was assessed by averaging two survey items asking respondents how much they value economic competition and hard work ($r = 0.38$).
  - Belief in government ownership asked about respondents' support for increased government ownership of business and industry.
  - Economic satisfaction was measured using a single item asking respondents on a ten-point scale how satisfied they were with their own financial situation.
- ***Institutional Confidence (five variables):*** We included five single-item measures assessing an individual's confidence on a four-point scale (from none at all to a great deal) in institutions that commonly intersect with beliefs about science, technology, and society. These included universities, business, government, churches, and environmental organizations.

- ***Media Use (two variables):*** We measured media use by way of multi-item indexes that assessed frequency of traditional news media use and frequency of digital media use. The measure of traditional news media averaged three single survey items asking respondents about the frequency of their consumption of print news, TV news, and radio news on a five-point scale. The measure of digital media use averaged three survey items asking about the frequency of use of mobile phones, email, and the Internet.
- ***Democratic Values (two variables):*** We included measures of the perceived importance of democracy and support for authoritarian governance.
  - Perceived importance of democracy was measured with a single item asking how important democracy was on a ten-point scale, with higher scores reflecting greater perceived importance.
  - Support for authoritarian governance included three averaged questions asking respondents about their support level for governance by way of a strong leader, experts, or the army instead of by way of a democratic system.

Predicting Optimism about Science, Technology, and Society

As Model 4 in Table 6 details, after entering all individual- and country-level covariates into the model, we found that populations of Muslim-majority and post-Soviet/Eastern Bloc countries were more likely to express optimism about the impacts of science and technology on society, believing that advances and innovations make their lives healthier, easier, and more comfortable, create more opportunities for the next generation, and make the world a lot better off.

In contrast, people in more-developed countries who enjoy a higher standard of living as measured by the Human Development Index and greater political freedoms via democratic development tended to be less optimistic about the benefits that science and technology may offer. Our finding is consistent with previous theorizing on the postindustrial paradox, in which publics in more-advanced economies become more ambivalent about the costs and trade-offs of scientific research and technological advances.

Yet even controlling for human, economic, and democratic development, people living in countries with greater scientific and technological development as measured by per capita scientific publications, patents, and citations tended to be more optimistic about science and technology. Whether such optimism creates a culture that drives scientific ambition and productivity or whether such outputs boost optimism is not a question we can answer with our data. The most likely explanation, however, is a reinforcing, virtuous circle of optimism driving output and output reinvigorating optimism, irrespective of the stage of economic and democratic development a country may be in. In all, controlling for individual-level factors within countries, our model predicts 53 percent of the between-country differences in terms of scientific optimism.

Finally, to compare the relative magnitude of each of the statistically significant country-level predictors of optimism about science and technology, we manually standardized each coefficient by taking the estimated unstandardized coefficient obtained from the HLM output, multiplying it by the standard deviation of the predictor variable, and dividing it by the standard deviation of the scientific optimism measure. In this case, the strongest country-level predictors of an individual's scientific optimism were science and technology development ($\beta = 0.17$), human development ($\beta = -0.16$), and residence (or not) in a post-Soviet/Eastern Bloc country ($\beta = 0.15$).

Shifting our focus to individual-level factors, as Table 6 details, we found that among those surveyed across the fifty-four countries, after all controls, men and those enjoying greater economic security were more likely to express optimism about science and technology. Somewhat surprisingly, neither socioeconomic class nor Christian denominational identity were significantly related to scientific optimism. Notably, expressions of scientific optimism were also associated with classical liberal values oriented toward the market, openness, free enterprise, free inquiry, and the pursuit of new knowledge, networks, and information. More specific, across countries, scientific optimists tended to believe in economic competition and the importance of democracy, they were more likely to use and seek out information and connections via digital media, and they were more likely to express economic satisfaction, along with confidence in universities, business, and civil society groups like environmental nonprofits.

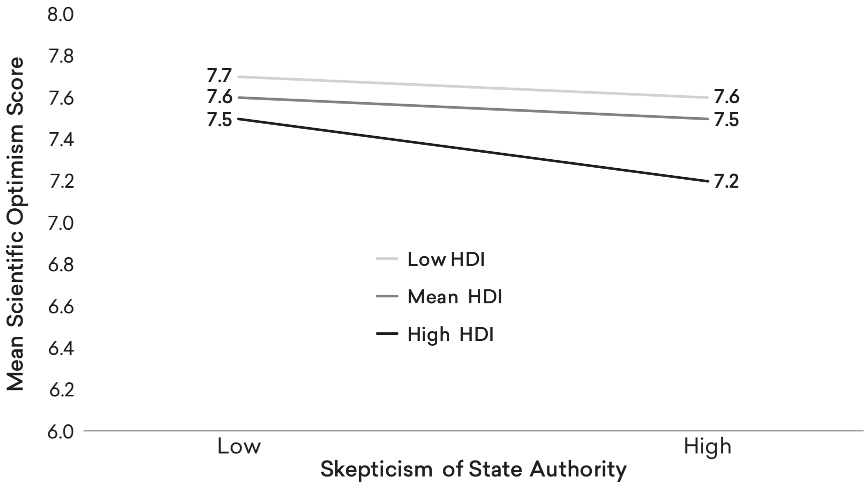
In contrast, respondents with greater confidence in religious institutions and who are more religiously devout scored lower on scientific optimism. As did respondents who are more distrustful of various forms of societal authority and conventional norms. Specifically, those who are defiant of traditional authority in the form of the family or national identity, who are more skeptical of state authority in the form of the police, military, and the courts, and who are morally relativistic are less likely to express optimism about science and technology.

Table 6: Predicting Scientific Optimism: Multilevel Model Results for the One-Way ANOVA Model (Model 1) and Models 2, 3, and 4 Evaluating Country- and Individual-Level Factors

	Model 1	Model 2	Model 3	Model 4
Intercept	7.47	7.54 (0.07)***	7.55 (0.05)***	7.55 (0.05)***
Country-level factors				
Democratic development	—	—	-0.01 (0.00)*	-0.01 (0.00)*
Human development	—	—	-2.18 (0.71)**	-2.19 (0.70)**
Science and technology development	—	—	0.03 (0.01)***	0.03 (0.01)***
Muslim-majority country	—	—	0.42 (0.15)**	0.41 (0.15)**
Post-Soviet country	—	—	0.64 (0.11)***	0.64 (0.11)***
Individual-level factors				
Age	—	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***
Gender (male)	—	0.12 (0.02)***	0.12 (0.02)***	0.12 (0.02)***
Educational attainment	—	0.03 (0.01)	0.02 (0.01)	0.02 (0.01)
Economic security	—	0.18 (0.03)***	0.18 (0.03)***	0.18 (0.03)***
Employed	—	-0.03 (0.02)	-0.03 (0.02)	-0.03 (0.02)
Socioeconomic class	—	0.03 (0.02)	0.03 (0.02)	0.03 (0.02)
Orthodox Christian	—	0.08 (0.06)	0.08 (0.06)	0.08 (0.06)
Protestant	—	0.01 (0.07)	0.01 (0.07)	0.01 (0.07)
Roman Catholic	—	0.06 (0.05)	0.06 (0.05)	0.06 (0.05)
Defiance of traditional authority	—	-0.75 (0.09)***	-0.75 (0.09)***	-0.73 (0.09)***
Moral relativism	—	-0.37 (0.06)***	-0.37 (0.06)***	-0.37 (0.06)***
Skepticism of state authority	—	-0.15 (0.05)	-0.15 (0.05)	-0.19 (0.05)***
Interaction with human development	—	—	—	-1.60 (0.42)***
Degree of religiosity	—	-0.40 (0.07)***	-0.40 (0.07)***	-0.41 (0.07)***
Political interest	—	0.03 (0.01)	0.03 (0.02)	0.03 (0.02)
Belief in economic competition	—	0.05 (0.01)***	0.05 (0.01)***	0.05 (0.01)***
Belief in government ownership	—	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Economic satisfaction	—	0.05 (0.01)***	0.05 (0.01)***	0.05 (0.01)***
Confidence in universities	—	-0.04 (0.01)***	-0.04 (0.01)***	-0.04 (0.01)**
Confidence in business	—	0.04 (0.01)**	0.04 (0.01)**	0.03 (0.01)*
Confidence in government	—	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)
Confidence in churches	—	0.05 (0.02)***	0.05 (0.02)***	0.04 (0.01)**
Confidence in environmental groups	—	0.04 (0.01)***	0.04 (0.01)***	0.04 (0.01)***
Frequency of traditional media use	—	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)
Frequency of digital media use	—	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)
Importance of democracy	—	0.16 (0.01)***	0.16 (0.01)***	0.16 (0.01)***
Support for authoritarian government	—	0.00 (0.02)	0.00 (0.02)	0.00 (0.02)
Country-level variance τ^{00}	0.254	0.254	0.119	0.119
Individual-level variance σ^2	3.056	2.600	2.600	2.597
Percentage of between-country variance explained	—	—	*53.1%*	*53.1%*
Percentage of within-country variance explained	—	*14.9%*	*14.9%*	*15.0%*

* $p < 0.10$; ** $p < 0.01$; *** $p < 0.001$. Unstandardized coefficients with robust standard errors reported.
Source: Author analysis of Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

Figure 1: Perceived Promise of Science and Technology by Skepticism of State Authority and Country-Level Human Development Index (HDI)



Source: Author analysis of Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

There is, however, one important caveat to these relationships. When we examined the relationship between individual-level beliefs about state authority and country-level context, we observed that the influence of state authority skepticism on scientific optimism is significantly more pronounced among those living in highly developed countries (see Figure 1). In wealthy countries, for individuals who distrust the police, military, or courts, they may be more prone to view the close association between scientific research, technological innovation, militarization, and surveillance as operating in the service of social control, rather than economic growth, as their counterparts in developing countries might primarily view science. Overall, our final model including country-level and individual-level factors accounted for 15 percent of within-country, individual variation in scientific optimism.

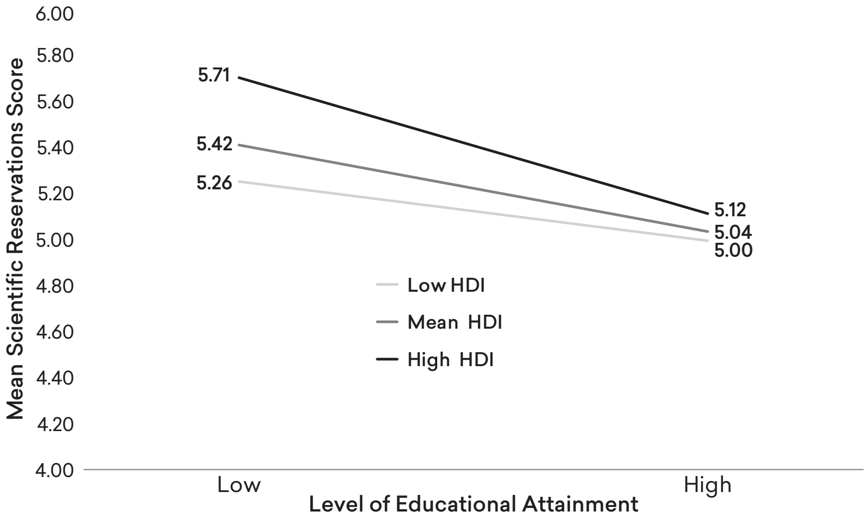
Last, to compare the relative magnitude of each of the statistically significant individual predictors of optimism about science and technology, we manually standardized each coefficient (see earlier discussion). In this case, the strongest individual-level predictors of scientific optimism were the perceived importance of democracy ($\beta = 0.19$), followed by economic security ($\beta = 0.09$) and moral relativism ($\beta = -0.08$).

Table 7: Predicting Reservations about Science and Technology: Multilevel Model Results for the One-Way ANOVA Model (Model 1) and Models 2, 3, and 4 Evaluating Country- and Individual-Level Factors

	Model 1	Model 2	Model 3	Model 4
Intercept	7.47		5.19 (0.09)***	5.19 (0.09)***
Country-level factors				
Democratic development	—	—	0.00 (0.00)	0.00 (0.00)
Human development	—	—	2.2 (1.54)	2.2 (1.46)
Science and technology development	—	—	-0.06 (0.02)***	-0.06 (0.02)***
Muslim-majority country	—	—	-0.52 (0.22)*	-0.52 (0.22)*
Post-Soviet country	—	—	-0.44 (0.17)*	-0.44 (0.18)*
Individual-level factors				
Age	—	0.00 (0.00)***	0.00 (0.00)***	0.00 (0.00)***
Gender (male)	—	-0.04 (0.02)	-0.04 (0.02)	-0.05 (0.02)
Educational attainment	—	-0.03 (0.01)***	-0.04 (0.01)***	-0.04 (0.01)***
Interaction with human development	—	—	—	-0.34 (0.05)***
Economic security	—	-0.06 (0.03)	-0.06 (0.03)	-0.06 (0.03)
Employed	—	0.00 (0.02)	-0.01 (0.02)	0.01 (0.02)
Socioeconomic class	—	0.00 (0.00)	-0.03 (0.02)	-0.03 (0.02)
Orthodox Christian	—	0.24 (0.08)**	0.21 (0.01)**	0.18 (0.07)
Protestant	—	0.12 (0.06)	0.11 (0.06)	0.07 (0.05)
Roman Catholic	—	0.11 (0.06)	0.10 (0.05)	0.05 (0.05)
Defiance of traditional authority	—	-0.27 (0.13)	-0.26 (0.14)	-0.13 (0.11)
Interaction with democratic development	—	—	—	-0.02 (0.00)***
Moral relativism	—	0.17 (0.05)***	0.17 (0.05)***	0.18 (0.05)***
Skepticism of state authority	—	0.18 (0.06)	0.24 (0.07)***	0.15 (0.06)
Degree of religiosity	—	0.69 (0.15)***	0.71 (0.15)***	0.49 (0.11)***
Interaction with human development	—	—	—	4.91 (0.92)***
Political interest	—	-0.08 (0.02)***	-0.08 (0.02)***	-0.07 (0.02)
Belief in economic competition	—	-0.07 (0.01)***	-0.07 (0.01)***	-0.07 (0.01)***
Belief in government ownership	—	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)
Economic satisfaction	—	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)
Confidence in universities	—	-0.04 (0.01)		-0.04 (0.01)
Confidence in business	—	0.04 (0.01)	0.02 (0.01)	0.03 (0.01)
Confidence in government	—	-0.02 (0.01)	-0.02 (0.01)	-0.02 (0.01)
Confidence in churches	—	0.05 (0.02)	0.05 (0.02)	0.04 (0.02)
Confidence in environmental groups	—	-0.02 (0.01)	-0.02 (0.02)	-0.01 (0.02)
Frequency of traditional media use	—	0.00 (0.02)	0.00 (0.02)	-0.02 (0.02)
Frequency of digital media use	—	-0.04 (0.01)***	-0.04 (0.01)***	-0.04 (0.01)***
Importance of democracy	—	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Interaction with human development	—	—	—	-0.28 (0.07)***
Support for authoritarian government	—	0.17 (0.02)***	0.17 (0.02)***	0.16 (0.02)***
Country-level variance τ^{00}	0.384	0.384	0.344	0.348
Individual level variance σ^2	3.437	3.30	3.30	3.252
Percentage of between-country variance explained	—	—	*10.4%*	*9.4%*
Percentage of within-country variance explained	—	*4.0%*	*4.0%*	*5.4%*

* $p < 0.10$; ** $p < 0.01$; *** $p < 0.001$. Unstandardized coefficients with robust standard errors reported.
Source: Author analysis of Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

Figure 2: Reservations about Science and Technology by Education and Country-Level Human Development Index (HDI)



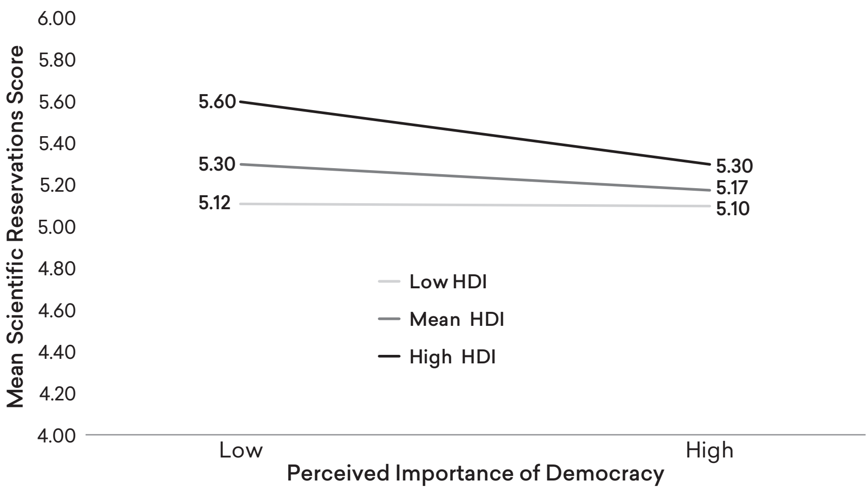
Source: Author analysis of Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

Predicting Reservations about Science, Technology, and Society

Turning to reservations about science and technology, as Model 4 in Table 7 details, after all controls, in parallel to the findings on scientific optimism, the populations of Muslim-majority and post-Soviet/Eastern Bloc countries were less likely to express concerns about the impact of science and technology on faith and morality, and less likely to question whether science was important to their lives. Similarly, after controlling for every other variable in the model, those individuals living in nations with greater levels of scientific activity and innovation were less likely to express reservations about their impact than their counterparts living in other countries. When we compared the relative magnitude of these statistically significant predictors of reservations (see earlier discussion), we found that a country's level of scientific and technological development was by far the most influential variable ($\beta = 0.32$), followed by whether or not an individual lived in a Muslim-majority country ($\beta = -0.12$). Interestingly, in contrast to scientific optimism, a nation's human development and democratic development were not predictive of individual reservations about science and society.

Among individual-level socioeconomic factors, only education was significantly related to scientific reservations, with the better educated

Figure 3: Reservations about Science and Technology by Perceived Importance of Democracy and Country-Level Human Development Index (HDI)



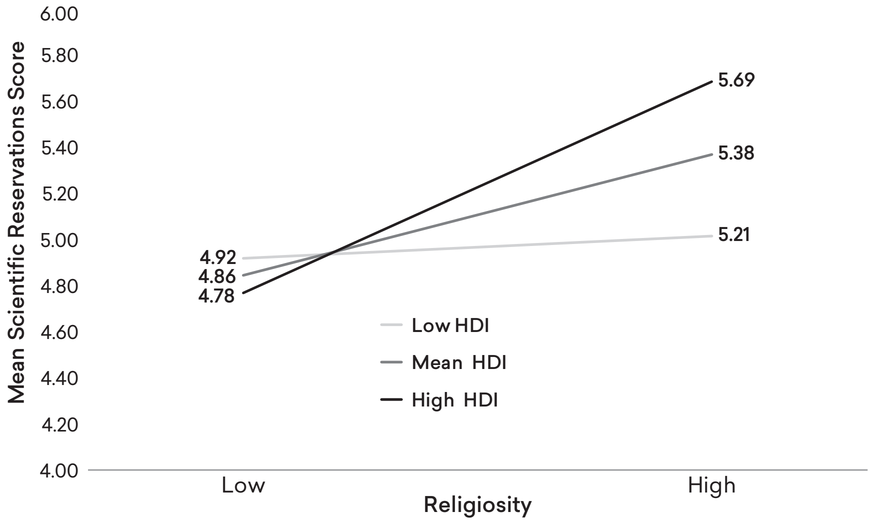
Source: Author analysis of Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

expressing fewer reservations. The influence of education, however, varied across countries by level of human development. The least educated living in the richest countries tended to express much higher levels of scientific reservations than the least educated living in poorer countries. These individuals may justifiably believe that they cannot afford or do not have access to medical advances or technological innovations; or they may fear that such innovations in areas like robotics or automation will disrupt their jobs and communities. In contrast, the well-educated across societies are likely to view science and technology in terms of bettering their lives and professions. Lower levels of reservations among highly educated individuals, regardless of the country in which they live, is consistent with formal education having a socializing influence that shapes individuals' views about science in terms of progress and optimism, rather than in terms of the moral and religious implications (see Figure 2).[35]

Similar to scientific optimism, after all controls, those individuals across countries who hold classical liberal values, specifically those who believe in economic competition and value the openness and connections

35. Dominique Brossard and Matthew C. Nisbet, "Deference to Scientific Authority among a Low Information Public: Understanding U.S. Opinion on Agricultural Biotechnology," *International Journal of Public Opinion Research* 19 (1) (2007): 24–52.

Figure 4: Reservations about Science and Technology by Religiosity and Country-Level Human Development Index (HDI)



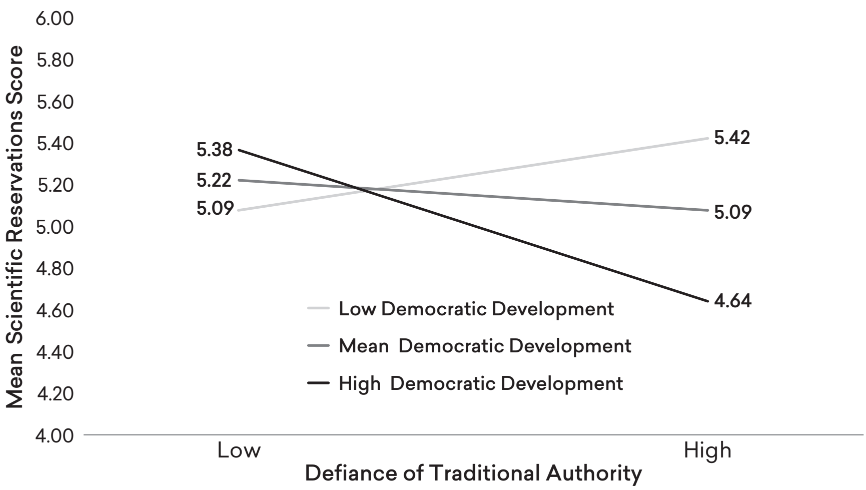
Source: Author analysis of Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

made possible by digital media use, tend to hold fewer reservations about science and technology. In contrast, those who discount the importance of democracy in favor of authoritarianism express greater levels of scientific reservations. This relationship is the most pronounced in highly developed countries (see Figure 3). The reason for this relationship is unclear, but it may relate to the rise of authoritarianism, anti-elitism, and populist distrust of technocrats in Europe and the United States over the past decade.[36]

Given that the reservations-related questions asked directly about the impact of science on faith and morality, it is not surprising that people across countries who are more religiously devout scored higher on the measure. But in this case, there is a contingency to note. Expressions of anxiety among the most religious tend to be greatest for those living in highly developed countries. For religious individuals lucky enough to live in a country that has achieved a high material standard of living, the normative trade-offs relative to new scientific advances appear to become more personally relevant than for their religious counterparts living in countries where science may still be seen as an essential vehicle for escaping material deprivation (see Figure 4).

36. Pippa Norris and Ronald Inglehardt, *Cultural Backlash: Trump, Brexit, and Authoritarian Populism* (Cambridge: Cambridge University Press, 2019).

Figure 5: Reservations about Science and Technology by Defiance of Traditional Authority and Country-Level Democratic Development



Source: Author analysis of Ronald Inglehart, Christian Haerpfer, Alejandro Moreno, et al., World Values Survey Wave 6 (2010–2014) (Madrid: JD Systems Institute, 2014).

Apart from the religious, those who are more distrustful of various forms of societal authority and conventional norms also expressed greater reservations about science. Somewhat paradoxically, moral relativism across countries is significantly related to reservations about the impact of science and technology on faith, morality, and the perceived importance to life. Notably, the relationship between defiance of traditional authority and scientific reservations varies strongly by the level of democratic development in a country. In countries with fewer civil liberties and press freedoms, science may still be closely associated with forms of government and societal control; thus, those who are distrusting of traditional authority expressed higher levels of scientific reservations. In contrast, their counterparts living in strongly democratic countries expressed far fewer reservations about science and technology (see Figure 5).

Finally, to assess which of the statistically significant individual-level predictors in the model had the greatest influence on reservations about science and technology, we standardized each of the respective variable's coefficients (see earlier discussion). In this case, after all controls, an individual's degree of religiosity had the strongest relationship with reservations ($\beta = 0.11$), followed by support for authoritarian governance ($\beta = 0.08$) and belief in economic competition ($\beta = -0.08$).

Conclusion

We began our analysis by assessing the significance of national and cultural context on public views of science and society. At first, we were somewhat surprised to see Muslim-majority and post-Soviet/Eastern Bloc countries stand out in terms of their optimism about science and technology and their comparatively fewer reservations. These findings, however, are consistent with a long-standing emphasis in former communist countries on science as a vehicle for progress and the admiration that Muslim publics have expressed when asked in polls about Western science, medicine, and technology. In both cases, as conflict persists between NATO countries and Russia or between Western and Muslim-majority countries, an emphasis on scientific collaboration and technological innovation to solve common problems may prove a valuable form of "soft power" and public diplomacy. Even when controlling for both human and democratic development, people living in countries with greater scientific and technological development as measured in terms of scientific publications, patents, and citations tend to be more optimistic about science and technology and to hold fewer reservations. Yet it remains unclear whether a national culture of scientific optimism that expresses fewer social reservations drives scientific ambition and productivity, or whether national ambition and productivity boosts public optimism and limits the expression of reservations.

Dialogue about Moral Reservations

Our findings are also consistent with past theorizing on the postindustrial paradox. People living in less-developed countries are generally more optimistic about science and technology, expressing fewer reservations. People living in economically advanced countries and more-democratic countries are generally less optimistic and more likely to express stronger reservations. Turning to how national context interacts with individual-level factors, we also found that religious individuals living in more-advanced countries with greater political freedom were more willing to express their reservations than their similarly devout counterparts living in countries that lacked such freedoms. Several related processes may account for these findings. First, as people living in more-advanced countries achieve greater personal and societal security, they appear to be no longer willing to overlook the potential risks, economic costs, or moral trade-offs associated with scientific advances and innovations. To the extent that individuals living in more-advanced countries also enjoy greater political freedom, they can also express these reservations without fear of political sanction. In contrast, for populations living in less-developed countries, they may not only view science and technology in terms of social progress and enhanced security, but also as a source of national pride and global competitiveness. To the extent that they live in a country with fewer political freedoms, even if they did hold reservations, they may not be willing to express them for fear of reprisal.

Such processes may help explain differing patterns in national policy in relation to emerging scientific and technological advances, such as gene editing. China, South Korea, and Singapore have far fewer restrictions on human embryo, stem cell, and gene editing research than do the United States or European countries. The more-permissive research culture in these nations—one that many Western experts argue poses serious ethical questions—is likely in part due to differences in religious tradition and political governance, but also likely enabled by Asian publics who have yet to express strong opinions about the need for limits to such research or demand public participation in policy decisions.

In contrast, U.S. polling, for example, shows that Americans hold fairly consistent opinions and judgments about gene editing, even as they currently possess very little information about the complex subject. To do so, individuals actively draw on their religious and cultural values, familiar narratives from popular culture, and similarities to past debates. In one 2016 survey, when asked about the moral acceptability of gene editing techniques intended to give healthy babies a reduced risk of disease, only 28 percent of Americans considered the application acceptable, compared with 30 percent who said it is unacceptable and 40 percent who were not sure. Notably, among the one-third of Americans who can be classified as highly religious, only 15 percent consider such applications morally acceptable. When asked separately if such an application meddled with nature and crossed a line that should not be crossed, 64 percent of highly religious Americans agreed.[37]

But as various survey findings indicate, it is not just strongly religious Americans who have moral reservations about gene editing. Even among nonreligious Americans, 17 percent responded that gene editing to give babies a much-reduced risk of disease is morally unacceptable, and 37 percent reported being unsure. In a follow-up question, more than one-quarter of nonreligious respondents indicated that they oppose gene editing to improve the health of a baby because it would be meddling with nature and cross a line that should not be crossed. When asked more specifically

37. Nisbet, "The Gene-Editing Conversation," 15–20.

if saving a baby's life required testing on human embryos or altering the genetic makeup of the whole population, about half of all Americans replied that such scenarios would make the application less acceptable to them.

What explains the reservations voiced by both religious and nonreligious Americans, or similar reservations to be found in more-secular countries such as Germany, a nation that has comparatively stricter limits on embryo research than the United States? Bioethicists, for example, have used the term "yuck factor" to describe a "visceral repugnance" and "emotional opposition" felt by the public when they first hear about human genetic engineering. This repugnance, wrote University of Chicago ethicist Leon Kass in an oft-cited 1997 article in *The New Republic*, is an "emotional feeling of deep wisdom" that leads an individual to "intuit and feel, immediately without argument, the violation of things that we rightfully hold dear."[38] The yuck factor likely has its origins in Kantian and Christian philosophies of human dignity that permeate Western culture. These traditions, as political theorist Francis Fukuyama describes in his 2002 book *Our Posthuman Future: Consequences of the Biotechnology Revolution*, emphasize that human life has a higher moral place than the rest of the natural world. Therefore, according to these philosophies, even at its earliest stages of development, human life should always be treated with a sacred respect.[39]

Such teachings have shaped Western culture to the extent that their principles are passed on even to those who have never set foot in a church. Across Western countries, the yuck factor is therefore a relatively intuitive response, a reaction formed below the level of conscious deliberation on the part of an individual, often in the absence of substantive information. When asked about emerging gene editing techniques that would involve altering human embryos or engineering babies to express desired physical or mental traits, most individuals living in Western countries probably have difficulty articulating why they believe it to be morally questionable; they just know it when they feel it.

In relation to gene editing and similarly morally fraught issues, major investments in public dialogue across advanced economies are needed. In 2017, for example, the National Academies of Sciences, Engineering, and Medicine recommended that scientists invest in ongoing input from the public regarding the benefits and risks of human genome editing, and that more research be conducted to better understand how to facilitate such a process. But to lead a national and global conversation about gene editing

38. Leon R. Kass, "The Wisdom of Repugnance," *The New Republic*, June 2, 1997.

39. Francis Fukuyama, *Our Posthuman Future: Consequences of the Biotechnology Revolution* (New York: Farrar, Straus, and Giroux, 2003).

and other powerful scientific advances, scientists will need help not only from their colleagues in the humanities, social sciences, and creative arts, but also from journalists and philanthropists. Informed public discussion about gene editing is not possible without high-quality, sustained reporting from journalists with deep knowledge of the subject. And, short of increased state investments, new initiatives designed to understand public attitudes, to facilitate public dialogue, and to report on the complexities of gene editing will not be possible without financial support from philanthropists.[40]

Addressing Inequality

Across countries, our findings indicate that those individuals who share classical liberal values oriented toward free enterprise, free inquiry, and the pursuit of knowledge, networks, and information, and who have thrived in a globalized market economy tended to be among the most optimistic about science and technology and to express fewer reservations. There were, however, important caveats and contingencies to these relationships based on the country-context in which an individual lived. The least educated residing in the richest countries tended to express much higher levels of scientific reservations than the least educated living in poorer countries: they may justifiably believe that they cannot afford or do not have access to medical advances or technological innovations; they may also fear that such innovations in areas like robotics or automation will disrupt their jobs and communities.

There is no clear "communication fix" for the deep-seated reservations that many individuals have about science and technology, reservations that our data suggest are at least partially rooted in widening levels of inequality and the role that innovation plays as a main driver of such disparities. Across advanced economies, scientific innovations have generated vast wealth for those professionals at the top of the knowledge economy, just as those same innovations have eliminated millions of jobs among those at the bottom, transforming entire industries and regions. Scientists and engineers, therefore, have both a strategic and an ethical imperative to help society cope with the negative effects of globalization and automation, forces that their advances and innovations have helped set in motion. We need broader strategic thinking about the handful of policy goals and

40. National Academies of Sciences, Engineering, and Medicine, *Human Genome Editing: Science, Ethics, and Governance* (Washington, D.C.: National Academies Press, 2017); Scheufele et al., "U.S. Attitudes on Human Genome Editing," 553–554; and Nisbet, "The Gene Editing Conversation."

investments that scientists and engineers can join with others in pursuing that would help alleviate inequality, and the threats posed to the scientific enterprise if such policies are not pursued.[41]

Rebuilding Trust in Institutions

Our findings also indicate that in wealthier countries like the United States, those expressing greater skepticism of traditional forms of authority such as the family, nation, and state were less optimistic and held stronger reservations about science and technology than their counterparts in poorer countries. In wealthy countries, those skeptical of traditional forms of authority may be more prone to view the close association between scientific research, technological innovation, militarization, and surveillance as operating in the service of elite control rather than economic growth and progress, as their counterparts in developing countries might primarily view science.

For many in the U.S. science community, there persists a strong nostalgia for mid-twentieth-century America, a Cold War era marked by large-scale public-sector investment in scientific research and technological innovation. Scientific expertise, especially in fields like physics and engineering, was considered a vital strategic asset against the Soviet Union and a major source of national pride.[42] Yet over the past few decades, as scientists and their partners have attempted to marshal stronger public sector actions to address problems like climate change, relying on technocratic expertise to justify the shift, multiple dimensions of American society have been moving in the opposite direction, becoming more diffuse, decentralized, and distrustful of technocrats.

The brief mid-twentieth-century moment was a period of unusually high institutional confidence and optimism about government specifically. When President John F. Kennedy in 1962 made his famous "we go to the moon" speech pledging to land astronauts on the moon within a decade, he infused the need for government spending and leadership on scientific research with a sense of patriotic urgency. His successful effort to mobilize federal spending came at time when nearly 80 percent of Americans said they trusted the federal government "always" or "most of the time." A

41. Matthew Nisbet, "Ending the Crisis of Complacency in Science: To Survive the Trump Administration, Scientists Need to Invest in a Strategic Vision That Mobilizes Social Change," *American Scientist* 105 (1) (2017): 18–22.

42. Matthew C. Nisbet and Dietram A. Scheufele, "What's Next for Science Communication? Promising Directions and Lingering Distractions," *American Journal of Botany* 96 (10) (2009): 1767–1778.

similar level of trust in government existed in 1970 when President Richard Nixon, responding to expert warnings about pollution and environmental degradation, signed into law the Clean Air Act and Clean Water Act and established the Environmental Protection Agency. Today, during an era of perpetually divided party control of government, as experts once again call for government mobilization and spending to address looming problems, public trust in the federal government stands at just 18 percent.[43]

So although a healthy majority of Americans continue to say that they have confidence in the leaders of the scientific community, the ability of scientific expertise to be leveraged on behalf of public-sector solutions to problems like climate change is intricately connected to and limited by waning public trust in government and almost every other major institution, including the news media, business, the legal system, universities, elites generally, and even capitalism itself. Like in the case of economic inequality, there is no communication fix for this widespread erosion in trust. Rather, the scientific community must join with the leaders of other societal sectors to identify and pursue policies and investments for restoring the health of our civic culture.[44]

43. Matthew C. Nisbet, "Sciences, Publics, Politics: The Green New Dilemma," *Issues in Science and Technology* 35 (3) (2019): 29–31.

44. The authors would like to thank John Besley of Michigan State University for commenting on an earlier version of this paper.

Appendix A: About the Authors

Matthew C. Nisbet is Professor of Communication, Public Policy & Urban Affairs at Northeastern University, Editor-in-Chief of the journal *Environmental Communication*, a columnist at *Issues in Science and Technology* magazine, and creator of the blog Wealth of Ideas (www.wealthofideas.org).

Erik C. Nisbet is Associate Professor of Communication at Ohio State University, Codirector of the Eurasian Security and Governance Program at the Mershon Center for International Security Studies, and Coprincipal Investigator on its Comparative National Elections Project.

Appendix B: Public Face of Science Steering Committee and Staff

Steering Committee

Richard A. Meserve, *Chair,* Senior Of Counsel, Covington & Burling LLP; President Emeritus, Carnegie Institution for Science

Emilio Bizzi, Institute Professor, Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology

Geoffrey Cowan, University Professor, Annenberg Family Chair in Communication Leadership, and Director of the Center on Communication Leadership & Policy, University of Southern California

Ellen Futter, President, The American Museum of Natural History

Sylvester James Gates, Jr., Ford Foundation Professor of Physics and Affiliate Professor of Mathematics, Brown University

Robert M. Hauser, Executive Officer, American Philosophical Society; Vilas Research Professor and Samuel Stouffer Professor of Sociology, Emeritus, University of Wisconsin-Madison

Rush D. Holt, Jr., Chief Executive Officer and Executive Publisher of *Science*, American Association for the Advancement of Science

Kathleen Hall Jamieson, Elizabeth Ware Packard Professor of Communication, University of Pennsylvania's Annenberg School for Communication; Walter and Leonore Annenberg Director of the Annenberg Public Policy Center, University of Pennsylvania; Program Director of the Annenberg Foundation Trust at Sunnylands

Venkatesh Narayanamurti, Benjamin Peirce Research Professor of Technology and Public Policy, Harvard University

Nora S. Newcombe, Laura H. Carnell Professor of Psychology, Temple University

Kenneth Prewitt, Carnegie Professor, Special Advisor to the President, and Director of the Future of Scholarly Knowledge Project, Columbia University

Rebecca W. Rimel, President and Chief Executive Officer, The Pew Charitable Trusts

Cristián Samper, President and Chief Executive Officer, Wildlife Conservation Society; former Director, Smithsonian National Museum of Natural History

Samuel O. Thier, Professor of Medicine and Health Care Policy, Emeritus, Harvard Medical School; President Emeritus, Brandeis University; former President, Massachusetts General Hospital; former President, Institute of Medicine, National Academy of Sciences

Project Staff

John Randell
Erica Palma Kimmerling
Rebecca Tiernan

American Academy of Arts & Sciences
Cherishing Knowledge, Shaping the Future

Since its founding in 1780, the American Academy has served the nation as a champion of scholarship, civil dialogue, and useful knowledge.

As one of the nation's oldest learned societies and independent policy research centers, the Academy convenes leaders from the academic, business, and government sectors to address critical challenges facing our global society.

Through studies, publications, and programs on Science, Engineering, and Technology; Global Security and International Affairs; the Humanities, Arts, and Culture; Education and the Development of Knowledge; and American Institutions, Society, and the Public Good, the Academy provides authoritative and nonpartisan policy advice to decision-makers in government, academia, and the private sector.

American Academy of Arts & Sciences

Selected Publications of the American Academy

Lessons from the Clean Air Act: Building Durability and Adaptability into U.S. Climate and Energy Policy by Ann E. Carlson and Dallas Burtraw (Executive Summary, 2019)

Encountering Science in America (2019)

Science During Crisis: Best Practices, Research Needs, and Policy Priorities by Rita R. Colwell and Gary E. Machlis (2019)

Perceptions of Science in America (2018)

"Science & the Legal System," *Dædalus*, edited by Shari Seidman Diamond & Richard O. Lempert (2018)

To order any of these publications please contact the Academy's Publications Office. Telephone: 617-576-5085; Fax: 617-576-5088; Email: publications@amacad.org

AMERICAN ACADEMY OF ARTS & SCIENCES

@americanacad

www.amacad.org