Theoretical/research paper

P | U | S

Science for good? The effects of education and national context on perceptions of science

Public Understanding of Science
1–20

DOI: 10.1177/0963662519863575
journals.sagepub.com/home/pus
SAGE

Shiri Noy
Denison University, USA

Timothy L. O'Brien
University of Wisconsin–Milwaukee, USA

Abstract

Pressing environmental, social, and economic problems require interventions informed by scientific expertise yet skepticism of organized science runs high among some groups. Numerous studies show how individual-level experiences and identities translate into attitudes about science, but less is known about the contextual factors that shape these beliefs. We employ regression models using data from the International Social Survey Program and the World Development Indicators to examine how national levels of scientific activity influence public perceptions of science. Our analysis of data from 76,858 individuals in 41 countries finds that education is associated with greater appreciation of science cross-nationally. This relationship is amplified in countries with high levels of scientific activity and attenuated in countries with less scientific activity. These results underscore the importance of national context for understanding perceptions of science, and suggest that improving science attitudes requires attention to both individual and country-level factors.

Keywords

cross-national research, education, public perspectives on science, science in society

1. Introduction

Educational attainment is one of the most consistent predictors of perceptions of science both in general and in specific areas of science. Researchers debate the underlying cause of this relationship, but numerous studies conclude that people with more education tend to view science favorably and are more likely to support the specific policy priorities of the scientific community (Allum et al., 2008; Evans, 2014; Gauchat et al., 2017; Miller, 2004; Sturgis and Allum, 2004). Numerous studies focus on contested science and the social cleavages that divide how people think about issues such as climate change, vaccines, and bioethics (Evans, 2018; Motta, 2019; Myers et al., 2017). However, there

Corresponding author:
Shiri Noy, Department of Anthropology & Sociology, Denison University, Granville, OH 43023, USA.
Email: snoy@denison.edu

are also wide differences in how different groups of people think about the role of science writ large in society (Chan, 2018; Myers et al., 2017; Noy and O'Brien 2016; O'Brien and Noy, 2018).

These studies provide critical insights about the individual-level dynamics that shape science attitudes, but they are often limited to samples in the United States or the United Kingdom. These within-country analyses necessarily set aside questions about how contextual factors may guide perceptions of science. Yet, social contexts have powerful effects on how people think about a wide range of social and political issues (Finke and Adamczyk, 2008; Franzen and Meyer, 2010; Summers, 2016). If science attitudes also depend on contextual factors, then findings from within countries may not generalize to other places. It would also mean that improving public perceptions of science may require country-specific strategies that account for the unique cultural contexts in which people form their opinions of science.

In this article, we examine how individual and contextual factors interactively shape perceptions of science. We are especially interested in whether national scientific contexts affect the relationship between education and science attitudes. Although science is often thought of as a method of gathering information or the body of subsequent knowledge, researchers also stress its normative orientation, which reflects core values of modernity such as secularism, rationality, and liberalism (Drori et al., 2003; Evans, 2018). Materially, we anticipate that these values are reflected in the overall levels of scientific activity present in a society. Societies where scientific values are most central are likely to be characterized by extensive levels of investment in research and development (R&D) and large scientific workforces. In these contexts, not only are social attitudes more heterogeneous, personal identities and experiences are more important for their formation (Giddens, 1991; O'Brien and Noy, 2018). Thus, the individual-level bases of perceptions of science have their greatest impact on science attitudes in settings with the highest levels of scientific activity. In contrast, in places where scientific values are less central, social attitudes are more homogeneous and personal identities are less important to them. In these settings, the link between education and science attitudes is relatively weak.

We test these ideas using data from the International Social Survey Program (ISSP). Our analysis of data from 76,858 individuals in 41 countries supports our claims. We find that higher levels of educational attainment are associated with more favorable science attitudes across countries. However, the relationship is strongest in countries with the most scientific activity and weakest in those with the least. These findings underscore the importance of contextual level factors in steering perceptions of science. They also suggest that increasing exposure to science through education may be most effective at minimizing resistance to science in places where scientific values are relatively prominent.

2. Literature review

Science in society

Researchers' attention to the role of science in society and publics' response to this arrangement intensified alongside the increasing scope of scientific activity after World War II, especially in the areas of defense and economics (Mejlgaard and Bloch, 2012; Nowotny et al., 2005). Contemporary research on science attitudes continues to investigate these issues and has expanded its focus to issues such as public health, the environment, and privacy. Altogether, the importance of science as a framework for addressing social problems related to security, economics, the environment, and other issues suggests that whether and how publics understand science is a problem of countries, societies, and governments, rather than individuals.

Recent social scientific work reflects a growing recognition that science attitudes are guided not only by individuals' identities and experiences, but also by the national contexts that provide the normative backdrop against which socio-political attitudes are formed (Chan, 2018; Evans, 2014; O'Brien and Noy, 2018; Price and Peterson, 2016). To date, however, there is relatively little research about how national contexts moderate the relationships between individual characteristics and perceptions of science. Instead, existing research often focuses on individuals' exposure to science and how this experience steers their perceptions of science.

Education and orientations toward science

The individual-level experiences and identities that shape perceptions of science have been a central focus of research on public understanding of science for decades. One of the most consistent findings from these studies is that education has a positive association with attitudes about science (Allum et al., 2008; Miller, 2004; Snow and Dibner, 2016). However, the mechanisms connecting educational attainment to perceptions of science continue to be debated.

One possibility is that education exposes people to science and increases their appreciation of science by increasing awareness of its benefits and reducing fears of its risks (Miller, 2004). In this view, exposure to science's intellectual content is the vehicle that translates education into science attitudes. Cross-nationally, this research often emphasizes measuring science literacy among students, and concludes that science education is key to increasing public appreciation of science (Hofstein et al., 2011). Public resistance to science is believed to be rooted in ignorance and misunderstanding of science and fear of its potential risks (Irwin and Wynne, 1996; Sturgis and Allum, 2004). Although the effects detected by these studies are typically modest, there is some empirical support for this argument. For example, one meta-analysis found that attitudes about science were correlated with knowledge of scientific facts cross-nationally (Allum et al., 2008). Moreover, populations with higher levels of education report more trust in science compared with less educated populations (Gauchat, 2011; Inglehart, 1997). In sum, this perspective suggests that formal education increases exposure to science and in turn enhances appreciation of science, and that this relationship is not anchored to a particular cultural context.

Alternatively, a growing body of research on science attitudes approaches science in terms of its normative orientation, rather than its epistemological content. In this view, the mechanism connecting education to science attitudes is cultural rather than intellectual. Specifically, orientations toward science are thought to reflect values and tastes acquired through contact with Western cultural institutions, such as schools (Bourdieu, 1984; Drori et al., 2003). From this vantage, the education system is seen primarily as an agent of socialization rather than a means for transmitting knowledge. Scientific values such as rationality and secularism are embedded throughout the education system, and students gradually internalize these preferences as alternative values sets that are made invisible. Thus, the positive effect of education on science attitudes does not stem from science's intellectual content, but from the value orientation instilled by the education system. Given the cultural specificity of this relationship, however, it suggests that the link between exposure to science and attitudes is moored to a particular cultural context and does not generalize cross-nationally.

National context and perceptions of science in society

Weber's work on rationalization paid some of the earliest social scientific attention to the role of science in society (Weber, 1930 [1904]). More than a century later, social scientists continue to investigate processes of modernization (Drori et al., 2003; Gorski, 2012; Locke, 2001; Schofer, 2004). Habermas (1981) has been especially influential in developing a model of modernity in which instrumental rationality increasingly displaces other ways of knowing. Proponents of this view cite the secularization of public institutions (Gorski, 2012) and the declining formal influence of religious leaders in Western countries (Bruce, 2002; Inglehart and Baker, 2001) as evidence of the increasing prevalence of a scientific mind-set. In general, these scholars argue that the pervasiveness of science in modern society reflects widespread adherence to instrumental rationality among individuals (Habermas, 1981; Locke, 2001).

Cross-national psychological research also points to systematic differences in cultural orientations across societies. In particular, Hofstede (2011) argues that societies exist on a spectrum ranging from collectivism to individualism, with more individualist societies characterized by rights of privacy, personal self-expression, and a focus on tasks over relationships. Similarly, Gelfand et al. (2011) characterizes societies on a continuum from "looseness" to "tightness" depending on the strength of societies' social norms. A society's place on this construct is also likely important for guiding its members socio-political attitudes. However, a society's location on this continuum is distinct from its degree of modernity. In particular, cultural "tightness" is determined both by ecological and historical threats, such as conflict and natural disasters, and by its own institutions, such as its legal system and media. Further, high levels of scientific activity and some scientific, rational values may be present in either loose or tight countries in terms of norms and sanctions (e.g. the U.S. as compared with Japan).

Also related to processes of modernization, a society's level of affluence may affect its members' trust in science. For example, Bauer et al. (1994) found that attitudes about science are more favorable in countries with high levels of economic development compared with low levels of economic development. Evans (2014) corroborated this finding more recently. Empirically, researchers have used indicators of economic development to explain international variation in the public's appreciation of science (Allum et al., 2008; Bauer et al., 1994, 2000; Price and Peterson, 2016). Specifically, these studies show that countries with higher levels of economic development tend to report higher levels of appreciation of science.

Although national economic development is often associated with national levels of scientific activity, the link is not inevitable. For example, less affluent countries may maintain scientific institutions to signal legitimacy to the international community (Drori et al., 2003). One recent study found that national levels of scientific activity predicts perceptions of science and religion, net of differences in economic development (O'Brien and Noy, 2018). Scholars also argue that the bases of science attitudes depend on economic context. Skepticism of science in the least industrial countries is thought to result from weaker education systems and less familiarity with science. In contrast, skepticism of science in the most industrialized European societies is thought to reflect a critical stance toward science that stems from a higher degree or familiarity with science and active engagement with its impact (Dierkes and Von Grote, 2000; Pardo and Calvo, 2002). However, these studies say little about how different countries with similar levels of economic development steer their members' worldviews. Furthermore, examining levels of scientific activity, rather than economic growth or development, may better capture countries' emphases on instrumental rationality.

Cross-national studies suggest that macro-level factors such as a society's relationship to scientific values may affect public attitudes about science. In general, these studies suggest that perceptions of science are more favorable in societies where scientific values are most central. However, it is not clear whether macro-level scientific contexts mediate the effect of individual level predictors of perceptions of sciences. On one hand, it is possible that high levels of scientific activity intensify the relationship between individual level predictors, such as education, and attitudes about science. High levels of scientific activity signal the importance of scientific values, such as rationality and liberalism. In these contexts, social attitudes are more diverse and individual experiences are more salient in their formation. Thus, individual characteristics may be more prominent in shaping individuals' social attitudes in these contexts. On the other hand, it may be that scientific activity at the national level weakens the relationship between individuals' exposure to science and science attitudes. In these countries, the prominence of scientific values may lead to more positive attitudes about science in general, regardless of individuals' educational attainment or other sociodemographic characteristics. That is, in societies characterized by relatively high levels of scientific activity, individual experiences such as education may not be as closely related to individuals' perspectives on science.

3. Data

We use data from the ISSP to examine perceptions of science. Since the 1980s, researchers have fielded annual surveys to national samples in countries around the world. We focus on the 2008 and 2010 surveys, which contain a measure of the perceived costs and benefits of science. We exclude cases with missing information on variables of interest and analyze responses from 76,858 individuals in 41 countries.[1] The mean sample size is 1300 individuals per country. Of the 41 countries we analyze, 26 participated in both waves of data collection and 15 participated only in 2008 or 2010.

Dependent variable

Perceptions of science. The dependent variable comes from a survey question that asked if respondents strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree with the following statement: "Overall, modern science does more harm than good." We collapse the disagree and strongly disagree categories to create a binary variable, comparing respondents who disagree that science does more harm than good to others. Figure 1 summarizes the dependent variable by country. To facilitate the presentation of results, we present the binary specification of the outcome variable in the article noting that additional analyses of the original five-category coding of the variable, contained in Supplemental Appendix A, led to similar conclusions (see Supplemental Table A1, Figures A1 and A2).

Independent variables

Education. The literature reviewed earlier suggests that exposure to science shapes people's perceptions of science. Because the ISSP lacks information on exposure to science or scientific education, we rely on educational attainment. As formal schooling progresses, students are increasingly exposed to scientific information. This may in turn shape their views of science (Allum et al., 2008; Evans, 2014; Gauchat, 2015; Miller, 2004; Sturgis and Allum, 2004). To measure individuals' educational attainment, we use a six-category variable ranging from "no formal educational qualification" to "university degree." While a measure of science education would be preferable as it captures exposure to science more directly, the measure of degree attainment we use is valuable because it allows for cross-national comparisons between countries with different education systems. Table 1 contains summary statistics for independent variables in our analysis.

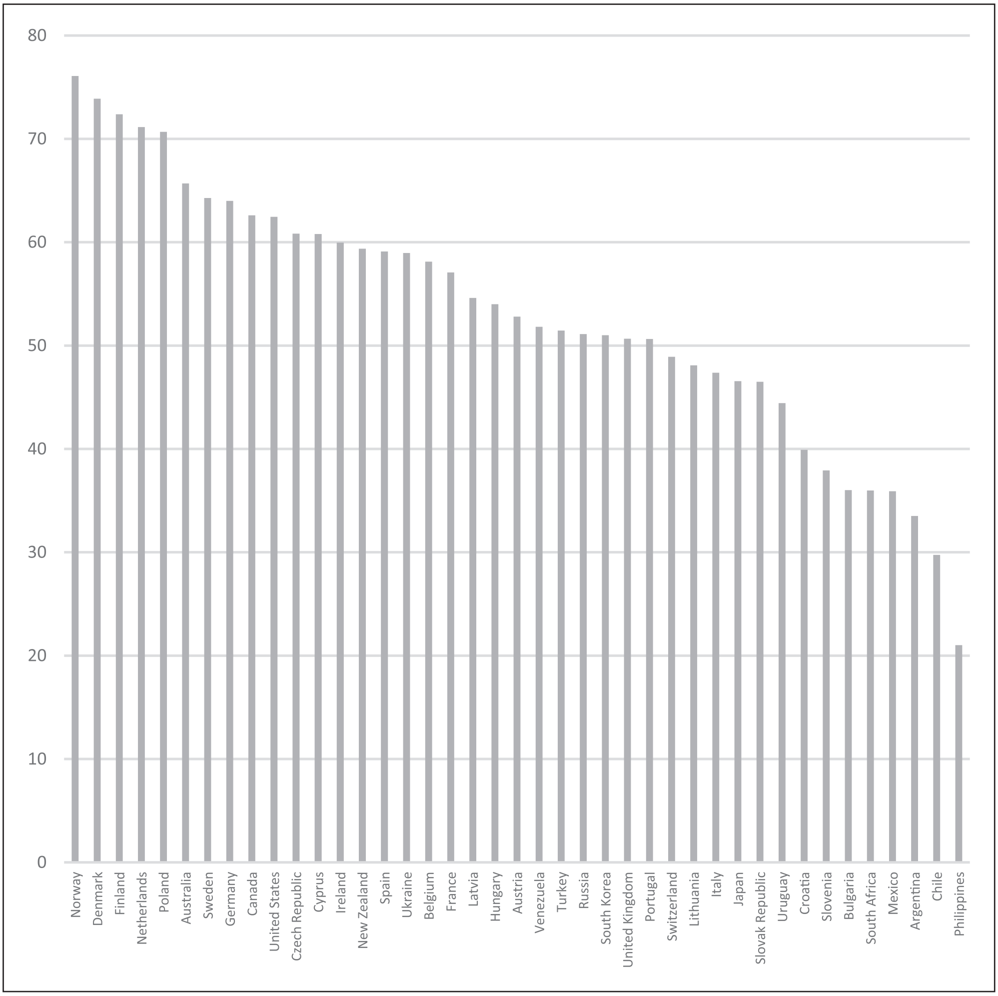

Figure 1. Percent of respondents by country who disagree science does more harm than good.
Source: 2008 and 2010 ISSP (n = 76,858).

National scientific activity. There is also reason to expect that national scientific context matters for how people think about science. To measure national scientific context, we use a variable from the World Development Indicators that specifies the size of a country's R&D workforce per 1000 residents. The World Bank defines this variable as the number of

> professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned. Postgraduate PhD students engaged in R&D are included. Data on researchers and technicians in R&D are measured in both full-time equivalent and headcount but are shown in full-time equivalent only. (World Bank, 2019)

We interpret this item as an indicator of a nation's overall level of scientific activity. Analyses of several alternative measures of scientific activity such as R&D spending as percentage of gross

Table 1. Descriptive statistics for independent variables.

	Mean/ proportion	Standard deviation	Minimum	Maximum
Individual level variables (n = 76,858)				
Education (highest degree earned)[a]	2.77	1.48	0	5
Religiosity (attendance at religious services)[b]	3.84	2.30	1	8
Female	0.55	–	0	1
Age (years in decades)	4.71	1.73	1.50	9.80
Religious tradition				
Catholic	0.36	–	0	1
No religion	0.30	–	0	1
Protestant	0.17	–	0	1
Orthodox	0.06	–	0	1
Jewish	<0.01	–	0	1
Muslim	0.05	–	0	1
Buddhist	0.02	–	0	1
Hindu	<0.01	–	0	1
Other	0.03	–	0	1
Household income				
<50% CMI	0.13	–	0	1
50%–80% CMI	0.11	–	0	1
80%–120% CMI	0.12	–	0	1
>120% CMI	0.52	–	0	1
missing income	0.12	–	0	1
Country level variables (n = 41)				
R&D workforce (number of research and development workers per 1000 residents)	2.85	1.84	0.08	7.69
National political rights (higher is more rights)	5.51	1.08	1	6
GDP per capita (natural log transformed)	10.24	0.52	8.58	11.08

Source: 2008 and 2010 ISSP.
CMI: country mean income; R&D: research and development; GDP: gross domestic product.
[a]Categories are "none," "lowest credential," "above lowest credential," "secondary degree," "above secondary degree," and "university degree"
[b]Categories are "never," "less than once a year," "once a year," "several times a year," "once a month," "two to three times a month," "once a week," and "more than once a week."

domestic product (GDP), the number of scientific articles produced, and the percentage of the population with Internet access all produced similar results.[2]

Control variables. Regression models control for several individual-level characteristics that may influence people's perceptions of science. We control for religious differences in two ways. First, we use a survey question that asked respondents how frequently they attend religious services on an 8-point scale ranging from "never" to "more than once a week." Second, we control for religious traditions using binary variables indicating whether respondents were Catholic, Protestant, Orthodox Christian, Jewish, Muslim, Buddhist, Hindu, another religion, or unaffiliated with organized religion. We measure gender using a binary variable that equals one for female respondents. We measure age in decades. We measure income by comparing respondents' household income to their country's mean level of household income (country mean income (CMI)). Income categories are (1) less than 50% of CMI, (2) 50%–80% CMI, (3) 80%–120% CMI, and (5) greater than 120% CMI. We include the roughly 12% of cases with missing income data as a separate category in regression analyses.

We also control for country-level differences in political culture and economic development. We measure political culture using the 2008 Freedom House ratings of political rights.[3] In our analysis, higher scores are coded to indicate more rights. We measure economic development with a natural log transformation of GDP per capita, which was obtained from the World Development Indicators. Finally, since data are pooled from two waves of ISSP data collection, we include a binary measure of survey year.

4. Analytic strategy

To account for the data's hierarchical structure—individuals nested within countries—we use mixed-effects binary logistic regression models (Rabe-Hesketh and Skrondal, 2013). In these models, intercept and slope coefficients are functions of country-level variables, which allow us to examine how science attitudes are shaped by both individual and national characteristics. We estimate a series of random intercepts models to determine the effects of individual- and country-level variables on perceptions of science. The regression model is

$$\log\left(p_{ij}\left(y=1\right)\right)=\beta_{0j}+\beta_1 P_{ij}+\beta_2 C_j+\varepsilon_{ij}$$

where $p_{ij}(y=1)$ is the probability that respondent *i* in country *j* disagrees that science does more harm than good. β_{0j} is a country-specific intercept, *P* and *C* are individual- and country-level independent variables, respectively, and ε is an error term. The country-specific intercept depends on a normally distributed random component, with a mean of zero and nonzero variance, which is represented as

$$\beta_{0j}=\beta_0+\zeta_j$$

5. Results

Cross-national variation in perceptions of science

Figure 1 contains descriptive statistics for the dependent variable. It shows that attitudes about science are relatively favorable worldwide. In roughly two out of every three countries in these data (27 of 41), a majority of respondents disagree that science does more harm than good. However, there is substantial cross-national variation. For example, only one in five Filipinos disagrees that science does more harm than good, compared with three out of four Norwegians. The intra-class correlation coefficient (not shown) indicates that approximately 7% of the variance in perceptions of science results from differences between countries. This suggests that although individual-level differences account for much of the variation in these beliefs, country context also plays an important role.

Individual-level determinants of perceptions of science

Table 2 contains results from mixed-effects binary logistic regressions of perceptions of science. Model 1 contains only individual-level variables. As anticipated, it suggests that people with higher

Table 2. Mixed effects binary logistic regressions of attitudes about the effect of science on covariates ($n = 76{,}858$).

	Model 1 Individual-level covariates	Model 2 + country-level covariates	Model 3 + cross-level interaction
Individual-level variables			
Education	0.24***	0.24***	0.14***
	(0.01)	(0.01)	(0.01)
Religiosity	−0.05***	−0.05***	−0.05***
	(0.00)	(0.00)	(0.00)
Female	−0.17***	−0.17***	−0.17***
	(0.02)	(0.02)	(0.02)
Age	<0.01	0.01	−0.01
	(0.01)	(0.01)	(0.01)
No religion[a]	0.06**	0.06**	0.06**
	(0.02)	(0.02)	(0.02)
Protestant[a]	−0.11***	−0.11***	−0.10***
	(0.03)	(0.03)	(0.03)
Orthodox[a]	0.01	0.02	0.02
	(0.05)	(0.05)	(0.05)
Jewish[a]	0.07	0.07	0.06
	(0.17)	(0.17)	(0.17)
Muslim[a]	−0.33***	−0.31***	−0.30***
	(0.07)	(0.07)	(0.07)
Buddhist[a]	−0.05	−0.06	−0.02
	(0.07)	(0.07)	(0.07)
Hindu[a]	0.18	0.19+	0.21+
	(0.11)	(0.11)	(0.11)
Other religious tradition[a]	−0.10+	−0.09+	−0.10*
	(0.05)	(0.05)	(0.05)
<50% CMI[b]	−0.21***	−0.21***	−0.21***
	(0.03)	(0.03)	(0.03)
50%–80% CMI[b]	−0.09**	−0.09**	−0.09**
	(0.03)	(0.03)	(0.03)
>120% CMI[b]	0.16***	0.16***	0.16***
	(0.03)	(0.03)	(0.03)
missing income[b]	−0.10**	−0.10**	−0.08**
	(0.03)	(0.03)	(0.03)
Country-level variables			
R&D workforce		0.06	−0.04
		(0.05)	(0.05)
Political rights		−0.06	−0.05
		(0.06)	(0.06)
Log of GDP per capita		0.49**	0.48**
		(0.18)	(0.18)
Cross-level interaction			
Education (L1) * R&D Workforce (L2)			0.04***
			(0.00)

(Continued)

Table 2. (Continued)

	Model 1 Individual-level covariates	Model 2 + country-level covariates	Model 3 + cross-level interaction
Year, 2008	0.64***	0.64***	0.64***
Constant	−0.67***	−5.55***	−5.24***
Country variance	0.22***	0,12***	0.12***
Log likelihood	−48737.53	−48725.41	−48652.91
Bayesian information criterion	97688.80	97698.32	97564.57

Source: 2008 and 2010 International Social Survey Program.
CMI: country mean income; R&D: research and development; GDP: Gross domestic product.
Standard errors in parentheses.
[a]Catholic is referent.
[b]80%–120% CMI is referent.
*$p < 0.05$, +p<0.10, *p<0.05, **p<0.01, ***p<0.001 (two-tailed tests).

levels of education have more positive views of science, net of other differences. Several control variables also have significant effects in expected directions. For example, women, religious people, and people with less income have less favorable views of science compared with men, less religious people, and those with more income. In addition, compared with Catholics, Protestants and Muslims each hold less favorable views of science while those who are unaffiliated with religion have more favorable beliefs, all else equal. Although our primary focus is on education, these patterns are consistent with existing research that finds that gender, religiosity, and social class each steer how people think about science (Chan, 2018; O'Brien and Noy, 2018). These results, therefore, provide evidence of the model's validity.

Contextual determinants of perceptions of science and cross-level interactions

Model 2 in Table 2 adds country-level variables for scientific activity, political culture, and economic development. Only economic development has a statistically significant effect in the model. Specifically, residents of wealthier nations have more favorable views of science, all else equal. This aligns with other studies of economic development and science attitudes (Evans, 2014; Price and Peterson, 2016). Notably, the effect of national scientific activity is not significant in Model 2. That is, a society's level of engagement with science does not appear to differentiate its residents' science attitudes on average.[4] However, social attitudes in modern societies depend heavily on personal experiences and identities (Giddens, 1991). This suggests that country contexts may moderate the link between individuals' education and their science attitudes.

We test this possibility in Model 3 in Table 2, which includes an interaction between individuals' level of education and countries' level of scientific activity. The coefficient for the interaction is significant, indicating that the strength of the relationship between education and support for science is moderated by national scientific context. The positive direction of the interaction coefficient means that the positive relationship between education and science attitudes is stronger in countries that invest more in science and weaker in societies that invest less.[5]

Figure 2 illustrates these findings by graphing the predicted probabilities of disagreeing that science does more good than harm for individuals at each level of educational achievement in three different country contexts: those with low, average, and high levels of scientific activity.[6] Two key

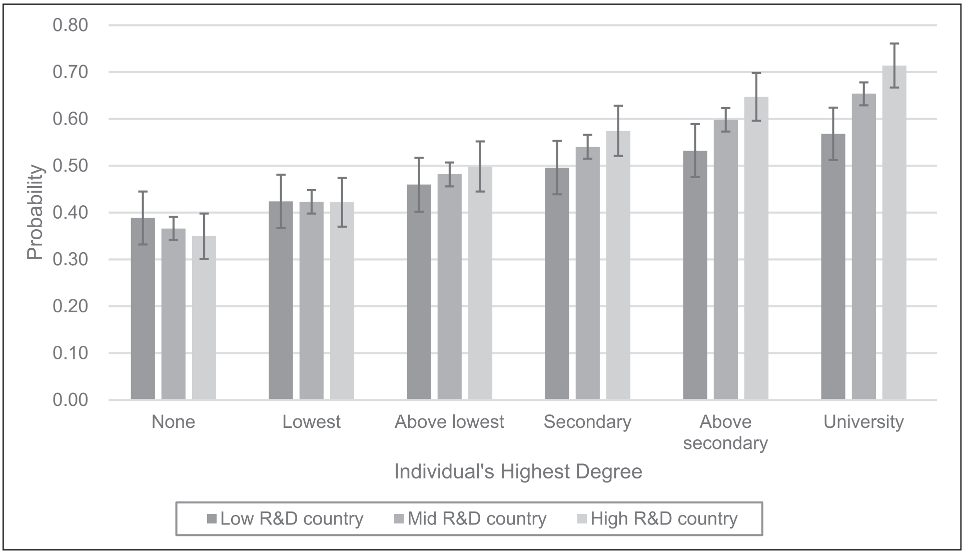

Figure 2. The effect of education on attitudes about the effects of science by levels of national scientific activity. Graph contains the predicted probabilities with 95% confidence intervals of disagreeing that science does more harm than good, adjusted for respondents' personal characteristics and national contexts. High, middle, and low national engagement with science are defined as countries at the 90th, 50th, and 10th percentiles of the R&D workforce variable. Predictions are based on Model 3 in Table 2. Data are from 2008 and 2010 ISSP ($n = 76{,}858$).

findings stand out. First, the probability of disagreeing that the harm of science outweighs its good increases as education increases. This suggests that the positive effect of education on science attitudes generalizes across countries. Second, Figure 2 indicates that the relationship between education and science attitudes strengthens as national levels of scientific activity increases. For example, the first cluster of bars indicates that among those without a formal educational credential, there is little difference in science attitudes across country contexts. However, as education increases, so too do the gaps between those in different country contexts. The final cluster of bars in the figure illustrates that among university degree holders, the probability of disagreeing that science causes more harm than good is considerably higher in countries with high levels of scientific activity compared with low levels of scientific activity (.71 vs .57). In other words, highly educated individuals in countries with high levels of scientific activity are more optimistic about science compared with their educational peers in countries where science is less central.

To further illustrate the differential effect of education on science attitudes, Figure 3 contains the marginal difference in science attitudes between the most and least educated people in countries with low, average, and high levels of scientific activity. The first bar shows the effect of education on science attitudes in countries with low levels of scientific activity. It indicates that the difference in the probability of observing the outcome between the most and least educated members of these countries is .18. The effect of education grows by more than half to .29 in countries with average levels of scientific activity, and grows further to .36 in countries with high levels of scientific activity. In other words, while education is linked to more favorable views of science cross-nationally, its effect on science attitudes is roughly twice as large in countries with high levels of scientific activity compared with low levels of scientific activity.[7]

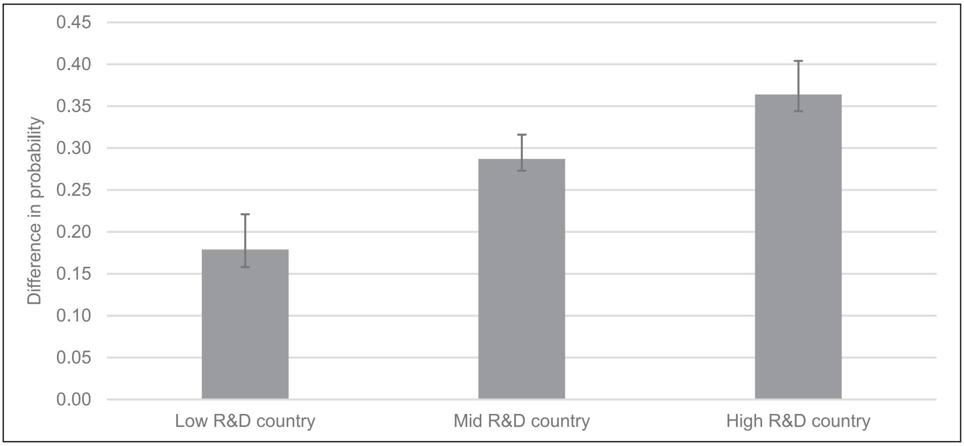

Figure 3. Marginal education differences in attitudes about the effect of science adjusted for individual- and country-level characteristics. Graph contains marginal differences in predicted probabilities with 95% confidence intervals of disagreeing that science does more harm than good between individuals with a college degree and those with no formal educational credential. Results are presented for countries at the 90th, 50th, and 10th percentiles of the R&D workforce variable. Predictions are based on Model 3 in Table 2. Data are from 2008 and 2010 ISSP (n = 76,858).

6. Discussion

Overcoming political opposition to science-based decision making requires a firm understanding of public perceptions of science. Exposure to scientific information and values through formal education is often identified as one of the most important determinants of these beliefs. Yet, much less is known about how social contexts affect these attitudes, or how contextual factors may influence the relationship between individual-level factors and perceptions of science. This article contributes to research on the public understanding of science by examining whether (1) the link between education and science attitudes generalizes across countries and if so (2) whether the relationship varies across national levels of scientific activity.

Our analysis of international survey data found that educational attainment is associated with science attitudes in countries around the world. People with more education tend to be more optimistic about science, across a variety of countries. Social scientists have proposed multiple explanations for the relationship between education and perceptions of science. While it is difficult to support strong causal claims with cross-sectional data, these results suggest that the mechanism linking education to science attitudes is not culturally specific. Although this study cannot rule out the possibility that education leads to more favorable science attitudes for different reasons in different countries, at a minimum, this article shows that the empirical patterns are similar in countries around the world.

We found also that national scientific contexts affect the relationship between education and science attitudes. More concretely, the effect of education on science attitudes is roughly twice as large in countries with high levels of scientific activity compared with low levels of scientific activity. We argue that this reflects the value orientation of societies with large investments in science and technology. Specifically, these societies' emphasis on rationality and individualism makes personal experiences and identities more important in the formation of social attitudes (Giddens, 1991). When it comes to science attitudes, the positive effect of education on these beliefs is therefore strengthened in settings where scientific activity is relatively high. In other words, national scientific activity affects how education translates into people's opinions of science in society. This also implies that in contexts with high levels of scientific activity, a lack of exposure to science is especially important to understanding opposition to science. Our confidence in this interpretation of results is bolstered by supplementary analysis of individualism as a country-level indicator (results not shown). These additional analyses examined Hofstede's (2019) measure of country-level individualism and found that the link between education and science attitudes is strongest in the most individualistic societies. Unfortunately, this alternative measure of individualism is only available for a subset of the countries in the ISSP data set, and publicly available for 2015, which is several years after the survey waves we analyze.

These results provide new information about the foundations of science attitudes, but should be interpreted in light of several features of the data. First, the survey question that we analyzed as a dependent variable does not distinguish between the social or individual effects of science. Respondents may have interpreted this question to refer to the role that science plays in their own lives or in society more broadly. While these data cannot evaluate the meaning respondents attributed to survey questions, the dependent variable came from a series of survey questions focused on societal rather than individual level issues. For example, it appeared on the survey questionnaire alongside items that asked respondents to consider statements such as "looking around the world, religions bring more conflict than peace" and "modern science will solve our environmental problems with little change to our way of life." This feature of the survey design suggests that respondents were primed to think about the role of science in society more broadly rather than in their own personal lives.

Moreover, cross-sectional data such as these do not allow us to empirically disentangle the mechanisms we suspect are driving the results. It may be that formal education represents a cultural and value orientation which makes individuals more appreciative of science, and that in societies with high levels of scientific activity schooling is an especially important source of these values. However, it is also plausible that in more scientific societies the scientific information conveyed through schooling is of higher quality, which accounts for its greater impact on people's attitudes about science in these contexts. Further study is needed to determine which, if either of these processes accounts for the empirical patters documented in this article. However, even without a definitive understanding of the causal mechanism, this study provides new evidence that national scientific activity intensifies the relationship between education and science attitudes. These results, therefore, suggest that national context must be considered in efforts to communicate scientific information to the public.

Recent research emphasizes the importance of interest in science for understanding science attitudes (Motta, 2019). Unfortunately, these data do not provide information about respondents' interest in science. International surveys such as the ISSP should continue to develop more fine-grained tools for measuring individuals' experience with and interest in science, and should also extend data collection to a wider variety of countries. The ISSP is admirable in its collection of high-quality cross-national data, but future research should widen the scope further by including more countries from the global south and other developing regions.

Despite these limitations, this article offers new insight about how people weigh the potential harm and good caused by science. Results offer some evidence that programs aimed at increasing public exposure to science may be effective at improving public perceptions of science, especially in countries with high levels of scientific activity. Importantly, however, these results also suggest that efforts to increase exposure to science will meet different levels of success depending on country context. In sum, as science communicators, educators, and others consider ways to improve public perceptions of science, their strategies must account for the individual-level identities and experiences that shape how people think about science as well as the cultural contexts in which these beliefs are formed.

Acknowledgements

The authors thank Shawna Smith, the editor, and anonymous reviewers for comments and suggestions that have served to strengthen the manuscript.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Shiri Noy https://orcid.org/0000-0002-0755-1652
Timothy L. O'Brien https://orcid.org/0000-0001-7382-8245

Notes

1. A total of 15% of the sample is excluded due to missing data on individual-level independent variables. Compared with cases included in the analysis, excluded respondents were less educated and less religious, on average. They were also slightly older and more likely to be female.
2. We find that education's positive effect on attitudes about science is most pronounced in countries that produce the most scientific publications, spend the most on R&D, and have populations with the greatest Internet penetration. The effect of each of these alternative measures of national scientific activity are consistent with the effect of the R&D workforce variable that we analyze in this article. Altogether, the similarity of patterns associated with each of these measures bolsters our confidence in the validity of the measure of scientific activity presented in the article.
3. According to Freedom House,

   countries and territories with a rating of 1 enjoy a wide range of political rights, including free and fair elections. Candidates who are elected actually rule, political parties are competitive, the opposition plays an important role and enjoys real power, and the interests of minority groups are well represented in politics and government. Countries and territories with a rating of 2 have slightly weaker political rights than those with a rating of 1 because of such factors as political corruption, limits on the functioning of political parties and opposition groups, and flawed electoral processes. Countries and territories with a rating of 3, 4, or 5 either moderately protect almost all political rights or strongly protect some political rights while neglecting others. The same factors that undermine freedom in countries with a rating of 2 may also weaken political rights in those with a rating of 3, 4, or 5, but to a greater extent at each successive rating. Countries and territories with a rating of 6 have very restricted political rights. They are ruled by authoritarian regimes, often with leaders or parties that originally took power by force and have been in office for decades. They may hold tightly controlled elections and grant a few political rights, such as some representation or autonomy for minority groups. Countries and territories with a rating of 7 have few or no political rights because of severe government oppression, sometimes in combination with civil war. While some are draconian police states, others may lack an authoritative and functioning central government and suffer from extreme violence or rule by regional warlords. (Freedom House, 2019). No country in our sample was rated at 7 in the original Freedom House coding, that is, the lowest level of national political rights.
4. We also examined a curvilinear specification of scientific activity, which was not statistically significant.
5. We also examined an additional dependent variable based on a survey question that asked respondents their level of agreement with the statement: "Modern science will solve our environmental problems with little change to our way of life." Results were consistent with those discussed in this article, namely, the link between perceptions of science and education is moderated by national levels of scientific activity.

6. In Figures 2 and 3, we define low, average, and high levels of scientific activity as the 10th, 50th, and 90th percentiles of the R&D workforce variable.
7. Analyses of the untransformed five-category dependent variable, summarized in Supplemental Appendix A, led to similar conclusions about the link between education, scientific activity, and perceptions of science. Supplemental Figure A1 contains predicted probabilities based on a mixed effects ordinal logit regression model contained in Supplemental Table A1. The figure shows that the probability of "strongly agreeing" and "agreeing" that science does more harm than good each decrease as individuals' educational attainment increases. However, the decrease is most pronounced for residents of countries with high levels of scientific activity. Supplemental Figure A1 also shows that the probabilities of "strongly disagreeing" and "disagreeing" both increase as individuals' education increases. Once again, the relationship is strongest among countries with the highest levels of scientific activity. Supplemental Figure A2 illustrates these differences more directly by graphing the differences in predicted probabilities between the most and least educated individuals in each country context (i.e. those with university degrees compared with those with no formal schooling). The figure shows that there is a significant education gap in the probabilities of "strongly agreeing" and "agreeing" that science does more harm than good, that is–those with lower education are more likely to agree and strongly agree that science causes more harm than good, and that the gap is larger in countries with higher levels of scientific activity compared with lower levels of scientific activity, though this effect is less pronounced for the "strongly agree category. Conversely, Supplemental Figure A2 indicates that there is also a significant education gap in the opposite direction (that is, the less educated are less likely to disagree that science does more harm than good) in the probabilities of "strongly disagreeing" and "disagreeing" that science does more harm than good, which increases alongside national scientific activity. Overall, these additional analyses suggest that patterns of results at each level of the five-category outcome variable are similar to those from analyses of the binary transformation of the variable presented in the main text. Given the large number of comparisons needed to interpret findings from the ordinal logit models, we focus our discussion in the main text on the binary coding of the outcome variable.

References

Allum N, Sturgis P, Tabourazi D and Brunton-Smith I (2008) Science knowledge and attitudes across cultures: A meta-analysis. *Public Understanding of Science* 17(1): 35–54.

Bauer, M, Durant, J, and Evans, G (1994) European Public Perceptions of Science. *International Journal of Public Opinion Research* 6(2): 163–86.

Bauer, M, G Gaskell, J Durant, C Midden, M Liakopoulous, and L Scholten (2000) Two cultures of public understanding of science and technology in Europe. Pp. 131–156 In M Dierkes and C von Grote (eds.) *Between Understanding and Trust: the Public, Science and Technology*. Routledge, Amsterdam, The Netherlands.

Bourdieu P (1984) *Distinction: A Social Critique of the Judgement of Taste*. Cambridge, MA: Harvard University Press.

Bruce, S (2011) *Secularization: In Defense of an Unfavorable Theory*. Oxford: Oxford University Press.

Chan E (2018) Are the religious suspicious of science? Investigating religiosity, religious context, and orientations towards science. *Public Understanding of Science* 27(8): 967–984.

Dierkes M and Von Grote C (eds) (2000) *Between Understanding and Trust: The Public, Science and Technology*. Amsterdam: Harwood Academic Publishers.

Drori GS, Meyer JW, Ramirez FO and Schofer E (2003) *Science in the Modern World Polity: Institutionalization and Globalization*. Stanford, CA: Stanford University Press.

Evans JH (2014) Faith in science in global perspective: Implications for transhumanism. *Public Understanding of Science* 23(7): 814–832.

Evans, JH (2018) *Morals not knowledge: recasting the contemporary US conflict between religion and science*. Oakland,CA: University of California Press.

Finke R and Adamczyk A (2008) Cross-national moral beliefs: The influence of national religious context. *The Sociological Quarterly* 49(4): 617–652.

Franzen A and Meyer R (2010) Environmental attitudes in cross-national perspective: A multilevel analysis of the ISSP1993 and 2000. *European Sociological Review* 26(2): 219–234.

Freedom House (2019) Methodology. Available at: https://freedomhouse.org/report/methodology-freedom-world-2018 (accessed 28 March 2019).

Gauchat G (2011) The cultural authority of science: Public trust and acceptance of organized science. *Public Understanding of Science* 20(6): 751–770.

Gauchat G (2015) The political context of science in the United States: Public acceptance of evidence-based policy and science funding. *Social Forces* 94(2): 723–746.

Gauchat G, O'Brien TL and Mirosa O (2017) The legitimacy of environmental scientists in the public sphere. *Climatic Change* 143(3–4): 297–306.

Gelfand M, Raver JL, Nishii L, Leslie LM, Lun J, Lim BC, et al. (2011) Differences between tight and loose cultures: A 33-nation study. *Science* 332(6033): 1100–1104.

Giddens A (1991) *Modernity and Self-identity: Self and Society in the Late Modern Age*. Stanford, CA: Stanford University Press.

Gorski PS (2012) Secularization: In defence of an unfashionable theory. *Sociology of Religion* 73(1): 99–100.

Habermas J (1981) *The Theory of Communicative Action: Lifeworld and System: A Critique of Functionalist Reason, vol. 2*. Boston, MA: Beacon.

Hofstede G (2011) Dimensionalizing cultures: The Hofstede model in context. *Online Readings in Psychology and Culture* 2(1): 8.

Hofstede G (2019) Dimension data matrix. Available at: https://geerthofstede.com/research-and-vsm/dimension-data-matrix/ (accessed 23 March 2019).

Hofstein A, Eilks I and Bybee R (2011) Societal issues and their importance for contemporary science education —A pedagogical justification and the state-of-the-art in Israel, Germany, and the USA. *International Journal of Science and Mathematics Education* 9(6): 1459–1483.

Inglehart R (1997) *Modernization and Postmodernization: Cultural, Economic, and Political Change in 43 Societies*. Princeton, NJ: Princeton University Press.

Inglehart, R and W Baker (2000) Modernization, Cultural Change, and the Persistence of Traditional Values. *American Sociological Review* 64: 19–51.

Irwin A and Wynne B (eds) (1996) *Misunderstanding Science? The Public Reconstruction of Science and Technology*. Cambridge: Cambridge University Press.

Locke, S (2001) Sociology and the public understanding of science: from rationalization to rhetoric. *British Journal of Sociology* 52 (1): 1–18.

Mejlgaard N and Bloch C (2012) Science in society in Europe. *Science and Public Policy* 39(6): 695–700.

Miller J (2004) 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.

Motta M (2019) Explaining science funding attitudes in the United States: The case for science interest. *Public Understanding of Science* 28(2): 161–176.

Myers TA, Kotcher J, Stenhouse N, Anderson AA, Maibach E, Beall L, et al. (2017) Predictors of trust in the general science and climate science research of US federal agencies. *Public Understanding of Science* 26(7): 843–860.

Nowotny H, Pestre D, Schmidt-Assman E, Shultze-Fieltz H and Trute HH (2005) *The Public Nature of Science Under Assault*. Hamburg: Springer.

Noy S and O'Brien TL (2016) A nation divided: Science, religion, and public opinion in the United States. *Socius: Sociological Research for a Dynamic World* 2: 1–15.

O'Brien TL and Noy S (2018) Cultural authority in comparative context: A multilevel analysis of trust in science and religion. *Journal for the Scientific Study of Religion* 57(3): 495–513.

Pardo R and Calvo F (2002) Attitudes toward science among the European public: A methodological analysis. *Public Understanding of Science* 11: 155–195.

Price, AM and Peterson, LP (2016) Scientific progress, risk, and development: Explaining attitudes toward science cross-nationally. *International Sociology* 31(1):.57–80.

Rabe-Hesketh S and Skrondal A (2013) *Multilevel and Longitudinal Modeling Using Stata, 3rd edn*. College Station, TX: STATA Press.
Schofer E (2004) Cross-national differences in the expansion of science, 1970–1990. *Social Forces* 83(1): 215–248.
Snow CE and Dibner K (2016) *Science Literacy: Concepts, Contexts, and Consequences*. Washington, DC: The National Academies Press.
Sturgis P and Allum N (2004) Science in society: Re-evaluating the deficit model of public attitudes. *Public Understanding of Science* 13(1): 55–74.
Summers N (2016) Ethical consumerism in global perspective: A multi-level analysis of the interactions between individual-level predictors and country-level affluence. *Social Problems* 63(3): 303–328.
Weber, M ([1904] 1930) *The Protestant Ethic and the Spirit of Capitalism*. New York: Scribner's.
World Bank (2019) Researchers in R&D (per million people). Available at: https://tcdata360.worldbank.org/indicators/SP.POP.SCIE.RD.P6?country=BRA&indicator=2014&viz=line_chart&years=1996,2010 (accessed 25 March 2019).

Author biographies

Shiri Noy is an Assistant Professor of Sociology at Denison University. Her research interests are in globalization, development, and health in Latin America; public perspectives on science and religion; and comparative methods.

Timothy L. O'Brien is an Associate Professor of Sociology at the University of Wisconsin–Milwaukee. His research focuses on the cultural authority of science and the role scientists play in politics, law, and everyday life.

Appendix A. Supplementary Analyses

Table A1. Mixed effects ordered logistic regressions of attitudes about the effect of science in society on covariates, n=76,858.

	Model 1 Individual level covariates	Model 2 + country level covariates	Model 3 + cross-level interaction
Individual-level variables			
Education	0.23***	0.23***	0.13***
	(0.01)	(0.01)	(0.01)
Religiosity	−0.06***	−0.05***	−0.06***
	(0.00)	(0.00)	(0.00)
Female	−0.15***	−0.15***	−0.16***
	(0.01)	(0.01)	(0.01)
Age	−0.01*	−0.01*	−0.01**
	(<0.01)	(<0.01)	(<0.01)
No religion[a]	0.11***	0.11***	0.11***
	(0.02)	(0.02)	(0.02)
Protestant[a]	−0.10***	−0.10***	−0.09***
	(0.02)	(0.02)	(0.02)
Orthodox[a]	<0.01	0.01	0.01
	(0.04)	(0.04)	(0.04)

(Continued)

Table A1. (Continued)

	Model 1 Individual level covariates	Model 2 + country level covariates	Model 3 + cross-level interaction
Jewish[a]	0.20	0.20	0.19
	(0.15)	(0.15)	(0.15)
Muslim[a]	−0.24***	−0.22***	−0.22***
	(0.06)	(0.06)	(0.06)
Buddhist[a]	0.03	0.02	0.05
	(0.06)	(0.06)	(0.06)
Hindu[a]	−0.01	−0.01	0.01
	(0.10)	(0.10)	(0.10)
Other religious tradition[a]	−0.10*	−0.10*	−0.10*
	(0.04)	(0.04)	(0.04)
<50% CMI[b]	−0.20***	−0.20***	−0.20***
	(0.03)	(0.03)	(0.03)
50-80% CMI[b]	−0.11***	−0.11***	−0.11***
	(0.03)	(0.03)	(0.03)
>120% CMI[b]	0.17***	0.17***	0.17***
	(0.03)	(0.03)	(0.03)
missing income[b]	−0.09**	−0.09**	−0.07**
	(0.03)	(0.03)	(0.03)
Country-level variables			
R&D workforce		−0.06	−0.05
		(0.06)	(0.06)
Political rights		0.13**	0.02
		(0.04)	(0.04)
Log of GDP per capita		0.38*	0.38*
		(0.16)	(0.16)
Cross-level interaction			
Education (L1) * R&D Workforce (L2)			0.04***
			(<0.01)
Year, 2008	0.68***	0.69***	0.68***
Cut point 1	−2.32***	1.56	1.34
	(0.09)	(1.45)	(1.45)
Cut point 2	−0.62***	3.26*	3.04*
	(0.09)	(1.45)	(1.45)
Cut point 3	0.63***	4.52**	4.30**
	(0.09)	(1.45)	(1.45)
Cut point 4	2.49***	6.38***	6.16***
	(0.09)	(1.45)	(1.45)
Constant	0.24***	0.10***	0.10***
Log likelihood	−107491	−107474	−107368
Bayesian information criterion	215229.68	215229.05	215029.33

Source: 2008 and 2010 International Social Survey Program;
Notes: Standard errors in parentheses; + $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$ (two-tailed tests); [a] Catholic is referent, [b] 80%-120% CMI is referent.

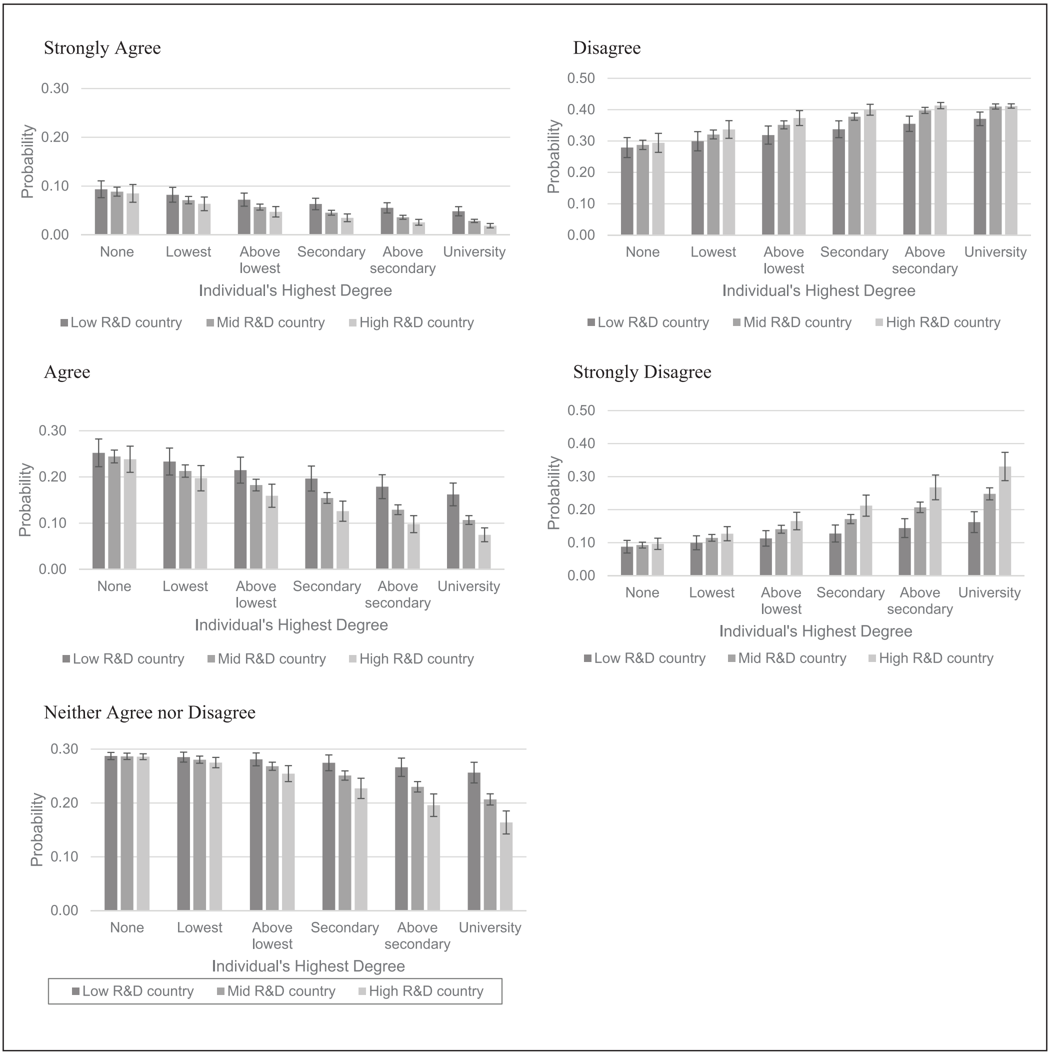

Figure A1. The effect of education on attitudes about the effects of science, by levels of national scientific activity.

Note: Graph contains the predicted probabilities with 95% confidence intervals of disagreeing/agreeing that science does more harm than good, adjusted for respondents' personal characteristics and national contexts. High, middle, and low national engagement with science are defined as countries at the 90th, 50th, and 10th percentiles of the R&D workforce variable. Predictions are based on Model 3 in Table A1. Data are from 2008 and 2010 ISSP (n=76,858).

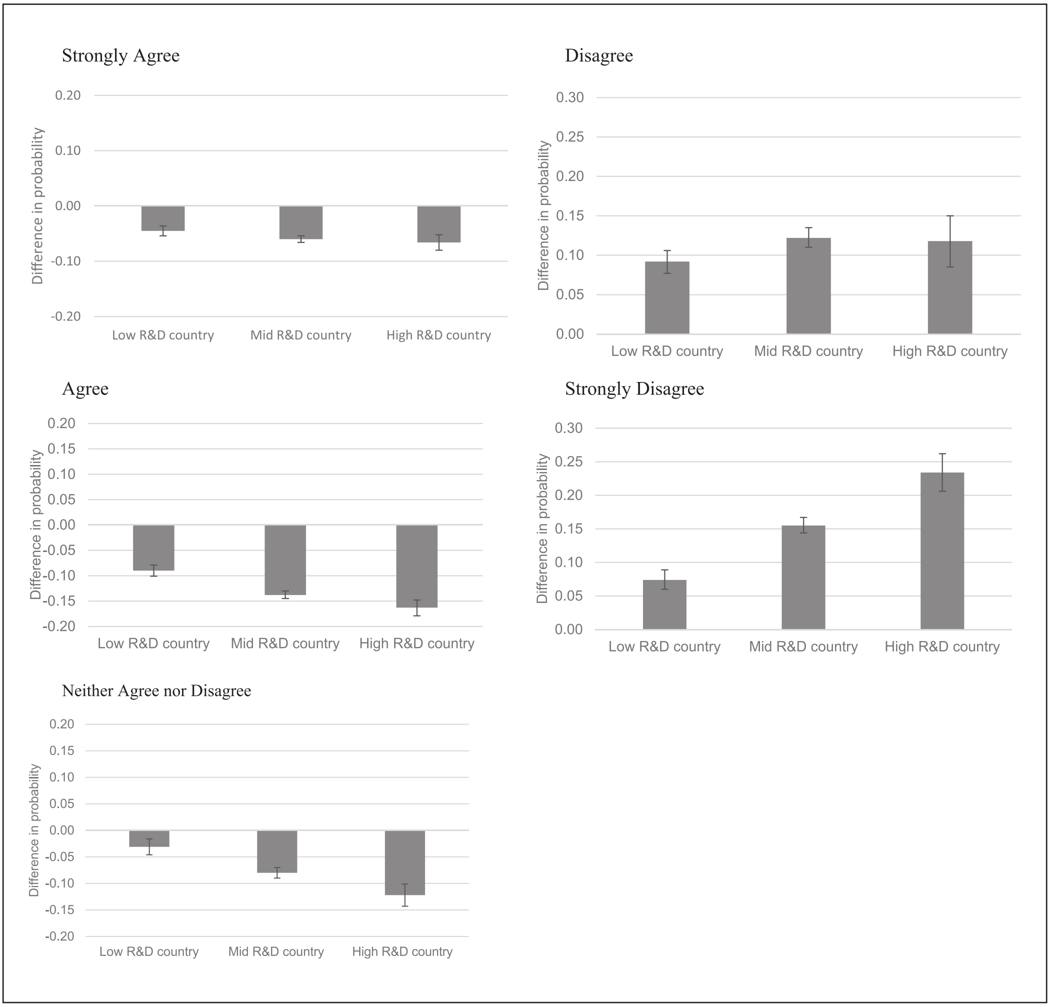

Figure A2. Marginal education differences in attitudes about the effect of science adjusted for individual- and country-level characteristics.

Note: Graph contains marginal differences in predicted probabilities with 95% confidence intervals of disagreeing/agreeing that science does more harm than good between individuals with a college degree and those with no formal educational credential. Results are presented for countries at the 90th, 50th, and 10th percentiles of the R&D workforce variable. Predictions are based on Model 3 in Table A1. Data are from 2008 and 2010 ISSP (n=76,858).