PUBLIC UNDERSTANDING OF SCIENCE IN AMERICA

A Thesis

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Scott Cantrell

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Department of Public Policy and Administration

Abstract

of

PUBLIC UNDERSTANDING OF SCIENCE IN AMERICA

by

Scott Cantrell

The United States is losing its global dominance in the fields of science and engineering largely because of underinvestment in research and development and the shift toward more knowledge-intensive industries that have greater emphasis on intellectual capital, science, and technology. Critical thinking skills, complex reasoning, and writing skills are lacking in undergraduates and recent college graduates in the United States. Scientific literacy is necessary for the U.S. to maintain its global competiveness and to also enable citizens to participate as more informed members in a pluralistic society. National survey data on scientific literacy in America collected by the National Science Foundation and General Social Survey indicates a deficit in factual scientific knowledge and understanding by the American public. National cross-sectional data from the 2008 General Social Survey was used in an Ordinary Least Squares regression to see if socioeconomic, political, and religious factors were significantly associated with scientific literacy, defined as the percentage of correct responses to 26 science and technology questions. Statistically significant regression coefficients were found on independent variables representing education level, generational cohort, income, gender, ethnicity, religiosity, and population size. Graduate, bachelor, and associate degrees had the largest positive association with scientific literacy. Black, Hispanic, and American Indian ethnic groups had the largest negative association with scientific literacy. A gender gap was also found with females showing lower scientific literacy. Policy interventions to assist ethnic groups and female K-12 students to stay in school, earn their high school diplomas, and improve their readiness for college are warranted.

_______________________________ , Committee Chair
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INTRODUCTION

Purpose of Thesis

Since the mid-1950s, social scientists in the United States and Great Britain have been collecting national survey data that measures the public's understanding of science and technology (Miller, 2004). There is an entire field of study focused on scientific literacy and its implications for public policy[1]. The journal *Public Understanding of Science* was first published in 1992 and includes articles based on both qualitative and quantitative research (Bennett & Jennings, 2011). Scientific literacy generally refers to the public's factual knowledge of science and the scientific process, including its overall objectives and general limitations (Miller, 2004; National Science Foundation, 2010). It also means having the ability to critically read and evaluate information and assess its veracity. Miller (2004) suggests scientific literacy requires one to have a basic understanding of the vocabulary used to describe scientific terms and concepts as well as a general understanding of the process used in scientific inquiry. He also suggested the public should have sufficient understanding of science to be able to read and comprehend the science column of *The New York Times, The Wall Street Journal*, or other major newspapers and magazines. Miller (1998, 2004) calls this level of scientific knowledge and understanding "civic scientific literacy."

[1] The term public understanding of science is preferred in Britain whereas in the United States the terms scientific literacy and public knowledge of science are used in the literature more commonly. I will use all these terms interchangeably in the thesis.

Civic scientific literacy is essential in virtually all aspects of American life to the public as members of the workforce, consumers of science and technology, and citizens of the body politic (National Science Foundation, 2010). Having a basic understanding of science can improve our knowledge of ourselves and give us a sense of our relationship to the natural world. It can help us evaluate the risks associated with taking certain medications or undergoing specialized medical procedures. It can help us understand the public debate on evolution and whether Creationism should be taught in high school science classes. It can help us weigh the risks we face with climate change and provide us a basis on which to evaluate governmental policies to reduce greenhouse gas emissions linked to global warming. In a democratic form of government, it is essential its citizens make informed decisions on public policy issues and know how to discern facts from opinions in political discourse.

The purpose of this thesis is to investigate the socioeconomic factors associated with the public's understanding of science in the United States. The most basic question I seek to answer is what is the contribution of political ideology, religiosity, demographics (age, gender, marital status, income, ethnicity, and geographic region of the country), and education to an individual's understanding of science? Knowing these contributions will help policymakers craft approaches and programs to address the gap in scientific knowledge and understanding found in the American public.

In the remainder of this chapter, I discuss why the thesis topic is an important public policy issue. I give examples of the politicizing of science; the religious right's push to teach Creationism in public schools; climate change denialism; how America is falling behind other nations in areas of education, science, and technology; and sources of scientific information in the media and why they cannot be wholly relied upon. Each of these examples illustrates the high stakes involved when the public lacks a basic understanding of science and critical reasoning abilities. I describe how conservative politics can undermine science itself through a variety of means, including the creation of pseudoscientific disciplines and scientific-sounding arguments; the suppression of science by political appointees; and by magnifying scientific uncertainties to create controversy where none really exists. Religious faith can also act as a perceptual filter that screens out factual, scientific information.

I also illuminate recent national educational assessment data on grade school and high school students and a recent longitudinal study of university students showing high numbers of students are coming out of these educational institutions with only very basic levels of scientific understanding and critical reasoning abilities. The United States is losing its competitive advantage in science and technology against other nations, especially China, because of its underinvestment in research and development. Finally, I depict data showing most Americans obtain information on science through the Internet and television. Given the vast amount of information available through these media, some valid and some spurious, it is critical consumers of this information have critical reasoning abilities.

Science and Politics

Several books have been published recently describing how scientific illiteracy is posing great threats to scientific progress, the environment, public health, and our nation's standing in the world with respect to education and economic competition. The author of *Denialism* (Specter, 2009) argues that illogical thinking, irrational fear of change, and political and religious ideology are hindering scientific progress and threaten our future. The author describes the public's mistrust of scientists and cynicism toward corporations, including pharmaceutical companies and the healthcare industry, to explain an unusual group of organized interests opposing vaccinations. These interest groups have established web sites with government-sounding names, including the National Vaccine Information Center[2] and websites less subtle in concealing their advocacy mission, including Vaccination Liberation.[3]

Mooney (2005), author of the *New York Times* bestseller titled *The Republican War on Science*, describes the political misuse of science by social conservatives, which pinnacled during the George W. Bush Administration from 2001 to 2009. During this period, there was a sharp increase in the number of former oil and coal lobbyists that became political appointees to key federal government agency positions under the Bush administration. Mooney provides evidence to show that President G.W. Bush was openly anti-science and allowed ideology and politics to trump scientific consensus. Even though G.W. Bush made a campaign pledge in 2000 to regulate carbon dioxide

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[2] http://www.nvic.org/
[3] http://www.vaclib.org/

emissions, one of his first actions in office was his refusal in 2001 to sign the international agreement enforcing the Kyoto Protocol to reduce greenhouse gas emissions linked to global warming, citing concerns over cost, loss of jobs in the United States and questioning the validity of science.[4] He also endorsed teaching “intelligent design” (a rebranding of creationism) in high school biology classes.

Mooney (2005) describes the rise of the modern American conservative movement, which has increasingly dominated the Republican Party’s agenda over the last 50 years. He describes key players such as William F. Buckley, Jr., American author and commentator, who founded the rightwing journal *National Review* in the mid-1950s, which had a major impact on the conservative movement. Mooney (2005) then describes Arizona Republican senator Barry Goldwater’s right-wing anti-intellectualism and distrust of the educated elite and the impact he had on the scientific community. Mooney (2005) also discusses the impact of President Nixon, George H. W. Bush and George W. Bush on scientific institutions and policies within their respective administrations culminating in the modern American conservative movement, which is a political philosophy that strongly resists changes to existing social and institutional structures and opposes “big government” regulation of industry and business. It is also a moralistic philosophy that has co-opted the Religious Right to expand its sphere of political influence.

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[4] http://usliberals.about.com/od/environmentalconcerns/p/KyotoProtocol.htm

As a recent example of how religion has crept into politics, the *Sacramento Bee* reported (Eckolm, 2011) that four potential candidates for the 2012 Presidential election including Mike Huckabee, Newt Gingrich, Haley Barbour, and Michele Bachman, founder of the House Tea Party Caucus, spoke at a two-day conference for pastors run by the Pastors Policy organization on March 24-25, 2011 in West Des Moines, Iowa.[5] The Policy Pastors organization has conducted conventions in at least 14 states in recent years. At these conventions, pastors have been told of the secular threats to conservative Christian values such as the sanctity of marriage, the rights of the unborn child, and the Divine right of freedom from big government. Pastors have been told it was their Christian duty to speak out against the excessive reach of the U.S. Environmental Protection Agency and the secular liberals attempt to take religion out of politics. Mooney (2005) believes it is critical for more scientists to speak out against pseudoscience and bogus claims made by science-abusing conservatives to preserve the integrity of the scientific process and the future of our planet. One of the best examples of pseudoscience involves the creation of scientific-sounding arguments and institutions to promote a religious belief and refute evolution. This subject is discussed in the following section.

Evolution and Creationism

In the General Social Survey (GSS) conducted by the University of Chicago in 2008, only slightly more than half (50.5%) of respondents agreed with the statement that

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[5] As of March 2012, Gingrich, Romney, Santorum, and Paul are the main contenders for the Republican Party nomination as a candidate to challenge President Obama in 2012.

human beings as we know them today evolved from earlier species of animals (General Social Survey [GSS], 2010).[6] It has been 150 years since the publication of Charles Darwin's seminal works on the origin of species, and currently only about half of the general public accepts evolution even while biologists are documenting evolutionary changes and adaptation in some species on a time scale of 10-20 years (Pitchford, 2010). Despite a preponderance of scientific evidence from various disciplines that the universe began with an event called the Big Bang 14 billion years ago, that the earth is 4.5 billion years old, and that humans evolved from earlier forms of primates, the public is still in denial about these well-established scientific theories. Many persons instead choose to cling to religious, faith-based convictions that are in denial of these facts. Young-Earth creationists, for example, believe the earth was created exactly as described in the Book of Genesis less than 10,000 years ago and that the Great Flood reshaped it. Since religion cannot be proved in fact and is instead based upon "faith," when facts counteract faith, the religious must usually choose faith or they would lose their religious beliefs.

Evolutionary theory contradicts dogmatic religious beliefs and literal interpretation of the Bible as the inerrant Word of God. Religious faith does not require skills in critical reasoning or standards of evidence nor peer review and hypothesis testing. It only requires faith and belief. Creationists have assumed the garb of science by creating pseudoscientific disciplines like Creation Science, Intelligent Design Theory, and Global Flood geology and establishing organizations like the Institute for Creation

[6]http://www3.norc.org/GSS+Website/Download/SPSS+Format/

Research (2012) and the Intelligent Design and Evolution Awareness Center, a 501(c)(3) non-profit organization promoting intelligent design theory, particularly focusing on university and high school students.[7] This is particularly concerning because these religious activities are targeting students and undermining science curricula which may in turn lead to students having a misinformed understanding of the nature of science as well as lack the ability to plan and conduct scientific investigations.

Climate Change Denialism

The cover story in the August 2007 edition of *Newsweek* magazine was on climate change denialists and the strategies being employed by well-organized, industry-funded think tanks and scientists who have created a miasma of doubt and uncertainty about climate change. Climate change denialists use a variety of tactics such as paid advertisements in the media, opinion editorials in major newspapers, white papers, studies, and lobbying to create uncertainty around the science of climate change. Climate change science has been called fraudulent, a great hoax, junk science, and a liberal environmentalist conspiracy.

In fall 2009, a computer hacker stole 1,000 e-mails and 3,000 documents from the Climatic Research Unit at the University of East Anglia in Britain. These e-mails spoke of scientists massaging and falsifying data, hiding data showing declines in global temperature, deleting incriminating e-mails, and so forth. Conservatives seized this opportunity to proclaim that global climate change is nothing but junk science based on

[7] http://www.ideacenter.org/

lies; some of the more extreme bloggers asserted that "globalists" are part of a liberal conspiracy to establish a world government. Since 2009, the global scientific community studying climate change has been in the mode of defending its research and deflecting a barrage of scornful criticism from the right-wing media and blogosphere. Unfortunately, it is usually the loudest and most persistent messages that get most of the attention in the media and that in turn shape public opinion.

In response to the controversy that arose over these e-mails stolen from the Climatic Research Unit, Senator Inhofe (Oklahoma-R) called for an investigation by the inspector general of the Commerce Department of the National Oceanic and Atmospheric Administration (NOAA) scientists implicated in the e-mails (Kaufman, 2011). In a February 2011 report by the Obama administration, the inspector general stated that no evidence of scientific misconduct could be found or that NOAA scientists inappropriately manipulated data. NOAA's top official was also exonerated of any wrongdoing.

In May 2010, a group of 255 members of the National Academy of Sciences published an open letter in the journal *Science*, which was also sent to the White House Office of Science and Technology.[8] The letter described grave concerns over the "political assaults on scientists in general and on climate scientists in particular" (Sills, 2010, p. 689). The letter described threats they had received of criminal investigations by Congress over e- mails between climate scientists leaked to the public. The authors of the letter emphatically stated, "There is compelling, comprehensive and consistent

[8] The National Academy of Sciences consists of about 2,100 members and 350 associates from other countries (http://www.nasonline.org/site/PageServer?pagename=MEMBERS_Main).

objective evidence that humans are changing the climate in ways that threaten our societies and the ecosystem on which we depend" (Sills, 2010, p. 689). And yet, despite overwhelming scientific evidence of climate change, a large proportion of the public still does not believe in global warming or that it is being largely caused by human activities.

In a 2010 survey conducted by the Yale Project on Climate Change Communication, 38% of respondents said there was a lot of disagreement among scientists whether global warming was actually occurring while 39% believed most scientists think global warming is real (Leiserowitz, Smith, & Marlon, 2010). The survey also showed that 63% of Americans believe global warming is occurring but did not know why it was occurring. Nineteen percent of respondents believed it is not occurring and the remainder said they did not know either way. The climate change issue is a good example of the various tactics used to politicize science by undermining science itself, targeting individual scientists, and magnifying scientific uncertainties (Gore, 2011; Mooney, 2005).

Science, Technology, and Education

The National Assessment of Educational Progress (NAEP) provides a nationwide, ongoing assessment of American students' knowledge of mathematics and science, reading and writing, arts, civics, economics, geography, and American history (National Center for Education Statistics [NCES], 2011). The last assessment was conducted in 2009; however, recent changes in the assessment methodology mean that these results cannot be compared to assessments done in prior years. Nevertheless, the 2009 assessment provides a benchmark for future assessments and presents interesting data on America's fourth-, eighth- and twelfth-grade students.

Achievement levels for the NAEP are set for each subject area and grade level and are reported as the percentage of students performing at Basic, Proficient, and Advanced levels. Only 1% of fourth graders and 12th graders and 2% of eighth graders performed at the Advanced level in NAEP science. The remaining students performed at either a Basic level (between 60% and 72%) or a Proficient level (between 21% and 34%) of science achievement. Another interesting finding of the 2009 NAEP report is that student performance varied by geographic region, ethnicity, family income, and type and location of school (public versus private school and city versus another location). The *San Francisco Chronicle* (Tucker, 2011) reported that results from the NAEP survey worried science education leaders because of students' poor performance on scientific subjects.

Another recent study paints a stark assessment of the critical thinking abilities of college graduates, which may put our nation at a competitive disadvantage with other nations. The *McClatchy Washington Bureau* (Rimer, 2011) describes a longitudinal study of several thousand undergraduates from 24 colleges and universities through four years of college. This study was conducted by New York University sociologist Richard Arum, who found that 45% of these undergraduates lacked critical thinking, complex reasoning, and writing skills after the second year of schooling. At the end of four years, 36% showed no significant improvements in these skills. It also showed that students pursuing traditional liberal arts degrees in subjects such as humanities, social science, mathematics, and science made greater gains in critical reasoning skills compared to students in business, education, social work, and communications. An additional finding of Arum's study is that large numbers of students avoided taking classes requiring substantial amounts of reading and writing (defined as more than 40 pages of reading a week and more than 20 pages of writing in the semester). This study suggests a deficit in critical reasoning abilities among college students that may be symptomatic of a broader problem in our educational system in which critical reasoning skills are not being adequately taught to students. These reasoning skills are also required for an understanding of science and its methods of enquiry.

The National Science Board, which oversees the National Science Foundation and the Foundation's Division of Science Resources Statistics, produces a bi-annual report on science, engineering, and technology data in the United States and foreign countries. The *Science and Engineering Indicators 2010* report (National Science Foundation, 2010) describes trends in public knowledge, understanding, and attitudes about science and technology (National Science Foundation, 2010). This report shows the United States is losing its global dominance in science and engineering largely because of underinvestment in research and development and the rapid growth of East Asian economies. The global economy is also shifting toward more knowledge-intensive industries that have greater emphasis on intellectual capital, science, and technology. According to an article published in the BBC News (Shukman, 2011) on a new study conducted by the Royal Society, China is projected to overtake the United States in terms of the number of science publications in reputable international journals in just two years. China has been investing heavily in research and development, growing by 20% since 1999, and now spends greater than $100 billion each year. It is also producing large numbers of science and engineering graduates from Chinese universities.[9]

Science and the Media: Sources of Information

In the GSS 2008 survey, respondents said their likely sources of information on science were the Internet (53.8%), television (22.0%), books and other printed material (8.0%), newspapers (5.9%), and magazines (5.0%) (GSS, 2010). Because of the tremendous amount of both valid scientific information and spurious information available to the public, especially through the Internet and TV, it is extremely important for the public to have a basic understanding of science and its methods and have the ability to distinguish pseudoscience from science and opinion from evidence-based statements. However, providing the public with more scientific facts and information may not be sufficient to improve scientific literacy because of the filtering effects of ideology. Nisbet and Goidel (2007) developed a theoretical framework that describes the "impact of value predispositions, schema, political knowledge and forms of mass media use in shaping public perceptions of science" (p. 421). Their findings indicate that religious and ideological values appear to act as perceptual filters of scientific information.

[9] In 2006, there were over 1.5 million graduates in the fields of science and technology.

Mooney and Kirshenbaum (2009) in the book *Unscientific America* suggest we cannot lay the blame of scientific illiteracy entirely upon members of the public and that scientists themselves could do a better job of communicating scientific information to the public and media. Scientists traditionally have not seen public communication as their responsibility and there are few incentives for doing so. The authors also describe the dumbing down of information and the decrease of science and technology coverage in the media over the last couple of decades. The media also does not always get its facts straight because of either inadvertence or by design. Political ideology strongly influences what gets covered in and the veracity of information reported by the media. Political and religious ideology also acts as a lens through which the public sees the world and shapes public opinion.

Organization of Thesis

In the next chapter, I discuss regression-based studies that evaluated the contributions of age, gender, marital status, income, education, ethnicity, geography, political ideology, and religiosity to scientific literacy. In Chapter 3, I describe the source of my data and rationale for my choice of the dependent variable and its relevance to the research topic as well as the choice of the independent variables and the functional form of my model. In the results chapter, I describe the outcomes of my regression analysis and make policy recommendations based on my findings. Understanding the relative contributions of socioeconomic factors to scientific literacy can help us develop targeted, evidence-based policies to increase public understanding of science in America and increase our global competiveness in science and technology.

Chapter 2

LITERATURE REVIEW

Substantial research has been conducted in the United States and in Europe since the mid-20th century to assess the various factors related to the public's understanding of science and technology, or what is also called scientific literacy. This topic has been studied by eminent institutions, including the National Science Foundation, National Opinion Research Center, which administers the General Social Survey (GSS)[10], British Royal Society, and the European Commission. Researchers have investigated the many dimensions of scientific literacy including the use of survey instruments to assess respondents' factual knowledge of science and its methods and to collect data on socioeconomics, trust, attitudes about scientific research, and the value of science to society, political affiliation, and religious beliefs (Sturgis & Allum, 2004).

Scientific literacy has been studied using survey instruments that include a battery of questions related to science and technology and the general principles and methods of science. Some authors have questioned the validity and reliability of these types of "know what" surveys aimed at assessing simple textbook knowledge of respondents without considering and controlling for cultural, social, and ethnographic factors to explain differences in public understanding of science (Pardo & Calvo, 2004; Sturgis & Allum, 2004). Smith (1996) discusses a concern that respondents may be more likely to guess true than false on these types of surveys, which would inflate the number of correct

[10] The GSS 2008 survey data was used for this thesis.

responses to questions that are in fact true. Guterbock participated in a workshop sponsored by National Science Foundation examining the survey instrumentation and adequacy of the questions used by the National Science Board to evaluate public knowledge of science (Guterbock, 2011). He writes in the scientific proceedings:

> It must be said at the outset that the current questionnaire items that form the basis for the 2010 *Science Indicators* report rest on a solid social science foundation. These indicators of "scientific literacy" have proven durable and serviceable in practice, and have been widely applied both nationally and internationally. It is clear that they pick up important, theoretically predictable variations in science knowledge. (p. 4)

The questionnaire items Guterbock (2011) identified were included in the GSS 2008 survey. I believe the GSS provides useful data that can be analyzed to gauge public knowledge of science in America.

I organize my review of the literature into three broad themes: socioeconomic factors; political context; and religion. These are the primary themes I use to categorize the independent variables I believe explain differences in public knowledge of science. I expand on these themes in the next chapter of my thesis, which describes the methodology and statistical model I used to perform the analysis.

I believe socioeconomic factors, including age, gender, marital status, income, education, ethnicity, and where one lives in America, may explain differences in scientific knowledge and understanding. In the political context, I believe political party affiliation and ideology are also explanatory factors. Finally, I think religion and views on the Bible, whether one has dogmatic religious beliefs or no religious affiliation at all, will help explain variation in scientific knowledge and understanding. These factors are explained in detail in Chapter 3. I now justify these beliefs through an examination of how these causal factors have appeared in the previous literature on this topic.

Socioeconomic Factors

Smith (1996) wrote a report on scientific knowledge around the world for the National Opinion Research Center (NORC) at the University of Chicago. Based on results from earlier studies of the public's understanding of science, the author hypothesized that scientific and environmental knowledge would be higher among men, younger adults, higher educated people, the less religious, people with higher incomes, people working in scientific fields including science teachers, and people living in major urban areas. The author used data from the 1993 International Social Survey Program, which administered surveys to 21 countries, to collect data on the public's scientific and environmental knowledge. One of these surveys was aimed at measuring scientific and environmental knowledge and consisted of a 12-item questionnaire spanning the topics of radiation, medicine and disease, atmospheric conditions, natural history, and astrology. Response options consisted of Definitely True, Probably True, Probably Not True, Definitely Not True, and Can't Choose and were scored numerically from 1 to 5. Thus, a perfect score would be equal to 12 and the worst possible score would equal 60 points. A score of 36 meant that the respondent did not attempt to answer any of the questions (Smith 1996). [11]

The author found strong support for all of his hypotheses. Bivariate correlations between socioeconomic factors (e.g., education, income, etc.) and environmental and scientific knowledge had standardized coefficients[12] that were almost all statistically significant in the hypothesized direction and were found in almost all the countries surveyed. The author found that education (one of the independent variables) had the strongest association with scientific knowledge (the dependent variable), with standardized coefficient averaging -.308 at the national level. The author found that nations with higher levels of economic development, measured by per capita gross national product, had increased scientific knowledge, possibly due to stronger science education standards in the classroom and broader coverage of science in the media with a standardized coefficient of -.217. This means that for each unit increase in income (measured by per capita gross national product), scientific knowledge (as measured by the 12-item survey) increases by .217.

The author also performed a multiple regression using the same variables included in the national surveys. At the individual level, higher levels of education have

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[11] Smith (1996, p. 15) explains that because of the scoring system he used, a lower score represents relatively higher scientific knowledge. Negative coefficients would be expected with variables such as education, income level, and so on.

[12] Standardization of variables is done when the units of measurement of each variable is different so the variances are equal to one. Standardized partial regression coefficients (þ$_i$) tell us the change in the dependent variable for each standard deviation change in the independent variable (ρ_i). A high absolute value of þ$_i$ indicates a strong influence on the dependent variable. The statistical test of a partial regression coefficient is H_0: $\beta_i = 0$ (Zar, 1984).

the highest association with scientific knowledge with a standardized coefficient of -.196. Occupations involving science or teaching careers have standardized coefficients equal to -.060 and -.065 for each respective occupational group. Individuals with some form of religiosity, measured by church attendance, belief in God, Protestant and Catholic, showed equivocal results regarding the effects on scientific knowledge.

The European Commission has been conducting public opinion surveys in its member countries since 1973. It monitors such topics as social context, health, culture, economics, politics, and education. A survey instrument called the “Eurobarometer” was administered by the European Commission in 1992 in 12 European countries to assess scientific literacy and collect socioeconomic data in the European Union (EU). The survey consists of a 12-item science quiz covering the scientific fields of biology, geology, physics, and chemistry taught in the curricula of primary and secondary schools. Pardo and Calvo (2004) analyzed the formal qualities of the Eurobarometer test, including the distribution of correct responses in the total sample (12 EU countries), with the mean and variance of these responses. Differences in reliability were found due to the structure of the test (e.g., relative proportion of true and false items, sequencing of questions, etc.) and made recommendations on how to improve the test. They also found variance in the discriminatory power of the test as a function of income level, years of education, and a country’s level of industrialization.

Pardo and Calvo (2004) found it difficult to discern differences in more developed countries and groups having higher education and income. They concluded that despite some methodological issues with the Eurobarometer test, it was able to identify major differences (not fine-grained differences) in scientific literacy in different societies and social groups within EU member countries. For example, in a one-way analysis of variance test for each nation, they found a highly significant positive relationship between years of education and scientific literacy. Every country showed that individuals with more than 20 years of education demonstrated a greater number of correct answers on the test compared to those with less than 15 years of education (Pardo & Calvo, 2004).

The British Royal Society established an ad hoc group (“Working Group”) to study ways in which public understanding of science could be improved and who should be directly involved in these activities. The Working Group on the Public Understanding of Science published its seminal report in 1985, which included strategic recommendations to improve formal education, promote science in the mass media, foster interest in science through museums and industry, and engage individual scientists and the scientific community in public relations and outreach (Royal Society, 1985).

Political Context

Sturgis and Allum (2004) investigated how scientific knowledge (the independent variable) influences public attitudes toward science (the dependent variable in their model is “support for science”). They describe the deficit model, which says, in part, that support for science is a function of the public’s understanding of science and what it means to study something scientifically (Sturgis & Allum, 2004). The deficit model is built on many years of survey-based tests of scientific knowledge. The authors also describe a “contexualist perspective” that includes ethnographic information such as cultural norms and public values in real-life settings to understand how these factors influence the public’s understanding of science (Nisbet & Goidel, 2007, p. 422). The authors constructed a model that includes all the variables in the deficit model as well as an additional variable called “political knowledge” to represent the public’s knowledge of governmental institutions and politics. The authors assume “political knowledge” can serve as a proxy for how science is used to develop policies and regulations (Sturgis & Allum, 2004, p. 58).

Sturgis and Allum (2004) found that scientific knowledge has a highly significant positive coefficient (.254) which means that for every unit increase in scientific knowledge (independent variable), support for science (dependent variable) increases by about 25%. This result is consistent with deficit model assumptions that the effect of scientific knowledge on attitudes toward science will be positive. They also tested the contextualist model, which assumes the presence of “knowledge domains that influence attitudes towards science and technology in opposite or conflicting ways to factual scientific knowledge” (Sturgis & Allum, 2004, p. 58). The authors tested whether support for science is influenced by political knowledge[13] and how the interaction of political knowledge and scientific knowledge may affect support for science.

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[13] Political knowledge is based on the knowledge of policy positions of the main political parties in Great Britain, measured by a six-item scale. This general level of political sophistication is intended to be a general proxy for the respondent’s understanding of scientific institutions and how they operate. The authors included an interaction variable called *political x scientific knowledge* in the model.

Political knowledge had a highly significant positive coefficient of .087, but the magnitude of the effect on science support was small. The interaction variable had a larger positive coefficient (.158) demonstrating support for the contextualist model. The top percentiles of both domains of knowledge increase favorable attitudes toward science by nearly 30 percentage points. The Sturgis and Allum (2004) study is important because it shows that increased scientific *and* political knowledge are determinants of support for science.

Nisbet and Goidel (2007) developed a conceptual framework showing how value predispositions, political knowledge, and various forms of mass media consumption influence public attitudes toward controversial scientific and technical issues. For their case studies, they conducted a nationwide random telephone survey to ascertain public understanding and attitudes toward embryonic stem cell research and human cloning. They found Christian conservatism had a negative coefficient of -.14, meaning that for each one-unit increase in religiosity, holding constant all the other independent variables, support for embryonic stem cell research decreased by 14%. With respect to support for therapeutic cloning, they found negative relationships with social ideology (coefficient of -.12) and age (coefficient of -.14), meaning that more conservative and older individuals were less supportive of cloning. Level of education had a positive relationship with support for cloning (coefficient of .13). The authors also found that regular media consumption of Christian-based and science programming on television and time spent reading religious and scientific newspaper and magazine articles were significant explanatory variables. Reading newspapers and watching science fiction programs on television had positive coefficients (.12 for both coefficients) that were highly significant, suggesting that these media provide a substantial portion of the social context used by individuals for evaluating these controversial science issues (Nisbet & Goidel, 2007).

Religion

Gibson (2004) states that public policy has traditionally been categorized into developmental, allocational, and redistributional policies, thought to be driven by socioeconomic factors and shaped by political subcultures. He argues for the inclusion of a third category of policy he calls “morality policy,” consisting of core moral values of individuals the author believes have strong influence on government policymakers. He believes morality policies on issues such as abortion, gay rights, and the creationism/evolution debate are becoming more forceful in shaping state moral values and political outcomes, more so than even socioeconomic factors (Gibson, 2004). Gibson describes political debate in America as a culture war between religious conservatives and progressives and examined whether states with large proportions of evangelical adherents had an impact on state morality policy, for which he used the teaching of evolution in a state’s public school science curriculum as a proxy.[14] He controlled for socioeconomic factors including state educational attainment level, percentage of urbanized area in the state, and per capita income. The author used

[14] The author cites a report by Thomas B. Fordham that evaluated state curricula with respect to the inclusion of evolutionary theory in state science standards (Gibson, p. 1137). Each state was given a letter grade A, B, C, D, or F based on how well it adhered to science standards.

multiple regression to test his hypothesis. His results show the coefficient of evangelical is highly significant (-5.03) and is negatively associated with how well evolution is included in a state's science curriculum. He concluded that a state's religious environment is a good predictor of state policies on science standards, which supports the morality policy framework.

Zigerell (2010) performed an OLS regression using data from the 2008 GSS. The study used percentage correct responses to sixteen science and technology questions as the dependent variable and found that respondents having a literal belief in the Bible had less scientific knowledge as indicated by the negative coefficient (-.12) on the independent variable called literal view of the Bible. As explained by the author, this coefficient means that after controlling for gender, age, race and other factors, respondents with a literal view of the Bible scored 12 percentage points less than the excluded variable, which corresponded to just less than two questions out of 16 possible (mean of 1.92 questions). The gap was still observed even after controlling for education and demography; however, the difference was substantially lessened (coefficient of -.05).

Sustersic (n.d.) was interested in understanding how education and religion affect belief in evolution. The author performed a logistic regression on the 2006 GSS dataset to analyze key explanatory variables such as race, religion, and education (independent variables) and how these factors affected the respondents' beliefs in evolution (dependent variable). The survey question was whether the respondent believed humans evolved from earlier forms of animal life. Susteric's (n.d.) paper was not clear on how regression coefficients were estimated and determined to be significant; however, it was reported that Black and Latino respondents had significant negative coefficients. These results mean if a respondent was coded as Black or Latino, while controlling for all other factors, the respondent would be less likely to agree with the statement that humans evolved from earlier forms of animal life. The same negative relationship was found in fundamentalist Christians and conservatives. Being a Catholic, believing that religion is important in one's life, and attending church service once or more a week, all had significant coefficients but the direction of the effect was not uniform. Respondents who took high school biology after 1963 was not found to be a significant factor associated with belief in evolution. However, the variable "college graduate" had a substantial positive effect on belief in evolution, while controlling for all other independent variables. The "post-graduate" variable had an even greater positive effect on the dependent variable. Sustersic (n.d.) also included variables representing broad geographic regions of the United States, but none were found significant.

Literature Review Conclusions

There are concerns about the validity and reliability of survey instruments (Pardo & Calvo, 2004). It is not clear whether respondents are showing acquiescence bias, which is a tendency to default to a "true" response for some questions. There is also concern about the varying level of difficulty between the questions and how representative these questions are of the public's understanding of science. Researchers have made recommendations on how to improve the survey methodology and suggested different ways of measuring scientific literacy (Laugksch, 2000). I found it is difficult to make comparisons or generalizations regarding the coefficients derived from the various studies I reviewed because there were many different models being tested, at both an individual and national level, along with differing assumptions and methodological approaches by individual researchers.

Despite the caveats and limitations of the survey format used in GSS 2008, I believe there is still much information that can be derived from this national survey database using OLS regression methodology.

I was surprised to find so few articles having a direct bearing on my topic of socioeconomic factors associated with scientific literacy in the United States. I found only a few studies that used OLS regression.[15] At the individual level, it appears scientific literacy is associated with level of age, education, income, ethnicity, religiosity, and attitude toward science (Pardo & Calvo, 2004; Smith, 1996; Sturgis & Allum, 2004; Sustersic, n.d.; Zigerell, 2010). There is also a positive relationship between scientific knowledge and respondents with a favorable view of science that supports what is called the deficit model[16] (Sturgis & Allum, 2004). At the national level there is evidence that higher scientific knowledge is found in men, younger adults, higher educated people, the less religious, people with higher incomes, people working in scientific fields including

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[15] In addition to my own database searches, I worked with two different research librarians on separate occasions in the library at California State University, Sacramento to assist me in finding relevant studies.

[16] The deficit model is the concept that the public is deficient in its knowledge of science and, therefore, doubts the value of science or is afraid of scientific innovation. This in turn leads to unfavorable views of science and scientific institutions (Sturgis & Allum, 2004).

science teachers, and people living in major urban areas (Pardo and Calvo, 1996; Smith, 1996).

Evidence for the contexualist perspective exists, which says the interaction between political knowledge and scientific knowledge can partially explain public attitudes toward science (Sturgis & Allum, 2004). Value predispositions including religiosity, political knowledge, and various forms of mass media consumption, all seem to act as filters through which the public views controversial scientific and technical issues, such as stem cell research and therapeutic cloning (Nisbet & Goidel, 2007).

Conservative religious views and ideology have been shown to be negatively associated with a belief in evolution (Sustersic, n.d.). Persons with a literal interpretation of the Bible have been shown to have less scientific knowledge compared to persons having less dogmatic views; however, when controlling for demographic and educational factors, the differences are greatly lessened (Zigerell, 2010). There is also evidence that a state’s religious environment is a good predictor of science educational policies and whether evolution is being incorporated into the science curriculum (Gibson, 2004).

I organized my discussion of the literature based on three broad themes: socioeconomic factors, political context, and religion. In the next chapter, I expand on each of these themes and describe variables that are proxies for each of these broad categories.

Chapter 3

METHODOLOGY

Introduction

The purpose of this chapter is to describe the analytical methods and source of data used in my investigation of differences in science knowledge among adults. I describe how I measured knowledge variation across adults using 2008 survey data collected in the General Social Survey. [17] I describe the analytical methods I used to perform my analysis on these data and why they are justified, followed by the specification of the functional form of my model. I then describe the broad categories of factors that emerged as being important to explain variation in science knowledge found in my literature review followed by a description of the dependent and independent variables in my model. I conclude with a description of an alternative specification of the model, my test of interaction variables, and how I tested for model bias. The remainder of this chapter contains the following sections to achieve each of these purposes: analytical approach; source of data; model specification and broad causal factors; independent variables; alternative specification of the model and interaction variables; multicollinearity; and heteroskedasticity.

Analytical Approach

My question is what is the contribution of political ideology, religiosity, demographics (age, gender, marital status, income, race, ethnicity, and area of the

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[17] The GSS 2008 survey data was used for my thesis.

country), and education to an individual's understanding of science? Institutions including the National Science Foundation, the National Opinion Research Center (NORC) which administers the General Social Survey (GSS), the British Royal Society, and the European Commission have used survey instruments to help answer this question. Researchers have investigated the many dimensions of scientific understanding to assess respondents' factual knowledge of science and its methods and looked for associations with socioeconomic factors, public trust toward scientists and research institutions, the value of science to society, political ideology, and religious beliefs (Sturgis & Allum, 2004). Researchers have used both qualitative and quantitative methods to study these various factors and their relationship with scientific understanding. Regression analysis is a standard statistical method that has been used to analyze survey data to determine the relative contributions of each of these factors to public understanding of science (Bauer et al., 2007; Laugksch, 2000).

Regression analysis is a method that makes quantitative estimates of the relationship between one variable, called the dependent variable, and one or more independent variables. In simple regression, in which only two variables are considered, it is a method of determining whether a functional dependence exists. We can never prove causation between two variables, only correlation. But with a well-specified model that controls for other factors expected to influence a dependent variable, we can be more certain of causation. A regression model estimates the average unit change in the dependent variable for each unit change in the independent variable and can be represented as a linear equation:

$$Y = \beta_0 + \beta_1 X + \varepsilon_i$$

where Y is the dependent variable, β_0 is the constant or intercept term and β_1 the slope coefficient on the independent variable X indicating how much the dependent variable changes with each unit increase of the X variable. These terms are called the deterministic components of the equation. The term ε_i represents the random error accounting for the variation in Y that cannot be explained or accounted for by the deterministic components.

Functional dependence between two variables means the dependent variable in some way depends on the value of the independent variable, whereas the reverse is not true. For example, age may be a determinant of blood pressure, but blood pressure does not determine age. There are also circumstances in which two variables may be positively or negatively correlated with each other, but which lack any kind of functional dependence. For example, daily high temperatures in Sacramento may be correlated with daily ice cream sales, but sales of ice cream do not determine air temperature. In other words, correlation does not imply causation. Proving causation requires more than just reporting correlation coefficients; it requires a sound description of potential causal mechanisms.

Multiple regression involves two or more independent variables and estimates their effects on the dependent variable. Multiple regression analysis provides estimates of how the value of the dependent variable changes with a change in any one of the independent variables while all the other independent variables are held constant. The partial effect of each independent variable is measured by the regression coefficient. Ordinary Least Squares (OLS) regression is a standard method to calculate the regression coefficients so as to minimize error of estimates in the model, or technically speaking, to minimize the sum of the squared residuals (Studenmund, 2006). OLS regression is the method I used to perform a cross-sectional analysis of GSS 2008 survey data (GSS, 2010). In my regression model, I examined whether there is functional dependence of public knowledge of science on independent variables such as age, gender, income, education, and political and religious ideology. I began my analysis with a linear model but settled on a quadratic model as my functional form, which I explain in the next section. I ruled out using a double-log and semilog functional form because the dependent variable has five observations that include zero (i.e., the percent correct responses were zero). In the next section, I describe the source of my data followed by a description of my regression model.

Source of Data

The General Social Survey (GSS) is a national survey conducted since 1972 by the National Opinion Research Center (NORC), part of the National Data Program for the Social Science, headquartered at the University of Chicago and includes field offices across the country. The GSS "[c]onducts basic scientific research on the structure and development of American society with a data-collection program designed to both monitor societal change within the United States and to compare the United States to other nations" (GSS, 2010, para. 1). The GSS is partially funded by the National Science Foundation and is one of NORC's longest running projects.

The GSS conducts random, personal-interview surveys to collect core socioeconomic and attitudinal data that lends itself to cross-sectional and trend analysis and cross-national comparisons. The 2006 GSS included a constructed variable called "science-quiz," which was computed as the sum of the number of correct responses to 10 science questions (Pollack, 2009). For example, respondents were asked to answer "true" or "false," or "don't know" to the following statements: electrons are smaller than atoms; lasers work by focusing sound waves; and antibiotics kill viruses as well as bacteria.

The 2008 GSS included an additional 16 questions on science and mathematics that were added to the 2006 survey to better reflect national standards for what K-12 students are expected to know (National Science Foundation, 2010). For example, respondents were asked a question and given the option of several possible responses, but there was only one correct answer. For example, respondents were asked questions such as: Which of the following is a key factor that enables an airplane to lift? For which reason many people experience shortness of breath more quickly at the top of a mountain than along a seashore? What property of water is most important for living organisms? These questions (and more) were included only in the 2008 survey and were not carried forward into GSS 2010. Therefore, I decided to perform my analysis on the GSS 2008 dataset since it contained all 10 questions from the 2006 GSS plus the 16 science questions added in 2008 (26 questions total). I performed all my statistical analyses using PASW© Statistics 18. In the next section, I describe the functional form of my statistical model, the broad causal factors that explain variations in public knowledge of science, followed by a description of the variables that serve as proxies for these factors.

Model Specification and Broad Casual Factors

In this section, I describe the functional form of my model and how it relates to my research question. In my literature review, I found studies showing scientific literacy to be associated with socioeconomic factors including level of education, ethnicity, gender, income, religiosity, and attitude toward science (Pardo & Calvo, 2004; Smith, 1996; Sturgis & Allum, 2004; Sustersic, n.d.). There is also evidence that higher levels of political sophistication and scientific knowledge are associated with positive attitudes toward science (Nisbet & Goidel, 2007; Sturgis & Allum, 2004).[18] Religious conservatism is negatively associated with public knowledge of science and support for scientific technology, including embryonic stem cell research and therapeutic cloning (Nisbet & Goidel, 2007). I believe the broad categories of socioeconomics, politics, and religion represents the range of potential factors that may be associated with public knowledge of science.

[18] I decided not to include variables in my model related to political sophistication and attitudes toward science because I chose to focus on socioeconomic, political ideology, and religious factors.

I constructed the dependent variable as the percentage of correct responses to 26 science questions in the GSS 2008[19]. I believe the dependent variable (Y) is influenced by the broad causal factors of socioeconomics, politics, and religion (represented by A, B, and C). This relationship can be expressed algebraically as:

$Y = f\,(A, B, C)$

The broad categories on the right side of the equation above can be decomposed into independent variables ($x_1, x_2, x_3 \ldots x_n$), which serve as proxies for these broad categories and can be expressed as:

$A = f\,(x_1, x_2, x_i)$ $\quad B = f\,(x_4, x_5, x_i)$ $\quad C = f\,(x_6, x_7, x_i)$

The functional form of my regression model can be specified as a linear equation[20]:

$Y = f\,(x_1, x_2, x_3, \ldots x_i)$ =>

$Y_i = \beta_0 + \beta i X i + \varepsilon_i$

where, i = 1, 2, …, n;

Y_i = the *i*th observation of the dependent variable;

X_i = the *i*th observation of the independent variable;

ε_i = the *i*th observation of the random error term;

β_0 = the intercept;

β_i = the regression coefficient on the *i*th independent variable; and

n = number of observations

[19] All questions are treated equally; there is no weighting of variables.
[20] In the next section I describe how, through model iteration, I settled on the quadratic functional form for my regression model.

The dependent variable, called "percentage of correct responses" in my regression equation, is computed as the percentage of correct responses to 26 questions from the GSS 2008 survey (see Appendix A). These questions were designed to assess the respondents' knowledge of the physical and biological sciences, understanding of charts and statistics, reasoning ability, and use of experimental and controlling variables in a scientific experiment. As stated in the National Science Foundation report (2010), "A good understanding of basic scientific terms, concepts, and facts; an ability to comprehend how science generates and assesses evidence; and a capacity to distinguish science from pseudoscience are widely used indicators of scientific literacy" (pp. 7-17). Factual questions have been included in science knowledge surveys by the National Science Foundation, General Social Survey (GSS), British Royal Society, and the European Commission for several decades. My approach, which was to use data derived from performance on the 26 science questions in the 2008 GSS, is consistent with these prior studies.

For each science question in the GSS 2008, there were several possible responses but only one correct answer. I created dummy variables to represent the correct responses for each of the questions. Ten of the questions required a response of "true, false or don't know." Fourteen of the science questions were multiple-choice questions for which there was only one correct answer. And finally, two of the questions required a short narrative response for which there was also only one complete and correct answer.

Because there is only one correct response to each of the survey questions, it was simple to compute the percentage of correct answers.[21]

In the next section, I describe the independent variables (e.g., age, income, gender, race, etc.) used in my model (see Table 1). I also describe the expected direction of effect of each coefficient on the dependent variable. Descriptive statistics that include the mean, standard deviation, and maximum and minimum values of each variable used in the model are shown in Table 2. I used PASW© Statistics 18 to generate a table of correlation coefficients between independent variables and to test for statistical significance (Table 3). I checked for high correlations (> .8) between independent variables that had significance at the .05 or .01 level (two-tailed test called Pearson's r). High correlations may be a sign of multicollinearity, which I discuss later in this chapter.

Independent Variables

Each of the broad causal factors shown on the right side of the equation below,

$$\text{Percentage of correct responses} = f\,(\text{socioeconomic factors, political factors, religion factors}) + \varepsilon$$

can be decomposed into independent variables, which shall serve as proxies for each of these broad categories:

$$Y = f\,(x_1, x_2, x_3, \ldots x_i) \Rightarrow$$

Next, I describe each of these independent variables and their expected direction of effect on the dependent variable.

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[21] I created dummy variables for correct responses and coded incorrect responses and "don't know" responses as zero.

Socioeconomic Factors

age = *f* {Baby Boomer (+), Generation X (+), Generation Y (+)}

The variable “age” is an interval-level variable coded in GSS 2008 as the exact age of the respondent at the time of the survey. Zigerell (2010) used an OLS regression and found a negative regression coefficient on age (-.14). I expect age may be an explanatory factor of variation in scientific literacy due to generational differences of respondents. I created dummy variables to represent persons born in the following generational cohorts and show the expected direction of effect on the dependent variable in parentheses: Traditionalist (the excluded variable) born 1900-1945 (-), Baby Boomer born 1946-1964 (+), Generation X born1965-1980 (+), and Generation Y born 1981-1999 (+) (Lancaster & Stillman, 2002).[22]

I expect members of Baby Boomer, Generation X, and Generation Y to answer a higher percentage of science questions correctly compared to Traditionalists. Higher scientific knowledge may be found in younger generations because persons in these cohorts grew up at the time when personal computers started to become widely available to households along with Internet access. Generation Y is a highly connected group of individuals that has had nearly lifetime access to the Internet, including more recently, Internet access on a wide variety of mobile devices. It is important to recognize the Internet is the dominant source of science information (53.8%) followed by television (22.0%), according to survey respondents (GSS, 2010). In addition, the creation of

[22] Persons born since 2000 are in Generation Z, however; this cohort is younger than 18 and, therefore, does not meet the minimum age requirement to participate in the GSS survey.

public, educational, and government access television programming since about 1970, which includes channels devoted to science (such as NOVA, National Geographic, Animal Planet, and Nature), has probably had a positive impact on public knowledge of science overall.

gender = *f* {male (+)}

In the literature, I found only a few studies that looked at gender differences with respect to performance on scientific questionnaires, but none of these studies reported statistically significant differences (Miller, 1983; National Science Foundation, 2010; Susteric, n.d.). Miller (1983) constructed an index of scientific literacy and found that only 7% of respondents to a 1979 National Science Foundation survey were scientifically literate. This subgroup consisted of primarily males, respondents over 35 years of age, and college graduates. Miller (2004) used a structural equation analysis and found the variable female had a negative direction of effect on civic scientific literacy (-0.24). Zigerell (2010) used an OLS regression and found a negative regression coefficient on female (-.08). The Science and Engineering Indicators 2010 report (National Science Foundation, 2010) showed men scored higher than women on 15 of the 16 science factual knowledge science questions added in 2008 as part of the 2008 GSS. The regression study of belief in evolution by Susteric (n.d.) included a male dummy variable, but it was not found to be significant.

I think there is some evidence that gender may have an effect on public knowledge of science so I included a male dummy variable in my regression model. I think there may be cultural stereotypes and expectations that women should not be as good at math and science as men which may be reflected in the 2008 GSS performance on science questions. This stereotype may gradually be changing as more women enter the workforce and choose occupations with higher educational requirements.

marital status = *f* {married (+)}

I did not find any studies in the literature including marital status as a factor in public understanding of science. However, I think it is plausible there could be a positive effect on the dependent variable if the respondent is married and the spouse is college educated. I included a married dummy variable (+) to test whether it had a significant effect on scientific knowledge.

income = *f* {low income (+); moderate income (+), high income (+), and very high income (+)}

I expected income to be a factor explaining some of the variation in public knowledge of science, an idea also supported in the literature (Pardo & Calvo, 2004; Smith, 1996). I expected that compared to very low income (the excluded variable), higher levels of income would have a positive relationship with scientific literacy since higher income affords greater opportunities to obtain information and to get a college education.

Cook (2010) describes total family income changes from 2008 to 2009 based on U.S. Census Bureau data from 2009 (U.S. Census Bureau, 2011), which categorizes total family income into quintiles[23], which are fifths of the U.S. population ordered by their amount of income. These quintiles break down as follows (Cook, 2010):

First or bottom income quintile: < $20,453

Second quintile: $20,454 to $38,550

Third quintile: $38,551 to $61,801

Fourth quintile: $61,802 to $100,000

Fifth or top income quintile: >$100,000

In GSS 2008 there are 25 categories of income ranging from under $1000 per year at the low end to the highest reported income category of $150,000 or more per year. Therefore, I could not use the specific income as an explanatory variable and had to create dummy variables to represent income brackets. I took the GSS 2008 income data and collapsed 25 categories into five income brackets, which are close approximations of the quintiles described above. I then created low income (second quintile), moderate income (third quintile), high income (fourth quintile) and very high income (fifth quintile) dummy variables. The first quintile, very low income, is the excluded variable.

education = *f* {high school diploma (+); junior college degree (+); bachelor degree (+); graduate degree (+)}

I expected educational attainment to have a positive direction of effect on scientific literacy, which is also supported by the literature (Pardo & Calvo, 2004; Smith, 1996; Susteric, n.d.; Zigerell, 2010). I expected respondents having a high school

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[23] A quintile is one of the four values dividing a range of data into five equal parts consisting of 20% each.

diploma, junior college degree, bachelor degree, and graduate degree to have a positive effect on scientific knowledge compared to respondents having less than a high school education (the excluded variable). I created dummy variables for each of these categories of educational attainment.

ethnicity[24] = *f* {black (-); American Indian (-); Asian (-); Hispanic (-)}.

I found limited evidence in the literature suggesting race may be a factor in public understanding of science. Whites, Blacks, and Hispanics comprised over 95% of the sample while all other ethnic groups cumulatively made up the remaining percentage in the GSS 2008 survey. These other ethnic groups consisted of Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, some other Asian race, native Hawaiian, some other Pacific Islander, or some other race. Cumulatively, these racial groups comprised less than 4% of the sample. I decided to compress these categories and code them as one group called Asian. I expected Hispanics, Blacks, Asians, and American Indian ethnic groups to show a negative direction of effect on scientific literacy compared to Whites (the excluded variable), potentially due to cultural differences. Susteric's (n.d.) regression analysis of GSS 2006 data to evaluate belief in human evolution showed that Blacks and Latinos had large negative coefficients that were statistically significant. Zigerell (2010) used an OLS regression and found a negative regression coefficient on African American (-.05).

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[24] The 2008 GSS question on ethnicity allowed the respondent to indicate one or more races they considered themselves to be. The response is coded as the first race they mention.

geography = *f* {Middle Atlantic (+); E. North Central (-); W. North Central (+); South Atlantic (-); E. South Central (-); W. South Central (-); Mountain (-); Pacific (+); population size (+)}

I included in my model the United States Census divisions in which the surveys took place (New England division was the excluded variable). My expectation was that census divisions with mostly Democrat-leaning blue states[25], including the Pacific and Middle Atlantic division, would show a positive direction of effect on public knowledge of science. In the remaining census divisions dominated by red states I expected a negative direction of effect on scientific knowledge due to higher political and religious conservatism. I expected large, negative effects in the Bible Belt, which is a socially conservative area of the south-eastern and south-central United States dominated by evangelical Protestantism. There is some evidence that political and religious conservatism is negatively associated with public knowledge of science (Nisbet & Goidel, 2007; Susteric, n.d.). Gibson (2004) showed that a state's religious environment is a good predictor of science educational policies. I believe the culture in which a person lives may act to further enhance and reinforce one's core values and beliefs which in turn may impact public knowledge of science.

While I did not find any literature examining the influence of urban versus rural settings on public knowledge of science, I expected the size of the community in which

[25] The terms blue states and red states came into usage in the 2000 general election and denote states in which residents tend to vote for either Democratic or Republican candidates for the Presidency, respectively.

the GSS interview occurred to show a positive direction of effect on scientific literacy because of the greater opportunity in an urban environment to access various sources of scientific information. I included a variable called population size squared in my quadratic specification of the regression model to see if there was a non-linear relationship of size of community with public knowledge of science. The units of population size are expressed in terms of the size of the community to the nearest 1000 in which the GSS survey took place. I used calculus to find the size of the community in which the maximum benefit occurs from living in a more populated area in terms of percentage of correct responses.

Political Factors

political = *f* {Republican (-); conservative (-)}

I expected political party identification and ideology to be associated with public knowledge of science. I expected Republican to have a negative direction of effect compared to Democrats and Independent Party members, which are the excluded variables. I also expected conservative to show a negative direction of effect compared to moderate and liberal ideology, which are excluded variables.

I believe Republicans and conservatives may have core values and religious beliefs that may act as perceptual filters of scientific information. In Chapter 1, I described how the modern American conservative movement has increasingly dominated the Republican Party platform and has co-opted the Religious Right to achieve its political goals (Eckolm, 2011; Gibson, 2004; Gross, 2006; Mooney, 2005). Specter

(2009) provides many examples of what he calls denialism of scientific information that does not comport with one's deeply held beliefs.

Religious Factors

religion = *f* {Bible believer (-)}

There are different views of the Bible which range from it being a collection of fables to it being the inerrant, literal Word of God, absent of errors in every conceivable way. There is also an intermediate view that the Bible was written by men divinely inspired but that not everything in the Bible is the literal Word of God. I created a dummy variable called Bible believer to represent respondents who believed the Bible was the literal Word of God or the inspired Word of God, since these beliefs are both strong indications of religious faith. The variable Bible believer shows effects on the dependent variable relative to respondents who said the Bible is a book of fables (the excluded variable).

I expected the variable Bible believer to have a negative direction of effect on public knowledge of science. Zigerell (2010) performed an OLS regression using data from the 2008 GSS and found a significant, negative coefficient (-.12) on the variable called literal view of the Bible. Gibson (2004) showed evidence of what he called "morality policy" on issues like abortion, gay rights, and evolution. He found that a state's religious environment is a good predictor of how well evolution is included in public school's curriculum. Miller, Scott, and Okamoto (2006) showed the public acceptance of evolution in the United States was second from the bottom of 34 countries surveyed in 2005; the authors believe it was due to widespread fundamentalism and political influence on science, a subject extensively discussed by Mooney (2005). Susteric (n.d.) also found negative relationships between belief in evolution and the variables fundamentalist Christian and conservative. Nisbet and Goidel (2007) found a negative relationship between religiosity and support for stem cell research.

Alternative Specification of the Model and Interaction Variables

Regression analysis requires an equation to be linear in the coefficients, according to the Classical Assumptions (Studenmund, 2006). It is not a violation of the Classical Assumptions to use alternative functional forms of a model. Therefore, I tested a quadratic model by including an additional independent variable called population size squared in my model. I also examined the potential interaction of variables including:

- Bachelor degree and Bible believer to see if a college education would change the effect of religiosity on the dependent variable;
- Bachelor degree and Hispanic to see if a college education would change the effect of religiosity on the dependent variable;
- High income and Hispanic see if a relatively high level of income would change the effect of Hispanic on the dependent variable;

Multicollinearity

Perfect multicollinearity occurs when a linear correlation exists between two or more of the independent variables of the model violating Classical Assumption VI, which states, “no explanatory variable is a perfect linear function of any other explanatory variables" (Studenmund, 2006, p. 246). Perfect in this sense means a perfect linear relationship between variables. Perfect multicollinearity is generally easy to avoid on a logical basis in the specification of the variables; however, imperfect multicollinearity can be a little more challenging to detect but can still be corrected for in the model. According to Studenmund (2006), the consequences of multicollinearity are:

1. Coefficient estimates will remain unbiased and centered around the true values in the population.
2. There will be an increase in the variance and standard errors of the estimated coefficients.
3. t-score values will be lower because of the increase in the standard errors.
4. Coefficient estimates will vary according to the type of model being specified.
5. Fit of the equation and coefficients of variables that are not multicollinear will not substantially change.

There are two ways to detect multicollinearity. The first method is to examine simple correlation coefficients between the independent variables (Studenmund, 2006). I performed a bivariate correlation and show the results in Table 3. If a correlation coefficient is high between two independent variables (generally, if the absolute value is >.8) then we can expect multicollinearity may be present. This however, is not a conclusive test.

The second way to detect multicollinearity is to examine the variance inflation factor (VIF) for each independent variable. As a rule of thumb, a VIF (β_i) > 5 is a sign that multicollinearity is severe (Studenmund, 2006). One solution to correct for multicollinearity is to drop one or more of the multicollinear variables.

Heteroskedasticity

Heteroskedasticity occurs when Classical Assumption V is violated, which requires "that observations of the error term are drawn from a distribution that has a constant variance" (Studenmund, 2006, p. 346). Heteroskedasticity typically occurs in cross-sectional data where it is not uncommon to have a large range between the highest and lowest observations from the same time period but across different, for example, geographic areas with varying population size (Studenmund, 2006, p. 349). In my paper, I am only referring to pure heteroskedasticity described by Studenmund (2006) in which he describes the consequences as:

1. Heteroskedasticity does not cause the estimate of coefficients to be biased and the distribution of the estimates are still close to the actual population value.
2. It effects ordinary least squares estimation of coefficients because heteroskedasticity causes the dependent variable to vary and the regression model incorrectly attributes this variation to the independent variables.
3. The estimate of the standard error is biased, which can cause incorrect t-statistics and inaccurate conclusions from hypothesis tests.

One of the ways to test for heteroskedasticity is to perform a Park test (Studenmund, 2006). The Park test is a procedure to test the residual errors in the model to see how they vary with what is called the proportionality factor, i.e., an independent variable you believe varies with the variance of the error term (Studenmund, 2006). To perform the Park test, I saved the residuals of the quadratic model corrected for multicollinearity. I then took the natural log of the squared residuals and used these values as the dependent variable in the regression. I then squared the variable called population size and took its natural log and used it as my independent variable. I then performed a regression using these variables and examined the model results for statistical significance.

Regression Coefficients and Ninety Percent Confidence Interval

I ranked the statistically significant regression coefficients (reported at the 0.10 level of significance) in order of importance as measured by their magnitude, i.e., causal factors that had the greatest influence; second, third, fourth, etc. on the dependent variable. I also describe the 90% confidence interval for each significant regression coefficient. The 90% confidence interval tells the range in which the regression coefficient will occur 90% of the time (i.e., we can be 90% confident the regression coefficient will fall within this range) and provides more information than a single point estimate (Studenmund, 2006). I conclude the chapter with a description of the overall fit of the model and a simulation of the best-case and worst-case scenario in terms of maximum effects of independent variables on scientific literacy.

Conclusion

This chapter described the source of my data and the analytical methods I used to examine my question of why there is relatively greater knowledge of science in some adults. I described how I used OLS regression to examine the effect of independent variables on public knowledge of science. I described a quadratic specification of my regression model, how I tested for model error, and the potential interaction between independent variables. Finally, I described how I evaluated regression coefficients in terms of their rank order of magnitude and the 90% confidence interval.

In the next chapter, I describe the results of my regression analysis and the significance, direction, and magnitude of regression coefficients for the quadratic regression model, the final functional form I chose for subsequent analysis. I describe the results of my tests for interaction between independent variables. I also describe the 90% confidence interval for significant coefficients. Finally, I describe the overall fit of the quadratic model as measured by R-squared value.

Chapter 4

RESULTS

Introduction

In this chapter, I discuss the descriptive statistics for the dependent and independent variables used in my model (Table 2). I then describe the results of my test for significant correlations between independent variables, which can be a sign of multicollinearity in the model (Table 3). Following this I describe the results of my OLS regression and the direction and magnitude of regression coefficients, along with statistical significance reported at the .10, .05, and .01 levels (Table 4). I describe my test for interaction variables and my test for error in the model. I then describe the regression coefficients in order of importance as measured by their magnitude and the 90% confidence interval of each coefficient (Table 5). Finally, I describe the worst- and best-case scenarios of science literacy (Table 6) and then segue into my last chapter on conclusions and recommendations.

Descriptive Statistics and Correlation Matrix

Table 2 shows descriptive statistics for the dependent and independent variables. The dependent variable, which is the percentage of correct responses to the 26 science and technology questions, has just over 1000 observations (N = 1045). The sample mean is 58.58 (meaning 58.58% correct responses) with a standard deviation of 22.50. The maximum percentage of correct responses is 100 and the minimum is zero. The mean value can be thought of as the average score of all respondents before controlling for any factors causing variation. According to academic grading in the United States, this average score falls on the border between a D and an F grade.[26]

Generational cohorts comprise the following proportions of the sample: 21% Traditionalist (excluded variable, not shown), 36% Baby Boomer, 29% Generation X, and 14% Generation Y (Table 2). Males comprise 46% and married respondents comprise 48% of respondents. Mean family income of respondents was categorized by income quintiles (see Chapter 3 for description) and breaks down to 22% very low income (excluded variable, not shown), 23% low income, 16% moderate, 25% high income, and 14% very high income. Respondents with less than a high school diploma (excluded variable, not shown) account for 13% of the respondents, followed by 50% with a high school diploma, 9% with a junior college degree (i.e., Associate Degree), 18% with a bachelor degree, and 10% having a graduate degree. Ethnic groups consisted of 78% white (excluded variable, not shown), 14% Black, 1% American Indian (includes native Alaskans), 3% Asian, and 4% Hispanic. Census divisions in which the 2008 GSS took place indicate the percentage of surveys that took place in each division and were returned as 4% New England (excluded variable, not shown), 13% Middle Atlantic, 17% E. North Central, 6% W. North Central, 22% South Atlantic, 5% E. South Central, 10% W. South Central, 8% Mountain, and 15% Pacific. The variable population size has a mean value of 368.9, which is the population size of the location in which the 2008 GSS took place (measured in thousands, the mean population size is 368,900). Republican

[26] http://en.wikipedia.org/wiki/Academic_grading_in_the_United_States

comprises 26% of the sample; Democrats and Independent Party (excluded variables, not shown) comprise 74% of respondents. Conservative comprises 20% of the sample and liberal and moderate ideology (excluded variables, not shown) comprise 80%. Finally, Bible believer comprises 79% of the sample; the remaining 21% of respondents believe the Bible is a book of fables (excluded variable, not shown).

Table 3 is a correlation matrix I constructed by performing a bivariate correlation between independent variables using PASW® Statistics 18. This is a simple, but not conclusive test for multicollinearity in the model as described in Chapter 3. By inspection it can be seen there are no correlation coefficients with an absolute value greater than 0.8 that are statistically significant, based on Pearson's r test. I later describe a more definitive test for multicollinearity by examining the Value Inflation Factor or VIF.

Regression Model Analysis

I first performed an OLS regression analysis on a linear model and found evidence that age, gender, income, education, ethnicity, and religion were significant factors (results not shown). I then performed an OLS regression analysis on a quadratic specification of my regression model, which included the squared value of population size. The quadratic model showed that population size and population size-squared had statistically significant regression coefficients. The R-squared value for the quadratic model was also slightly higher compared to the linear model. [27] Based on these findings,

[27] I describe the meaning and results of R-squared later in this chapter.

and on my theory that population size has a non-linear effect on the dependent variable, I settled on the quadratic model for further analysis.

The regression analysis showed evidence of an *age effect* on scientific literacy (Table 4). The independent variables Baby Boomer, Generation X, and Generation Y each were each significant and had positive regression coefficients, relative to the excluded variable, the Traditionalist generation born between 1900 and 1945. Furthermore, there was an increase in the magnitude of coefficients from Baby Boomer, to Generation X, and to Generation Y. This supports my thesis that younger generations would have relatively higher scientific literacy compared to Traditionalists. Baby Boomer had a positive regression coefficient of 7.121, which is the change in the dependent variable (percentage of correct answers) attributable to the independent variable Baby Boomer, controlling for other factors.[28] This coefficient means Baby Boomers got 7.121% more questions right (mean of 1.851 questions) compared to Traditionalists. Generation X had a positive coefficient value of 8.976, meaning this group got 8.976% more right (mean of 2.333 questions) than Traditionalists. Generation Y had an even higher coefficient of 12.558, 12.558% more questions right than Traditionalist (mean of 3.265 questions). This is an interesting pattern of increasing scientific literacy in younger generations I theorized would be found in the model.

I also found a *gender effect* in the regression model. The coefficient on the male dummy was 7.283 and in the positive direction. This result means males answered

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[28] In equation form, this looks like: percentage of correct responses = 37.220 + 7.121*(Baby Boomer).

7.283% more questions correctly compared to females, the excluded variable (mean of 1.893 questions). This finding supports my thesis that males would have higher scientific knowledge than females. Zigerell (2010) performed an OLS regression using data from the 2008 GSS and found the female dummy variable had a regression coefficient of -.08. This means females, as compared to males, got 8% more wrong answers on the 16-item science quiz (mean of 2.08 questions). Studies by Miller (1983), the National Science Foundation (2010), and Susteric (n.d.) also found men scored higher than women on scientific questionnaires, but there was not a theoretical basis described for these results nor was Susteric's (n.d.) result statistically significant. I believe females may still be subject to cultural stereotypes portraying them as being inferior to men at math and science, which becomes a self-fulfilling societal expectation. It also may be that more men are employed in scientific and technical careers than women and have the relevant college training.

I did not find a significant effect in the model associated with being married, but I was not too surprised by this result (Table 4). I believe I had a plausible theory why it might be an important factor so I included it in the model. I theorized married respondents would perform better on the science questions due in part to having a shared pool of life experience, interests, and other information that would available to one's spouse.

The results show an *income effect* on scientific literacy. Moderate, high, and very high income were each significant and had positive coefficients (Table 4). These effects are in comparison to the excluded variable which was very low income, i.e., the first quintile of income (<$20,453 per year). Furthermore, there was an increase in the magnitude of coefficients for each income category. Moderate income had a coefficient of 6.376, meaning 6.376% more questions were answered right compared to the very low-income group (mean of 1.657 questions). High income had a coefficient of 7.987, meaning 7.987% more questions were answered correctly (mean of 2.076 questions). Very high income had a coefficient of 10.551, meaning 10.551% more right answers compared to the very low-income group (mean of 2.743 questions). These results support my thesis that higher levels of income, compared to the very low-income category, would be associated with higher scientific literacy. These results might be explained by the greater diversity of cultural experiences available to high-income earners.

The results also show an *education effect* on scientific literacy. High school diploma, junior college degree, bachelor degree, and graduate degree were each significant and had positive coefficients (Table 4). These effects are in comparison to the excluded variable, respondents having less than a high school diploma. There was also an increase in the magnitude of coefficients as the level of educational attainment increased. High school diploma had a positive regression coefficient of 11.283, meaning high school graduates had 11.283% more right answers (mean of 2.933 questions) compared to respondents without a high school diploma. Junior college degree had a positive regression coefficient of 18.605 or 18.605% more right (mean of 4.837

questions) compared to respondents without a high school diploma. Bachelor degree had a positive regression coefficient of 26.210 or 26.210% more right (mean of 6.814 questions) compared to respondents without a high school diploma. Finally, graduate degree had a positive coefficient of 29.776 or 29.776% more right (mean of 7.741 questions) compared to respondents without a high school diploma. These results support my thesis that educational attainment would have a positive effect on scientific literacy.

It is interesting to note the benefit of high school diploma to scientific understanding as indicated by its regression coefficient (11.283 or 11.283% more correct) compared to respondents with less than a high school diploma. This result suggests that policy intervention might include programs aimed at keeping kids in school and increasing the national high school graduation rate.

I also found an *ethnicity effect*. Black, American Indian, and Asian each had negative coefficients that were significant (Table 4). These effects are in comparison to the excluded variable, White respondents. These comparisons tell us what the effects are of race, controlling for all other factors. In other words, if two respondents were exactly the same in all characteristics except one is Black and one is White, for example, the regression coefficient on Black tells the magnitude and direction of effect that being Black versus White has on scientific literacy. Black had the highest magnitude coefficient among ethnic variables. The coefficient on Black was negative and equal to -16.323, meaning 16.323% more wrong answers compared to White (mean of 4.243

questions), followed by Hispanic with a coefficient of -13.078, meaning 13.078% more wrong compared to White (mean of 3.400 questions). American Indian had a coefficient -9.472, meaning 9.472% more wrong compared to White (mean of 2.462 questions). Finally, Asian had a coefficient -6.347, meaning 6.347% more wrong answers compared to White (mean of 1.650 questions). I speculate these results may be explained in part due to a lower *quality* of education received by these ethnic groups in economically disadvantaged areas. Proficiency in the English language may also be acting as a partial barrier to understanding the survey questions, particularly for the Asian ethnic group. Susteric (n.d) constructed a logit model with belief in evolution as the dependent variable and included Black and Latino ethnic groups as independent variables, along with factors including religiosity and education, to examine how the various factors affect a person's belief in evolution.[29] Susteric's (n.d.) paper was not clear on how regression coefficients were estimated and determined to be significant; however, it was reported that Black and Latino respondents had significant negative coefficients, just as I have found in my model.

The model results did not show any significant regression coefficients for geographic variables, based on United States Census divisions (Table 4). The South Atlantic division variable had a VIF greater than 5 but is of very little concern because there was no other included variable closely correlated with South Atlantic, so there was

[29] In a logit regression the coefficient on the dependent variable is the probability that it is equal to 1.

not any threat of multicollinearity. I therefore did not drop it from the model and corrections were unnecessary.

Model results also did not show a political effect for either the Republican or the conservative variable (Table 4). This was a surprising result suggesting party identification and ideology do not provide good estimates of percentage of correct responses to the science questions in the 2008 GSS after controlling for other factors.

The model showed a significant *religion effect*. The coefficient on Bible believer was -5.331, meaning Bible believers answered 5.331% more questions wrong (mean of 1.386 questions) compared to respondents believing the Bible is just a book of fables, the excluded variable (Table 4). Zigerell (2010) performed an OLS regression using data from the 2008 GSS and found a negative coefficient (-.12) on the independent variable called literal view of the Bible and its effect on scientific knowledge. This coefficient translates into 12 percentage points less, or about two questions out of 16 possible (mean of 1.92 questions). This coefficient is in the same negative direction, but larger in magnitude than the regression coefficient on Bible believer included in my model. Susteric's (n.d.) logit model had a regression coefficient on fundamentalist Christian that was also in the negative direction.

Finally, my model showed a significant *population size effect*. Population size and population size squared were statistically significant, however, with very small, coefficients (0.003 and -5.171E-7, respectively), meaning there was a non-linear effect of population size on the dependent variable. The combined effect of population size and population size squared was determined by using calculus to obtain the first derivative in order to find where the slope of the combined effect of population size was equal to zero. I then solved for population size. The steps in this calculation were as follows:

(1) population effect = 0.003(population size) – 0.0000005(population size)^2

(2) d(population effect)/dp = 0.003(population size) - 0.0000005(population size)^2

= 0.003 - (2)(0.0000005)(population size)

= 0.003 – 0.00001(population size) => the first derivative;

(3) setting the first derivative equal to zero, I solved for population size:

0.003 – 0.00001(population size) = 0

0.00001(population size) = 0.003

population size = 3000 (which, multiplied by 1000, equals 3 million).

The coefficient of population size squared becomes -1.03E5 after taking the first derivative. So for every 10,000 increase in population size (recall, units of population size are expressed in 1000s), the positive effect of population size on the dependent variable diminishes and the slope becomes zero at a population size of 3 million people. This suggests that up to a population size of three million, we can expect to see increasing scientific understanding. When population size exceeds three million people, the effect of population size on the dependent variable has a diminishing effect. This is consistent with my theory that living in a more urban setting provides more opportunities for education and interaction among people and an exchange of ideas, up to a point, and then larger communities start seeing attributes characteristic of densely populated areas (e.g., higher ethnic diversity, economically disadvantaged areas, etc.).

Interaction Variables

I performed three tests to see if there were interactions between certain independent variables that in turn had effects on percentage of correct responses. The tests for interaction between variables and my rationale were as follows:

- *Bachelor degree x Bible believer* to see if a college education would change the effect of religiosity on the dependent variable. I expected the percentage of correct responses to increase. I also expected the coefficient on Bible believer to decrease and potentially become insignificant;
- *Bachelor degree x Hispanic* to see if a college education would change the effect of Hispanic on the dependent variable. I expected the percentage of correct responses to increase. I also expected the coefficient on Hispanic to become less negative and potentially become insignificant;
- *High income x Hispanic* to see if a relatively high level of income would change the effect of Hispanic on the dependent variable. I expected the percentage of correct responses to increase. I also expected the coefficient on Hispanic to become less negative and potentially become insignificant.
- None of these interaction variables were found to be significant (results not shown).

Multicollinearity and Heteroskedasticity

As previously described in this chapter, the South Atlantic division variable had a VIF greater than 5 but since there was no other included variable closely correlated with South Atlantic, there was not any threat of multicollinearity. I therefore did not drop it from the model and corrections for multicollinearity were unnecessary.

To test for heteroskedasticity, I performed the Park test. I saved the residuals of the quadratic model and then took the natural log of the squared residuals and used these values as the dependent variable in a new regression model. I then took the natural log of population size and used it as my independent variable. I then performed a regression using these variables and examined the model results for statistical significance. The coefficient on the natural log of population size was not statistically significant and, therefore, indicates there is no heteroskedasticity in the quadratic model (results not shown).

Regression Coefficients and Ninety Percent Confidence Intervals

I ranked the statistically significant regression coefficients (reported at the 0.10 level of significance) in order of importance as measured by their magnitude, i.e., causal factors that had the greatest influence; second, third, fourth, etc. on the dependent variable (Table 5). I also describe the upper and lower bound of the 90% confidence interval (CI) for each regression coefficient. The 90% CI tells the range in which the regression coefficient will occur 90% of the time (i.e., we can be 90% confident the regression coefficient will fall within this range) and provides more information than a single-point estimate (Studenmund, 2006). I will discuss the implication of these results in my conclusions and recommendations chapter where I make suggestions for policy interventions to improve public knowledge of science.

Graduate degree, bachelor degree, and junior college degree had the top three highest regression coefficients, which fall within the range of 29.7 to 18.6 (Table 5). This suggests higher education is an important factor in explaining variations in scientific literacy. Graduate degree had a positive coefficient of 29.776 or 29.776% more correct responses compared to respondents without a high school diploma (mean of 7.741 questions). The upper bound of the 90% CI for graduate degree was an astonishing 34.155 which means 34.155% more correct responses (8.880 questions) compared to respondents lacking a high school diploma. The lower bound of the 90% CI was 25.397 or 25.397% (6.603 questions). I can therefore state with 90% confidence that a respondent with a graduate degree will answer between 6.603 and 8.880 more questions correctly compared to respondents lacking a high school diploma. Bachelor degree had a positive regression coefficient of 26.210 or 26.210% more right answers (mean of 6.814 questions) compared to respondents lacking a high school diploma. The upper bound of the 90% CI was 29.799 meaning 29.799% more correct (7.747 questions) and the lower bound was 22.622 meaning 22.622% more correct answers (5.881 questions). Again, I can therefore state with 90% confidence that a respondent with a bachelor degree will answer between 5.881 and 7.747 more questions correctly compared to respondents lacking a high school diploma. Junior college was next in magnitude with a positive regression coefficient of 18.605 or 18.605% more correct answers (mean of 4.837 questions) compared to respondents without a high school diploma. The upper bound of the 90% CI was 22.589, meaning 22.589% more correct answers (6.731 questions) and the lower bound was 14.620 or 14.620% more correct answers (3.801 questions).

The next group of variables in rank order of magnitude was Generation Y, high school diploma, and very high income, with coefficients that fall in the range 12.5 to 10.5. Generation Y had a coefficient of 12.558, meaning 12.558% more correct answers (mean of 3.265 questions) compared to the excluded category, Traditionalist. The upper bound of the 90% CI was 15.911, which was 15.911% more correct answers (4.136 questions) while the lower bound was 9.204 or 9.204% more correct answers (2.393 questions). High school diploma follows next in rank order of magnitude with a positive regression coefficient of 11.283, meaning high school graduates had 11.283% more right answers (mean of 2.933 questions) compared to respondents without a high school diploma. The upper bound of the 90% CI was 12.214, meaning 12.214% more correct answers (3.175 questions) while the lower bound was 8.352 or 8.352% more correct answers (3.175 questions). The very high-income coefficient was 10.551, meaning 10.551% more right answers (mean of 2.743 questions) compared to the very low-income group (Table 5). The upper bound of the 90% CI was 14.231, meaning 14.231% more correct answers (3.700 questions) while the lower bound was 6.872 or 6.872% more correct answers (1.786 questions). These results support my theory that age, education, and income would each be significantly associated with scientific literacy.

The next group of variables in rank order of magnitude was Generation X, high income, male, Baby Boomer, and moderate income with coefficients that fall in the range of 8.9 to 6.3 (Table 5). Generation X had a positive coefficient value of 8.976, meaning this group got 8.976% more right (mean of 2.333 questions) compared to Traditionalists. The upper bound of the 90% CI was 11.750, meaning 11.750% more correct answers (3.055 questions) while the lower bound was 6.202 or 6.202% more correct answers (1.612 questions). High income is the next highest in magnitude with a coefficient of 7.987, meaning 7.987% more correct answers (mean of 2.074 questions) compared to the very low-income excluded category. The upper bound of the 90% CI was 11.001, meaning 11.001% more correct answers (2.860 questions) while the lower bound was 4.973 or 4.973% more correct answers (1.292 questions). Male had a positive coefficient of 7.283, meaning that compared to the excluded variable female, males answered 7.283% more questions correctly (mean of 2.035 questions). The upper bound of the 90% CI was 9.055 which means 9.055% more correct answers (2.354 questions) while the lower bound was 5.510 or 5.510% more correct answers (1.326 questions). Baby Boomer had a positive coefficient of 7.121, meaning 7.121% more correct answers (mean of 1.851 questions) compared to Traditionalists. The upper bound of the 90% CI was 9.726, meaning 9.726% more correct answers (2.528 questions) while the lower bound was 4.517 or 4.517% more correct answers (1.174 questions). Finally, moderate income had a coefficient of 6.376, meaning 6.376% more questions were answered correctly (mean of 1.657 questions) compared to the very low-income group. The upper bound of the 90% CI was 9.413, meaning 9.413% more correct answers (2.447 questions) while the lower bound was 3.338 or 3.338% more correct answers (0.878 questions).

The next variables I discuss have negative coefficients, meaning the effect on the dependent variable is negative. Bible believer, Asian, and American Indian had coefficients that fall within the range of -5.3 to -9.4 (Table 5). Bible believer had a negative coefficient of -5.331, meaning 5.331% more questions wrong (mean of 1.386 questions) compared to the excluded variable of Bible is just a book of fables. The upper bound of the 90% CI was -2.950, meaning 2.950% more wrong answers (0.767 questions) while the lower bound was -7.713, meaning 7.713% more questions wrong (2.005 questions). Asian had a coefficient -6.347, meaning 6.347% more wrong answers compared to White, the excluded variable (mean of 1.65 questions). The upper bound of the 90% CI was -1.149, meaning 1.149% more wrong answers (0.38 questions) while the lower bound was -11.545, meaning 11.545% more wrong answers (3.001 questions). American Indian had a negative coefficient of -9.472, meaning 9.472% more wrong answers compared to White, the excluded variable (mean of 2.462 questions). The upper bound of the 90% CI was -2.596, meaning 2.596% more wrong answers (0.674 questions) while the lower bound was -16.349, meaning 16.349% more questions wrong (4.250 questions).

The last two ethnic variables with negative regression coefficients, notable because of their large magnitudes, are Hispanic and Black. Hispanic had a coefficient of -13.078, meaning 13.078% more wrong answers compared to White, the excluded variable (mean of 3.400 questions). The upper bound of the 90% CI was -8.298, meaning 8.298% more wrong answers (2.157 questions) while the lower bound was -17.858, meaning 17.858% more questions answered wrong (4.643 questions). Black had the highest magnitude negative coefficient equal to -16.323, meaning 16.323% more wrong answers compared to White, the excluded variable (mean of 4.243 questions). The upper bound of the 90% CI was -13.687, meaning 13.687% more wrong answers (3.558 questions) while the lower bound was -18.958, meaning 18.958% more questions answered wrong (4.929 questions).

I speculate the effects of ethnicity described above may be explained in part due to a lower quality of education received by these ethnic groups compared to Whites or that perhaps the English language is acting as a partial barrier to understanding the survey questions, particularly for respondents in which English is spoken as a second language.

The regression coefficient on population size was positive (.003) whereas the coefficient on population size squared was negative (-5.171E-7), meaning population size squared is having a diminishing effect on the dependent variable as population size increases. As described earlier in this chapter, population size reaches a local maximum (with a slope of zero) at three million people. This is the size of the population in which this variable reaches its maximum effect on the dependent variable.

Overall Fit of the Model

The R-squared value (also written as R^2) is called the coefficient of determination and must be ≤ 0 $R^2 \leq 1$. The coefficient of determination measures how well the estimated regression equation fits the sample data and explains variation in the dependent variable, called the "goodness of fit." The closer R^2 is to one, the better the fit. The R-squared for my model was 0.497 meaning that almost 50% of the variation in scientific literacy was explained by the model.

We are cautioned by Studenmund (2006) never to try to maximize the R-squared value to obtain a better fit for our model. A regression model should be built upon a logical, theoretical framework using available data and information and common sense (Studenmund, 2006). It is also important from the very beginning to ask the right questions, be knowledgeable about the policy context, and carefully review the data.

In summary, I found evidence confirming my theory that socioeconomic factors and religious factors are associated with public understanding of science. I found age, gender, income, education, ethnicity, and religion were significant factors explaining variation in the percentage of correct responses. I found no evidence of significant effects that could be attributed to being married, to U.S. Census divisions, or due to political factors as represented by Republican Party and conservative ideology. I also found no evidence of interaction variables for the combinations of independent variables I tested.

Simulations of the best-case and worst-case scenario in terms of maximum effects of independent variables on scientific literacy are shown in Table 6. This table can be thought of as depicting respondent profiles of the highest and the lowest achievers. The best-case scenario for highest achievement consisted of a Generation Y, White male, having a very high income and graduate degree, and being a non-Bible believer living in a community of 3 million people. Conversely, the worst-case scenario for lowest achievement consisted of a Traditionalist, Black female, having a very low income and lacking a high school diploma, and being a Bible believer living in a community of 1000 people. These are interesting profiles that gave me ideas for policy interventions I describe in my final chapter on conclusions and recommendations.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

The environmental and social problems we face as a nation and as members of the world community are daunting. Climate change, extreme weather events, scarcity of fresh water, loss of biodiversity, perpetual war, economic recession, human disease, and overpopulation are grand problems requiring grand solutions. Conflicts between nations, political parties, interest groups, economic classes, and ethnic and religious factions will likely increase as competition for limited natural resources intensify, further impeding progress toward solutions. There is an urgent need for “believers” on all sides to get out of their silos, out of their entrenched positions, and stop trying so feverishly to promote their own particular view as preeminent. Communication and respect needs to be improved between different groups to foster collaborative problem solving.

To develop strategies to deal with these highly complex and interrelated issues, there first has to be agreement that a problem exists and that there are different approaches to solving problems. Without some level of agreement, it is unlikely there will be public support and political will to implement adaptation strategies and solutions to these grand problems. Consensus between various groups will be essential to progress.

I described in my introduction how denialism and the politicization of science are so pervasive in today’s politically charged environment. There are, for example, some people who do not believe in climate change, biological evolution, or the need for childhood vaccinations. Organized interest groups and lobbyists work through the policy and political process for the benefit of certain industries to gain access to decision makers. It is particularly concerning when the goal of these lobbying activities is to reduce environmental regulations for the benefit of corporate interests.

Illogical thinking, political ideology, and religious dogmatism are impeding scientific progress and threatening our future. Public understanding of science will enable citizens to be better informed on policy issues confronting us as a nation. With a basic understanding of science and what it means to study something scientifically, voters will be better informed when they register their preferences at the ballot box for political candidates and decide on various initiatives related to environmental and social issues they care about.

Scientific literacy is an essential element of a pluralistic society; it is important for citizens and policymakers to have a basic understanding of science. Policymakers especially need to understand what the science is telling them in order to make sound decisions on critical issues, such as adaption measures to deal with climate change or public health policies on AIDS. Higher public understanding of science is also associated with greater support for the work of science and scientific institutions, important for maintaining America's competiveness with other nations.

Social scientists have been studying public understanding of science for several decades, particularly in the United States and the United Kingdom. Scientific literacy is, however, not easy to define, nor do researchers or political leaders agree upon what people “need to know” when it comes to science. We also do not completely know all the factors associated with a public understanding of science.

Some of the early research on scientific literacy used survey methodologies that included a battery of science and technology questions, which were then analyzed to find associations with socioeconomic and demographic factors. Early work was based on the *deficit model* that assumed support for science was a function of the public understanding of science and its processes. If the gap in knowledge could be filled with scientific factual knowledge, it was believed the public would be more trusting and supportive of scientific institutions. In contrast, the *contextualist model* assumed science knowledge is necessarily related to time, place, culture, values, and particular circumstances. This model has spawned research in science communications, use of the media, and the role of scientists in society.

My thesis was influenced by the deficit model, oriented toward the importance of knowing science facts and methods, to see if I could find significant factors associated with scientific literacy using a regression-based analysis. My thesis posited that socioeconomic, political, and religious factors would be good predictors of scientific literacy, which I defined as the percentage of correct responses to 26 science and technology questions in the 2008 GSS. What I specifically wanted to find was the relative magnitudes of these factors in influencing a person’s scientific literacy. To do this, I described the independent variables I chose as proxies for each of the broad factors, performed an OLS regression analysis of cross-sectional survey data, and found statistically significant regression coefficients on some of the independent variables. I then compared the magnitudes of these statistically significant coefficients to see the relative influence of each. In this final chapter, I discuss the policy implications of each of my findings (summarized in italics) and my recommendations for policy interventions.

> *Respondents with a graduate degree, bachelor degree, associate degree, and a high school diploma performed better on the observed test of scientific literacy than respondents lacking a high school diploma.*

I was not surprised to find that educational factors had the largest magnitude, positive effects on scientific literacy. Respondents with a graduate degree would be expected to answer 29.776% more questions correctly than the excluded group (respondents lacking a high school diploma) and had the largest magnitude coefficient of all the independent variables in my model (Table 5). A respondent with a high school diploma would be expected to answer 11.283% more questions correctly in comparison to the excluded group indicating the tremendous value of completing a high school education (Table 5).

My results are consistent with findings of other researchers who found education was positively associated with scientific knowledge. Smith (1996) found educational attainment had the highest association with scientific knowledge, both at an individual level and a national level. Nations with higher levels of economic development, measured by per capita gross national product, had increased scientific knowledge. The author suggested this finding may be due to stronger science education standards in the classroom in wealthier nations. Pardo and Calvo (2004) found a highly significant positive relationship between years of education and scientific literacy in EU member countries. In each nation, they found that individuals with more than 20 years of education demonstrated a greater number of correct answers on the Eurobarometer science quiz compared to those individuals with less than 15 years of education. Zigerell (2010) performed an OLS regression on 2008 GSS data using percentage correct on a 16-item science quiz as the dependent variable, and found the regression coefficients on the independent variables formal education, high school science courses, and college science courses were in the positive direction and were statistically significant. Susteric (n.d.) constructed a logit model with belief in evolution as the dependent variable and found the independent variable college graduate was statistically significant. The variable post-graduate was also statistically significant and had an even larger effect.

Black, American Indian, Asian, and Hispanic ethnic groups were found to have lower levels of scientific literacy on the observed test. Males had higher levels of scientific literacy on the observed test compared to females.

Ethnic factors were shown to have the largest magnitude, negative effects on scientific literacy in comparison to Whites, the excluded group. Black, Hispanic, and American Indian ethnic groups had the highest magnitude coefficients in the negative direction of effect (Table 5). These results are consistent with the findings of other researchers who also found ethnicity associated with scientific knowledge. Susteric (n.d.) found the independent variables Black and Latino had negative coefficients that were statistically significant. Zigerell (2010) also found that African American had a coefficient in the negative direction of effect on scientific literacy. Race has always been an uncomfortable topic in the United States stifling an open discussion of issues that disproportionately impact certain groups of people. For example, statistics on high school graduation rates for ethnic minority groups is troubling. Gender was also found to be significant with males having higher levels of scientific literacy on the observed test. Males answered 7.283% more questions correctly than females (Table 5). My results are consistent with findings of other researchers who found gender associated with scientific knowledge. Smith (1996) found the variable male had a positive association with scientific knowledge. Zigerell (2010) made the same finding, but instead of a male dummy, used a female dummy variable, which had a negative coefficient. Susteric (n.d.) did not find a significant coefficient on the variable male.

A national report from Education Week and the Editorial Projects in Education (EPE) Research Center found high school graduation rates increased sharply in 2011 and reached their highest peak since the 1980s.[30] The national graduation rate for public schools for the class of 2008 was 71.7%. The report also showed that Latinos, African Americans, and Native Americans had graduation rates less than the national average (57%, 57%, and 54%, respectively). Asian Americans and Whites did much better with 83% and 78% graduation rates, respectively. Minority males had a graduation rate of less

[30] http://www.edweek.org/media/diplomascount2011_pressrelease.pdf

than 50%. Females had a higher graduation rate of 75% compared to males (68%) and it was higher than the national rate.

As described by the National Assessment of Educational Progress (NEAP)[31] data from 2009, only 1% of 12th graders performed at the Advanced level in NEAP science while 21% performed at or above the Proficient level and 60% performed at or above the Basic level. Black, Hispanic and female 12th graders also underperformed compared to White, male 12th graders. Other interesting findings were that 12th-grade Asian/Pacific islanders performed better than Whites and the average score of 12th graders was highest in suburbs and lowest in city school locations.

I believe the ethnic effect found in my results and described in the literature may be in part due to contrasts between the dominant culture of White Americans and the minority subcultures. These minority subcultures lack respect from the dominant culture and are subject to cultural stereotypes perpetuated on television and in other forms of media. Cultural pressures likely exist within these minority subcultures to conform to these dominant stereotypes or risk being ostracized by their own groups, an effect called "stereotype threat," which can cause stigmatized groups (including ethnic minorities, women, and individuals from lower socioeconomic backgrounds) to underachieve on standardized tests and have poor academic performance (Steele, 1997). It may also be that Whites take more science and technology classes and advanced placement courses

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[31] National Center for Education Statistics, http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2011451

compared to other ethnic groups, which was not accounted for in the GSS data. The GSS education data used in my regression model only coded educational attainment of respondents as categories (i.e., high school diploma, associate degree, bachelor degree, and graduate degree). There was no differentiation of science, technology, mathematics, and engineering degrees from liberal arts degrees. Drilling down into specific types of degrees and types of science courses taken by respondents would further improve my regression model.

My results, along with EPE and NEAP findings, suggest policy intervention is warranted and should focus on helping high school students stay in school, earn their diplomas, and improve college-readiness toward a four-year degree. Improvements to science curricula and educational performance standards may also be necessary. There also needs to be focused assistance to Black, Hispanic, American Indian, and female high school students, particularly in city schools. Assistance could take the form of after-school programs, tutoring programs, and mentoring with practicing scientists. We need to get students interested in science and technology at an early age while they are in K-12 grades. Strategies also need to be developed and implemented to further reduce the high school dropout rate.

Programs need to be developed to help K-12 female students increase their scientific knowledge and understanding; science education should begin in elementary school with hands-on experience in outdoor and indoor laboratories. We need to do a better job overall of educating our future scientists, engineers, business leaders, and public officials. Programs such as Girls RISE (Raising Interest in Science and Engineering) is a good model for engaging and motivating minority girls in grades six through 12 and developing the next generation of women professionals (Girls RISEnet, 2012). Girls RISE is a National Museum Network funded by the National Science Foundation. Its objectives are to:

- Utilize the national network of science centers and museums to raise awareness and broaden access for girls underrepresented in STEM.[32]
- Develop linkages between organizations with the common purpose of increasing the pipeline of minority female engineers.
- Facilitate translation of gender and diversity research into practice through a unified training program.
- Provide ongoing services, access to program materials, and tools to broaden the ability of science centers to provide relevant and engaging programming for girls. (Girls RISEnet, 2012, para. 3)

The Girls RISE program works to increase the capacity of science centers and museums across the nation to engage girls, particularly ethnic minorities, in science education activities. The program facilitates workshops and activities hosted by practitioners of science and technology, along with museum staff and also administers

[32] STEM is an acronym that refers to science, technology, engineering, and mathematics professions. For information on the STEM initiative (Kuenzi, 2008).

small grants and travel subsidies to assist practitioners and students (Girls RISEnet, 2012).

STEM is a national initiative to increase the number of students, teachers, and practitioners in the fields of science, technology, engineering, and mathematics in the United States (Kuenzi, 2008). There are many federal initiatives and funding sources promoting STEM education programs, including programs directed at primary and secondary schools, girls and young women, and underrepresented groups including ethnic minorities.

Generation Y, Generation X, and Baby Boomer respondents performed better than Traditionalist respondents.

I expected to see age factors associated with scientific literacy. Generation Y had 12.558% more correct answers than Traditionalist and had the largest coefficient among the generational cohorts. It is interesting to note the relative magnitudes of Baby Boomer, Generation X, and Generation Y, each in comparison to Traditionalist. I expected younger generations would have increasingly larger positive effects on scientific literacy. Given this trend, we might expect to see Generation Z, born since 2000 and also called the Internet Generation (Lancaster & Stillman, 2002) perform even higher than Generation Y on measures of scientific literacy. However, Generation Z individuals can only participate in the General Social Survey once they turn 18 years of age.

Smith (1996) hypothesized younger adults would have greater scientific and environmental knowledge because of new emerging science unknown or not widely covered when older adults received their education. He found knowledge was higher in younger adults and statistically significant. Zigerell (2010) also found age was associated with scientific literacy and was statistically significant.

Given the sharp increase in 2011 high school graduation rates, compared to the prior two decades, as described in the EPE study, I am cautiously optimistic we may see increased scientific literacy in Generation Z who earn their high school diplomas and transition on to college. I do not have any specific policy recommendations to address the age effect seen in my model. There is no particular problem that needs to be solved, per se. I believe we may start seeing an increase in scientific literacy as Generation Y and Generation Z become the next cohorts replacing retiring Baby Boomers.

Very high income, high-income, and moderate-income earners performed better than very low-income earners.

I expected income would be positively associated with scientific literacy. Respondents with high income and very high income performed better on the observed test of scientific literacy (7.987% and 10.551%, respectively) compared to the very low-income group. These results illustrate, at least with respect to scientific literacy, the disparity between the very high income and the very low-income earners in the United States. There are clearly advantages afforded to the very wealthy, an issue that has been gaining a lot of media coverage since the start of the Occupy Wall Street movement on September 17, 2011, bringing international attention to the issue of income inequality.

My results are consistent with findings of other researchers who found income was positively associated with scientific knowledge. Smith (1996) hypothesized that those with higher incomes would have more opportunity to consume more upscale and educational media. He found educational attainment had the highest association with scientific knowledge at the national level among nations with higher levels of economic development, measured by per capita gross national product. The author suggested this finding may be due to stronger science education standards in the classroom in wealthier nations. Pedro and Calvo (2004) also found that at the national level, the higher the level of income, the higher percentage of correct answers on a science literacy test. At the individual level, Smith (1996) did not find income was significant.

My policy recommendation is to help K-12 grade school students from economically disadvantaged groups stay in school, earn their diplomas, and improve college-readiness toward a four-year degree. Assistance could also take the form of after-school programs, tutoring programs, and helping disadvantaged groups obtain a General Equivalency Diploma. There also needs to be focused assistance to Black, Hispanic, American Indian and female high school students, particularly in city schools. We need to level the playing field and reduce the stark divisions existing between economic classes and between the educated and uneducated in the United States.

Bible believers performed worse on the survey questions compared to non-believers.

The Bible believer group exhibited 5.331% more wrong answers compared to non-believers (Table 5). I was somewhat surprised by this result because I thought religious dogmatism, represented by Bible believer, would have a much larger negative coefficient. The coefficient on Bible believer was smaller in magnitude than the coefficients on the ethnicity variables (Table 5).

My results are consistent with findings of other researchers who found dogmatic religious beliefs were negatively associated with scientific knowledge. Smith (1996) hypothesized scientific knowledge would be higher among the less religious. He believed this was because of the conflict between religious belief and some areas of science and because the more religious would be less interested and engaged in science. His model showed scientific knowledge was higher among those who do not believe in God. Individuals with some form of religiosity, measured by church attendance, belief in God, Protestant and Catholic, showed equivocal results. Zigerell (2010) found a literal interpretation of the Bible, compared to persons having less dogmatic views, was negatively associated with scientific knowledge. However, when controlling for demographic and educational factors, the differences were greatly lessened. Susteric (n.d.) found the variables fundamentalist and conservative were negatively associated with belief in evolution.

The negative coefficient on Bible believer may be due to respondents' being conflicted by their doctrinal belief. Christians who believe the Bible is inerrant and literally true may have chosen answers on the 2008 GSS survey consistent with their faith rather than based on scientific evidence. Three true/false questions in the 2008 GSS may have been particularly troubling to fundamentalist Christians (see Appendix A): (1) whether the universe began with a huge explosion (which brings into focus the Big Bang theory versus a divine fiat of the Creator as an explanation for the universe's origin), (2) whether the continents have been moving their locations for millions of years and will continue to do so (which requires acknowledging the Earth is older than about 6,000 years), and (3) whether or not human beings developed from earlier species of animals (consistent with evolutionary theory).

A federal advisory committee drew criticism from the White House and science educators when it decided to omit data on understanding of the Big Bang and evolution from the NSF 2010 Science and Indicators Report (Bhattacharjee, 2010; Guterbock, 2011). The National Science Board, which oversees the NSF, chose to omit this information from the report for scientific accuracy arguing that these survey questions are flawed indicators of scientific knowledge because they force respondents to make a choice between factual scientific knowledge and their own religious beliefs (Bhattacharjee, 2010). Jon Miller, a leader in the field of public understanding of science from Michigan State University, criticized the NSB decision stating, "Evolution and the big bang are not a matter of opinion. If a person says that the earth really is at the center of the universe, even if scientists think it is not, how in the world would you call that person scientifically literate? Part of being literate is to both understand and accept scientific constructs" (Bhattacharjee, 2010, p. 2).

In the 2008 GSS, only 32.3% of respondents answered true to the statement that the universe began with a huge explosion. Only 44.5% of respondents answered true to the statement that human beings as we know them today, developed from earlier species of animals. Guterbock (2011) states it is clear some respondents answered questions based on their doctrinal belief and cautions that the questions on Big Bang and human evolution involve complex and situational issues, and it would be a mistake to conclude respondents have a deficit in scientific knowledge based on answers to these questions. He advises that if the NSF were in the future to keep these questions in the *Science and Engineering Indicators* report, then they should be rephrased as "According to astronomers," and "According to evolutionary theory." This would allow respondents a way to answer these particular science questions without compromising their religious beliefs.

Because the effect of Bible believer on scientific understanding in my analysis appears to be small relative to other factors, I do not recommend specific policy interventions to address this effect. Further study is, however, warranted to evaluate the associations between the characteristics of respondents and answers to science questions that may be troubling to certain religious groups. I also recommend science and religious communities improve communications with each other in an attempt to facilitate greater appreciation and understanding of different ways of knowing the world.

A dichotomy of science and religion did not used to exist, and there is a legitimate role for both fields of study in the world today. It is also important to recognize religious beliefs and cultural factors are very difficult to change in people, whereas education can be changed earlier in life. More emphasis should be placed on providing better science education to students than trying to convince the faithful they lack scientific rigor in their beliefs. This would only lead to further conflict between science and religion.

Population size had a non-linear effect on science understanding, with more populated communities, up to about three million people, having a higher level of scientific literacy than less populated communities.

Population size had a statistically significant positive effect on scientific literacy, although the regression coefficient is rather small in magnitude (Table 5). An interesting finding was that population size had an increasing positive effect up to a community size of three million people, beyond which benefits diminished.

These results indicate a positive benefit of living in a more populated area. The benefits of living in more populated communities may include access to more cultural and educational experiences, including museums, colleges, and lectures, and also greater social opportunities. I do not have any policy recommendations dealing with population size. It is, however, an interesting outcome of the regression model and is why I chose a quadratic functional form. I did not discover any findings in the literature similar to my own regarding the population size effect.

Republican, conservative, and married respondents and geographic regions were not found to be statistically significant variables on the observed test of scientific literacy.

I was very surprised not to find statistical significance for the coefficients on Republican and Conservative. I assumed conservative party identification and ideology would have a negative direction of effect on scientific literacy. I was less surprised not to find statistical significance for the coefficients on the married dummy variable and geographic region variables. I had plausible explanations why these variables might be important factors associated with scientific literacy but I could not find any statistical significance to support my theory.

So is it in our collective interest for citizens to have a basic understanding of science and its methods of investigation? I absolutely believe it is in the public interest. But it raises the legitimate question of why emphasize science above other disciplines? Would not public understanding of American history be just as important as or more important than science for civic duty? Why not public understanding of sociology? Valid justifications could be constructed for these subject areas as well. I do not *think* I have suggested science is preeminent among all subjects of knowledge, and, as a matter of fact, I believe knowledge of religion and philosophy are just as important as science and are equally valid ways of experiencing the world around us. I, however, chose public understanding of science for my thesis topic partly because I have a scientific background, having received a Master of Science degree in Ecology from the University of California at Davis, in 1988. I also work professionally as a manager of about 40 environmental scientists in the California Department of Fish and Game. My thesis research has given me greater appreciation of the quantitative methods available (including OLS regression) to evaluate policy issues and options dealing with a subject close to my own professional life experience.

APPENDICES

APPENDIX A

Science and Technology Questions[33]

Variable scianheat: WHICH BODILY FEATURES BE BEST SUITED TO A SMALL ANIMAL LIVING IN A COLD CLIMATE
Please look at Card 1. The two objects shown there have the same mass, but object B loses heat more quickly than object A. Which combination of bodily features would be BEST suited to a small animal that lives in a cold climate and needs to minimize heat loss?

A) Long ears and a long body.
B) *Small ears and a short tail (52.4 %).*
C) A long nose and a long tail.
D) A short nose and large ears.
E) A long tail and a short nose.

Variable scibigbang: THE UNIVERSE BEGAN WITH A HUGE EXPLOSION
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don't know or aren't sure, just tell me so, and we will skip to the next question. Remember true, false, or don't know. The universe began with a huge explosion. (Is that true or false?) *true (32.3%)*

Variable sciboyorgr: FATHER GENE DECIDES SEX OF BABY
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don't know or aren't sure, just tell me so, and we will skip to the next question. Remember true, false, or don't know. It is the father's gene that decides whether the baby is a boy or a girl. (Is that true or false?) *true (61.9%)*

Variable scicondrift: THE CONTINENTS HAVE BEEN MOVING
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don't know or aren't sure, just tell me so, and we will skip to the next question. Remember true, false, or don't know. The continents on which we live have been moving their locations for millions of years and will continue to move in the future. (Is that true or false?) *true (76.7%)*

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[33] These are the questions from the General Social Survey of 2008 that I used to construct the dependent variable. Correct answers followed by the percentage of respondents answering correctly are shown in italics.

Variable scidaynight: WHEN DID MOST ERRORS OCCUR
Please look at Card 3. Day-night rhythms dramatically affect our bodies. Probably no body system is more influenced than the nervous system. The figure on Card 3 illustrates the number of errors made by shift workers in different portions of the 24-hour cycle. Based on the data illustrated in the figure, during which of these time periods did the most errors occur?

A) *2 A.M. to 4 A.M. (77.3%)*
B) 8 A.M. to 10 A.M.
C) 12 P.M. to 2 P.M.
D) 2 P.M. to 4 P.M.
E) 8 P.M. to 10 P.M.

Variable sciearthsun: THE EARTH GOES AROUND THE SUN
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don't know or aren't sure, just tell me so, and we will skip to the next question. Remember true, false, or don't know. Now, does the Earth go around the Sun, or does the Sun go around the Earth? *Earth around the sun (71.7%).*

Variable scielectron: ELECTRONS ARE SMALLER THAN ATOMS
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don't know or aren't sure, just tell me so, and we will skip to the next question. Remember true, false, or don't know. Electrons are smaller than atoms. (Is that true or false?) *true (51.6%)*

Variable scierosion: EXAMPLE OF EROSION
Which one of the following is NOT an example of erosion?

A) The wind in the desert blows sand against a rock.
B) A glacier picks up boulders as it moves.
C) A flood washes over a riverbank, and the water carries small soil particles downstream.
D) *An icy winter causes the pavement in a road to crack (56.0%).*

Variable scievolved: HUMAN BEINGS DEVELOPED FROM ANIMALS
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don't know or aren't sure, just tell me so, and we will skip to the next question. Remember true, false, or don't know. Human beings, as we know them today, developed from earlier species of animals. (Is that true or false?) *true (44.5%)*

Variable scifishexp1: WHAT IS SCIENTIST TRYING TO FIND OUT FROM THIS EXPERIMENT
Please look at Card 5. What is the scientist trying to find out from this experiment?

A) *If the number of fish in the fish bowl affects the behavior of the fish (40.4%).*
B) If the temperature of the fish bowl affects the behavior of the fish.
C) If the temperature and the amount of light affect the behavior of the fish.
D) If the number of fish, the temperature, and the amount of light affect the behavior of the fish.

Variable scifishexp2: WHY DID YOU CHOOSE THAT ANSWER

A) Because I already know what affects the behavior of fish.
B) *Because that is what is allowed to change in this experiment (38.1%).*
C) Because that is what stays the same in this experiment.
D) Because that is what the scientist decided to include in this experiment.

Variable scigenes: TRAITS ARE TRANSFERRED OVER GENERATION
Traits are transferred from generation to generation through the…

A) sperm only.
B) egg only.
C) *sperm and egg (79.2%).*
D) testes.

Variable scigills: HOW FISH GET OXYGEN
How do most fish get the oxygen they need to survive?

A) They take in water and break it down into hydrogen and oxygen.
B) *Using their gills, they take in oxygen that is dissolved in water (75.7%).*
C) They get their oxygen from the food they eat.
D) They come to the surface every few minutes to breathe air into their lungs.

Variable scigoldfish: EXPERIMENT ABOUT GOLDFISH AND TEMPERATURE
Please look at Card 5. What is the scientist trying to find out from this experiment?

A) *If the number of fish in the fish bowl affects the behavior of the fish (59.2%).*
B) If the temperature of the fish bowl affects the behavior of the fish.
C) If the temperature and the amount of light affect the behavior of the fish.
D) If the number of fish, the temperature, and the amount of light affect the behavior of the fish.

Variable scihotcore: THE CENTER OF EARTH IS VERY HOT
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don't know or aren't sure, just tell me so, and we will skip to the next question.

Remember true, false, or don’t know. First, the center of the Earth is very hot. Is that true or false? *true (82.6%)*

Variable scih2olife: WHAT PROPERTY OF WATER IS MOST IMPORTANT
What property of water is most important for living organisms?

A) It is odorless.
B) It does not conduct electricity.
C) It is tasteless.
D) *It is liquid at most temperatures on Earth (68.1%).*

Variable scilasers: LASERS WORK BY FOCUSING SOUND WAVES
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don’t know or aren’t sure, just tell me so, and we will skip to the next question. Remember true, false, or don’t know. Lasers work by focusing sound waves. (Is that true or false?) *false (48.7%)*

Variable scilftplane: KEY FACTOR THAT ENABLES AIRPLANE TO LIFT
Which of the following is a key factor that enables an airplane to lift?

A) *Air pressure beneath the wing is greater than that above the wing (53.8%).*
B) Pressure within the airplane is greater than that of the outside.
C) Engine power is greater than that of friction.
D) The plane’s wing is lighter than air.

Variable scilitmstxt: WHY LITMUS PAPER DOESN'T CHANGE COLOR IN MIXED SOLUTION
A solution of hydrochloric acid (HCl) in water will turn blue litmus paper red. A solution of the base sodium hydroxide (NaOH) in water will turn red litmus paper blue. If the acid and base solutions are mixed in the right proportion, the resulting solution will cause neither red nor blue litmus paper to change color. Explain why the litmus paper does not change color in the mixed solution. *Chemical reaction happens that results in products that don’t react with litmus paper (19.7%).*

Variable sciradioact: ALL RADIOACTIVITY IS MAN-MADE
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don’t know or aren’t sure, just tell me so, and we will skip to the next question. Remember true, false, or don’t know. All radioactivity is man-made. (Is that true or false?) *false (68.6%)*

Variable scisalth2o: OCEAN WATER FOR VEGETABLES

Please look at Card 4. A gardener has an idea that a plant needs sand in the soil for healthy growth. In order to test her idea she uses two pots of plants. She sets up one pot of plants as shown on the top part of the card. Which one of the pictures on the bottom part of the card shows what she should use for the second pot?

A) Yes, because there is plenty of ocean water.
B) Yes, because ocean water has many natural fertilizers.
C) *No, because ocean water is too salty for plants grown on land (85.0%).*
D) No, because ocean water is much more polluted than ocean water.

Variable sciseesand: WHICH PICTURE SHOWS WHAT SHE SHOULD USE FOR THE 2ND POT
Which ONE of the following should she use for the second pot of plants?

A) Sunlight. Sand and water.
B) Dark cupboard. Sand, soil, and water.
C) Dark cupboard. Soil and water.
D) Sunlight. Sand and soil.
E) *Sunlight. Soil and water (53.6%).*

Variable scistormtxt: DO YOU SEE LIGHTNING BEFORE HEARING THUNDER
Lightning and thunder happen at the same time, but you see the lightning before you hear the thunder. Explain why this is so. *Light travels faster than sound; light reaches eyes before sound reaches your ears (44.3%).*

Variable sciupbreath: WHY SHORT BREATH AT THE TOP OF A MOUNTAIN
For which reason may people experience shortness of breath more quickly at the top of a mountain than along seashore?

A) A slower pulse rate.
B) A greater gravitational force on the body.
C) *A lower percent of oxygen in the blood (68.5%).*
D) A faster heartbeat.
E) A slower circulation of blood.

Variable sciviruses: ANTIBIOTICS KILL VIRUSES AS WELL AS BACTERIA
Now, I would like to ask you a few short questions like those you might see on a television game show. For each statement that I read, please tell me if it is true or false. If you don't know or aren't sure, just tell me so, and we will skip to the next question. Remember true, false, or don't know. Antibiotics kill viruses as well as bacteria. (Is that true or false?) *false (53.4%)*

Variable sciweighing: WHICH IS THE BEST METHOD TO REPORT WEIGHT OF LEAF

As part of a laboratory experiment, five students measured the weight of the same leaf four times. They recorded 20 slightly different weights. All of the work was done carefully and correctly. Their goal was to be as accurate as possible and reduce error in the experiment to a minimum. Which of the following is the BEST method to report the weight of the leaf?

A) Ask the teacher to weigh the leaf.
B) Report the first measurement.
C) *Average all of the weights that were recorded (66.4%).*
D) Average the highest and lowest weights recorded.
E) Discard the lowest five weights.

APPENDIX B

Data Tables

Table 1

Dependent and Independent Variables

Variable Name	Description	GSS variable name
Dependent variable:		
Percentage of correct responses	Calculated percentage of correct responses to 26 science questions	Computed variable
Independent variables:		
Socioeconomic factors		
Age		age
Traditionalist (excluded variable)		
Baby Boomer	1=Baby Boomer dummy	
Generation X	1=Generation X dummy	
Generation Y	1=Generation Y dummy	
Gender		sex
Female (excluded variable)		
Male	1= Male dummy	
Marital status		marital
Not married (excluded variable)		
Married	1=Married dummy	
Income		income06
Very low income (excluded variable)		
Low income	1= Low income dummy	
Moderate income	1= Moderate income dummy	
High income	1= High income dummy	
Very high income	1= Very high income dummy	

Table 1 (continued)

Variable Name	Description	GSS variable name
Education		degree
Less than high school education (excluded variable)		
high school diploma	1= high school diploma dummy	
junior college degree	1= junior college degree dummy	
bachelor degree	1= BA or BS degree dummy	
graduate degree	1= graduate degree dummy	
Ethnicity		racecen1
White (excluded variable)		
Black	1= Black dummy	
American Indian	1= American Indian dummy	
Asian	1= Asian dummy	
Hispanic	1= Hispanic dummy	
Geographic region		region
New England (excluded variable)		
Middle Atlantic	1= Middle Atlantic dummy	
E. North Central	1= East North Central dummy	
W. North Central	1= West North Central dummy	
South Atlantic	1=South Atlantic dummy	
E. South Central	1= East South Central dummy	
W. South Central	1= West South Central dummy	
Mountain	1= Mountain dummy	
Pacific	1= Pacific dummy	
Size of community		size
Population size	continuous variable	
Population size squared	continuous variable	
Political factors		
Political party		partyid
Independent, Democrat Party (excluded variables)		
Republican	1= Republican Party dummy	

Table 1 (continued)

Variable Name	Description	GSS variable name
Political ideology		polviews
Liberal, moderate ideology (excluded variables)		
Conservative	1 = Conservative ideology dummy	
Religious factors		
Religious ideology		Bible
Bible is book of fables (excluded variable)		
Bible believer	1= Word of God/Inspired Word dummy	

Table 2

Descriptive Statistics

Model	N	Minimum	Maximum	Mean	Std. Deviation
Percentage of correct responses	1045	.00	100.00	58.5830	22.50493
Baby Boomer	2013	.00	1.00	.3597	.48002
Generation X	2013	.00	1.00	.2891	.45347
Generation Y	2013	.00	1.00	.1431	.35023
Male	2023	.00	1.00	.4592	.49846
Married	2018	.00	1.00	.4817	.49979
Low income	1774	.00	1.00	.2306	.42131
Moderate income	1774	.00	1.00	.1607	.36731
High income	1774	.00	1.00	.2554	.43618
Very high income	1774	.00	1.00	.1404	.34746
high school diploma	2022	.00	1.00	.4960	.50011
junior college degree	2022	.00	1.00	.0856	.27978
bachelor degree	2022	.00	1.00	.1756	.38055
graduate degree	2022	.00	1.00	.0959	.29459
Black	2012	.00	1.00	.1392	.34620
American Indian	2012	.00	1.00	.0134	.11509
Asian	2012	.00	1.00	.0089	.09418
Hispanic	2012	.00	1.00	.0413	.19892
Middle Atlantic	2023	.00	1.00	.1354	.34228
E. North Central	2023	.00	1.00	.1725	.37792
W. North Central	2023	.00	1.00	.0593	.23628
South Atlantic	2023	.00	1.00	.2190	.41366
E. South Central	2023	.00	1.00	.0479	.21371
W. South Central	2023	.00	1.00	.1038	.30508
Mountain	2023	.00	1.00	.0761	.26526
Pacific	2023	.00	1.00	.1458	.35302
Population size	2023	1.00	8008	368.91	1282.252
Population size squared	2023	1.00	64128064.00	1.7795E6	9.73519E6
Republican	2010	.00	1.00	.2561	.43658
Conservative	1933	.00	1.00	.2043	.40333

Table 2 (continued)

Model	N	Minimum	Maximum	Mean	Std. Deviation
Bible believer	1987	.00	1.00	.7866	.40980

Note that these N values are for the original 2008 GSS variables I used to create dummies for my model. For example, the GSS variable “age” (N=2013) was used to create the generation dummies shown in the table. Population size (in thousands) refers to the actual size of the place in which the interview occurred. It was measured to the nearest 1,000 of the smallest civil division listed by the U. S. Census. For example, 1 = 1000; 10 = 10,000 and so on.

Table 3

Correlation Matrix

		Baby Boomer dummy	Gener-ation X	Gener-ation Y	Male	Married	Low income	Moderate income	High income	Very high income	high school diploma	junior college degree	bachelor degree	graduate degree	Black	American Indian
Baby Boomer	Pearson Correlation	1	-.478**	-.306**	.039	.122**	-.109**	.022	.071**	.110**	-.028	.038	.002	.058**	.007	-.033
	Sig. (2-tailed)		.000	.000	.077	.000	.000	.356	.003	.000	.208	.088	.932	.009	.771	.136
	N	2013	2013	2013	2013	2010	1767	1767	1767	1767	2012	2012	2012	2012	2002	2002
Generation X	Pearson Correlation	-.478**	1	-.261**	.012	.054*	.010	.023	.029	.011	-.050*	.000	.079**	.038	.011	.002
	Sig. (2-tailed)	.000		.000	.603	.015	.670	.324	.217	.648	.025	.984	.000	.090	.622	.939
	N	2013	2013	2013	2013	2010	1767	1767	1767	1767	2012	2012	2012	2012	2002	2002
Generation Y	Pearson Correlation	-.306**	-.261**	1	-.021	-.259**	.034	-.023	-.066**	-.092**	.090**	-.021	-.053*	-.119**	.077**	.064**
	Sig. (2-tailed)	.000	.000		.339	.000	.151	.330	.006	.000	.000	.336	.017	.000	.001	.004
	N	2013	2013	2013	2013	2010	1767	1767	1767	1767	2012	2012	2012	2012	2002	2002
Male	Pearson Correlation	.039	.012	-.021	1	.046*	-.010	.001	.048*	.049*	-.014	.002	.026	-.004	-.036	.005
	Sig. (2-tailed)	.077	.603	.339		.040	.666	.965	.043	.037	.543	.934	.246	.864	.104	.816
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
Married	Pearson Correlation	.122**	.054*	-.259**	.046*	1	-.115**	.004	.238**	.216**	-.049*	.027	.089**	.062**	-.143**	-.057*
	Sig. (2-tailed)	.000	.015	.000	.040		.000	.867	.000	.000	.027	.225	.000	.005	.000	.010
	N	2010	2010	2010	2018	2018	1773	1773	1773	1773	2017	2017	2017	2017	2007	2007
Low income	Pearson Correlation	-.109**	.010	.034	-.010	-.115**	1	-.239**	-.321**	-.221**	.118**	-.003	-.105**	-.126**	.068**	.041
	Sig. (2-tailed)	.000	.670	.151	.666	.000		.000	.000	.000	.000	.883	.000	.000	.004	.084
	N	1767	1767	1767	1774	1773	1774	1774	1774	1774	1774	1774	1774	1774	1765	1765
Moderate income	Pearson Correlation	.022	.023	-.023	.001	.004	-.239**	1	-.256**	-.177**	.047*	.028	-.008	.017	-.018	-.017
	Sig. (2-tailed)	.356	.324	.330	.965	.867	.000		.000	.000	.048	.243	.745	.485	.452	.474
	N	1767	1767	1767	1774	1773	1774	1774	1774	1774	1774	1774	1774	1774	1765	1765

Table 3 (continued)

		Baby Boomer dummy	Gener-ation X	Gener-ation Y	Male	Married	Low income	Moderate income	High income	Very high income	high school diploma	junior college degree	bachelor degree	graduate degree	Black	American Indian
High income	Pearson Correlation	.071**	.029	-.066**	.048*	.238**	-.321**	-.256**	1	-.237**	-.053*	.029	.132**	.086**	-.075**	-.062**
	Sig. (2-tailed)	.003	.217	.006	.043	.000	.000	.000		.000	.024	.216	.000	.000	.002	.009
	N	1767	1767	1767	1774	1773	1774	1774	1774	1774	1774	1774	1774	1774	1765	1765
Very high income	Pearson Correlation	.110**	.011	-.092**	.049*	.216**	-.221**	-.177**	-.237**	1	-.139**	.001	.138**	.206**	-.117**	-.037
	Sig. (2-tailed)	.000	.648	.000	.037	.000	.000	.000	.000		.000	.953	.000	.000	.000	.118
	N	1767	1767	1767	1774	1773	1774	1774	1774	1774	1774	1774	1774	1774	1765	1765
high school diploma	Pearson Correlation	-.028	-.050*	.090**	-.014	-.049*	.118**	.047*	-.053*	-.139**	1	-.303**	-.458**	-.323**	.046*	.040
	Sig. (2-tailed)	.208	.025	.000	.543	.027	.000	.048	.024	.000		.000	.000	.000	.040	.076
	N	2012	2012	2012	2022	2017	1774	1774	1774	1774	2022	2022	2022	2022	2011	2011
junior college degree	Pearson Correlation	.038	.000	-.021	.002	.027	-.003	.028	.029	.001	-.303**	1	-.141**	-.100**	.000	-.020
	Sig. (2-tailed)	.088	.984	.336	.934	.225	.883	.243	.216	.953	.000		.000	.000	.984	.361
	N	2012	2012	2012	2022	2017	1774	1774	1774	1774	2022	2022	2022	2022	2011	2011
bachelor degree	Pearson Correlation	.002	.079**	-.053*	.026	.089**	-.105**	-.008	.132**	.138**	-.458**	-.141**	1	-.150**	-.092**	-.031
	Sig. (2-tailed)	.932	.000	.017	.246	.000	.000	.745	.000	.000	.000	.000		.000	.000	.162
	N	2012	2012	2012	2022	2017	1774	1774	1774	1774	2022	2022	2022	2022	2011	2011
graduate degree	Pearson Correlation	.058**	.038	-.119**	-.004	.062**	-.126**	.017	.086**	.206**	-.323**	-.100**	-.150**	1	-.062**	-.038
	Sig. (2-tailed)	.009	.090	.000	.864	.005	.000	.485	.000	.000	.000	.000	.000		.005	.089
	N	2012	2012	2012	2022	2017	1774	1774	1774	1774	2022	2022	2022	2022	2011	2011
Black	Pearson Correlation	.007	.011	.077**	-.036	-.143**	.068**	-.018	-.075**	-.117**	.046*	.000	-.092**	-.062**	1	-.047*
	Sig. (2-tailed)	.771	.622	.001	.104	.000	.004	.452	.002	.000	.040	.984	.000	.005		.035
	N	2002	2002	2002	2012	2007	1765	1765	1765	1765	2011	2011	2011	2011	2012	2012
American Indian	Pearson Correlation	-.033	.002	.064**	.005	-.057*	.041	-.017	-.062**	-.037	.040	-.020	-.031	-.038	-.047*	1
	Sig. (2-tailed)	.136	.939	.004	.816	.010	.084	.474	.009	.118	.076	.361	.162	.089	.035	
	N	2002	2002	2002	2012	2007	1765	1765	1765	1765	2011	2011	2011	2011	2012	2012

Table 3 (continued)

		Baby Boomer dummy	Gener-ation X	Gener-ation Y	Male	Married	Low income	Moderate income	High income	Very high income	high school diploma	junior college degree	bachelor degree	graduate degree	Black	American Indian
Asian	Pearson Correlation	-.085**	.133**	-.014	.010	.039	-.049*	-.021	.002	.108**	-.097**	-.019	.112**	.095**	-.077**	-.022
	Sig. (2-tailed)	.000	.000	.530	.653	.079	.041	.385	.936	.000	.000	.390	.000	.000	.001	.320
	N	1995	1995	1995	2005	2000	1759	1759	1759	1759	2004	2004	2004	2004	2005	2005
Hispanic	Pearson Correlation	-.076**	.085**	.082**	.030	-.060**	.045	-.019	-.034	-.066**	-.021	-.001	-.063**	-.067**	-.083**	-.024
	Sig. (2-tailed)	.001	.000	.000	.186	.007	.058	.417	.159	.005	.343	.955	.005	.002	.000	.278
	N	2002	2002	2002	2012	2007	1765	1765	1765	1765	2011	2011	2011	2011	2012	2012
Middle Atlantic	Pearson Correlation	-.004	.000	-.013	-.069**	-.023	-.035	-.023	.034	.068**	.012	.003	.011	.053*	.046*	-.008
	Sig. (2-tailed)	.872	.992	.570	.002	.292	.142	.343	.158	.004	.596	.897	.621	.018	.038	.708
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
E. North Central	Pearson Correlation	-.011	-.042	-.025	-.011	-.008	.057*	-.014	-.036	-.019	.009	.006	-.031	-.020	-.016	.004
	Sig. (2-tailed)	.609	.057	.253	.615	.715	.015	.556	.131	.419	.691	.796	.159	.380	.465	.860
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
W. North Central	Pearson Correlation	.043	-.054*	.005	.016	.060**	.034	.006	-.003	-.005	.002	-.017	.033	.003	-.071**	-.029
	Sig. (2-tailed)	.054	.015	.823	.462	.007	.152	.789	.893	.840	.929	.446	.142	.876	.001	.188
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
South Atlantic	Pearson Correlation	-.011	.037	-.014	.013	.030	-.022	.029	-.028	-.008	.039	-.025	-.028	.006	.148**	-.010
	Sig. (2-tailed)	.633	.101	.543	.548	.174	.346	.221	.247	.743	.081	.257	.215	.785	.000	.667
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
E. South Central	Pearson Correlation	.017	-.014	-.032	.021	.059**	-.029	-.005	.062**	-.022	.032	.006	-.031	-.010	.018	-.026
	Sig. (2-tailed)	.449	.525	.157	.352	.008	.225	.843	.009	.349	.152	.794	.169	.645	.425	.242
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
W. South Central	Pearson Correlation	-.002	.033	.000	.005	.009	.025	.030	-.033	-.057*	-.030	-.023	-.016	-.034	.051*	.031
	Sig. (2-tailed)	.936	.135	.993	.819	.678	.298	.200	.160	.016	.181	.301	.459	.128	.021	.163
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012

Table 3 (continued)

		Baby Boomer dummy	Gener-ation X	Gener-ation Y	Male	Married	Low income	Moderate income	High income	Very high income	high school diploma	junior college degree	bachelor degree	graduate degree	Black	American Indian
Mountain	Pearson Correlation	-.029	.018	.011	-.018	-.016	.032	.011	.005	-.032	.021	.019	.034	-.056*	-.099**	.015
	Sig. (2-tailed)	.197	.408	.638	.427	.484	.176	.630	.836	.181	.347	.398	.125	.012	.000	.489
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
Pacific	Pearson Correlation	-.017	.012	.086**	.063**	-.076**	-.029	-.035	.013	.029	-.037	.019	.008	-.001	-.101**	.001
	Sig. (2-tailed)	.455	.589	.000	.004	.001	.220	.146	.588	.223	.093	.397	.715	.948	.000	.970
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
Population size	Pearson Correlation	-.011	.045*	-.022	-.039	-.031	.015	.001	-.014	.015	-.022	-.029	.025	.029	.132**	.029
	Sig. (2-tailed)	.632	.041	.328	.079	.163	.521	.963	.567	.534	.321	.197	.262	.191	.000	.200
	N	2013	2013	2013	2023	2018	1774	1774	1774	1774	2022	2022	2022	2022	2012	2012
Republican	Pearson Correlation	-.004	-.018	-.062**	.006	.131**	-.101**	.008	.088**	.160**	-.012	.012	.097**	.004	-.210**	-.049*
	Sig. (2-tailed)	.862	.414	.006	.792	.000	.000	.730	.000	.000	.582	.608	.000	.871	.000	.029
	N	1965	1965	1965	1972	1968	1734	1734	1734	1734	1971	1971	1971	1971	1962	1962
Conservative	Pearson Correlation	.004	-.051*	-.057*	.015	.114**	-.059*	.018	.033	.047	-.009	-.027	.024	-.031	-.076**	-.010
	Sig. (2-tailed)	.874	.026	.012	.517	.000	.015	.458	.177	.052	.693	.237	.300	.172	.001	.646
	N	1923	1923	1923	1933	1929	1714	1714	1714	1714	1932	1932	1932	1932	1924	1924
Bible-believer	Pearson Correlation	-.008	-.036	-.007	-.136**	.077**	.008	.039	.008	-.091**	.096**	.024	-.096**	-.123**	.099**	-.056*
	Sig. (2-tailed)	.711	.105	.747	.000	.001	.749	.101	.732	.000	.000	.283	.000	.000	.000	.013
	N	1978	1978	1978	1987	1984	1754	1754	1754	1754	1986	1986	1986	1986	1977	1977

Table 3 (continued)

		Asian	Hispanic	Middle Atlantic	E. North Central	W. North Central	South Atlantic	E. South Central	W. South Central	Mountain	Pacific	Population size	Republican	Conservative	Bible-believer
Baby Boomer	Pearson Correlation	-.085**	-.076**	-.004	-.011	.043	-.011	.017	-.002	-.029	-.017	-.011	-.004	.004	-.008
	Sig. (2-tailed)	.000	.001	.872	.609	.054	.633	.449	.936	.197	.455	.632	.862	.874	.711
	N	1995	2002	2013	2013	2013	2013	2013	2013	2013	2013	2013	1965	1923	1978
Generation X	Pearson Correlation	.133**	.085**	.000	-.042	-.054*	.037	-.014	.033	.018	.012	.045*	-.018	-.051*	-.036
	Sig. (2-tailed)	.000	.000	.992	.057	.015	.101	.525	.135	.408	.589	.041	.414	.026	.105
	N	1995	2002	2013	2013	2013	2013	2013	2013	2013	2013	2013	1965	1923	1978
Generation Y	Pearson Correlation	-.014	.082**	-.013	-.025	.005	-.014	-.032	.000	.011	.086**	-.022	-.062**	-.057*	-.007
	Sig. (2-tailed)	.530	.000	.570	.253	.823	.543	.157	.993	.638	.000	.328	.006	.012	.747
	N	1995	2002	2013	2013	2013	2013	2013	2013	2013	2013	2013	1965	1923	1978
Male	Pearson Correlation	.010	.030	-.069**	-.011	.016	.013	.021	.005	-.018	.063**	-.039	.006	.015	-.136**
	Sig. (2-tailed)	.653	.186	.002	.615	.462	.548	.352	.819	.427	.004	.079	.792	.517	.000
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
Married	Pearson Correlation	.039	-.060**	-.023	-.008	.060**	.030	.059**	.009	-.016	-.076**	-.031	.131**	.114**	.077**
	Sig. (2-tailed)	.079	.007	.292	.715	.007	.174	.008	.678	.484	.001	.163	.000	.000	.001
	N	2000	2007	2018	2018	2018	2018	2018	2018	2018	2018	2018	1968	1929	1984
Low income	Pearson Correlation	-.049*	.045	-.035	.057*	.034	-.022	-.029	.025	.032	-.029	.015	-.101**	-.059*	.008
	Sig. (2-tailed)	.041	.058	.142	.015	.152	.346	.225	.298	.176	.220	.521	.000	.015	.749
	N	1759	1765	1774	1774	1774	1774	1774	1774	1774	1774	1774	1734	1714	1754
Moderate income	Pearson Correlation	-.021	-.019	-.023	-.014	.006	.029	-.005	.030	.011	-.035	.001	.008	.018	.039
	Sig. (2-tailed)	.385	.417	.343	.556	.789	.221	.843	.200	.630	.146	.963	.730	.458	.101
	N	1759	1765	1774	1774	1774	1774	1774	1774	1774	1774	1774	1734	1714	1754

Table 3 (continued)

		Asian	Hispanic	Middle Atlantic	E. North Central	W. North Central	South Atlantic	E. South Central	W. South Central	Mountain	Pacific	Population size	Republican	Conservative	Bible-believer
High income	Pearson Correlation	.002	-.034	.034	-.036	-.003	-.028	.062**	-.033	.005	.013	-.014	.088**	.033	.008
	Sig. (2-tailed)	.936	.159	.158	.131	.893	.247	.009	.160	.836	.588	.567	.000	.177	.732
	N	1759	1765	1774	1774	1774	1774	1774	1774	1774	1774	1774	1734	1714	1754
Very high income	Pearson Correlation	.108**	-.066**	.068**	-.019	-.005	-.008	-.022	-.057*	-.032	.029	.015	.160**	.047	-.091**
	Sig. (2-tailed)	.000	.005	.004	.419	.840	.743	.349	.016	.181	.223	.534	.000	.052	.000
	N	1759	1765	1774	1774	1774	1774	1774	1774	1774	1774	1774	1734	1714	1754
high school diploma	Pearson Correlation	-.097**	-.021	.012	.009	.002	.039	.032	-.030	.021	-.037	-.022	-.012	-.009	.096**
	Sig. (2-tailed)	.000	.343	.596	.691	.929	.081	.152	.181	.347	.093	.321	.582	.693	.000
	N	2004	2011	2022	2022	2022	2022	2022	2022	2022	2022	2022	1971	1932	1986
junior college degree	Pearson Correlation	-.019	-.001	.003	.006	-.017	-.025	.006	-.023	.019	.019	-.029	.012	-.027	.024
	Sig. (2-tailed)	.390	.955	.897	.796	.446	.257	.794	.301	.398	.397	.197	.608	.237	.283
	N	2004	2011	2022	2022	2022	2022	2022	2022	2022	2022	2022	1971	1932	1986
bachelor degree	Pearson Correlation	.112**	-.063**	.011	-.031	.033	-.028	-.031	-.016	.034	.008	.025	.097**	.024	-.096**
	Sig. (2-tailed)	.000	.005	.621	.159	.142	.215	.169	.459	.125	.715	.262	.000	.300	.000
	N	2004	2011	2022	2022	2022	2022	2022	2022	2022	2022	2022	1971	1932	1986
graduate degree	Pearson Correlation	.095**	-.067**	.053*	-.020	.003	.006	-.010	-.034	-.056*	-.001	.029	.004	-.031	-.123**
	Sig. (2-tailed)	.000	.002	.018	.380	.876	.785	.645	.128	.012	.948	.191	.871	.172	.000
	N	2004	2011	2022	2022	2022	2022	2022	2022	2022	2022	2022	1971	1932	1986
Black	Pearson Correlation	-.077**	-.083**	.046*	-.016	-.071**	.148**	.018	.051*	-.099**	-.101**	.132**	-.210**	-.076**	.099**
	Sig. (2-tailed)	.001	.000	.038	.465	.001	.000	.425	.021	.000	.000	.000	.000	.001	.000
	N	2005	2012	2012	2012	2012	2012	2012	2012	2012	2012	2012	1962	1924	1977

Table 3 (continued)

		Asian	Hispanic	Middle Atlantic	E. North Central	W. North Central	South Atlantic	E. South Central	W. South Central	Mountain	Pacific	Population size	Republican	Conservative	Bible-believer
American Indian	Pearson Correlation	-.022	-.024	-.008	.004	-.029	-.010	-.026	.031	.015	.001	.029	-.049*	-.010	-.056*
	Sig. (2-tailed)	.320	.278	.708	.860	.188	.667	.242	.163	.489	.970	.200	.029	.646	.013
	N	2005	2012	2012	2012	2012	2012	2012	2012	2012	2012	2012	1962	1924	1977
Asian	Pearson Correlation	1	-.040	.004	-.029	-.025	-.028	-.043	-.038	-.044*	.161**	.072**	-.011	-.016	-.020
	Sig. (2-tailed)		.077	.848	.189	.262	.203	.056	.087	.047	.000	.001	.623	.480	.365
	N	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	1955	1917	1970
Hispanic	Pearson Correlation	-.040	1	.005	-.055*	-.052*	-.019	-.046*	.069**	-.003	.099**	.058**	-.082**	-.038	-.016
	Sig. (2-tailed)	.077		.809	.014	.019	.387	.037	.002	.895	.000	.009	.000	.099	.485
	N	2005	2012	2012	2012	2012	2012	2012	2012	2012	2012	2012	1962	1924	1977
Middle Atlantic	Pearson Correlation	.004	.005	1	-.181**	-.099**	-.210**	-.089**	-.135**	-.114**	-.164**	.340**	-.019	-.060**	-.039
	Sig. (2-tailed)	.848	.809		.000	.000	.000	.000	.000	.000	.000	.000	.397	.008	.079
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
E. North Central	Pearson Correlation	-.029	-.055*	-.181**	1	-.115**	-.242**	-.102**	-.155**	-.131**	-.189**	-.044*	.015	.011	.013
	Sig. (2-tailed)	.189	.014	.000		.000	.000	.000	.000	.000	.000	.048	.501	.619	.560
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
W. North Central	Pearson Correlation	-.025	-.052*	-.099**	-.115**	1	-.133**	-.056*	-.085**	-.072**	-.104**	-.061**	-.012	-.004	-.055*
	Sig. (2-tailed)	.262	.019	.000	.000		.000	.011	.000	.001	.000	.006	.590	.869	.014
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
South Atlantic	Pearson Correlation	-.028	-.019	-.210**	-.242**	-.133**	1	-.119**	-.180**	-.152**	-.219**	-.123**	.026	.035	.059**
	Sig. (2-tailed)	.203	.387	.000	.000	.000		.000	.000	.000	.000	.000	.256	.127	.009
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
E. South Central	Pearson Correlation	-.043	-.046*	-.089**	-.102**	-.056*	-.119**	1	-.076**	-.064**	-.093**	-.049*	.029	.034	.084**
	Sig. (2-tailed)	.056	.037	.000	.000	.011	.000		.001	.004	.000	.027	.194	.133	.000
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987

Table 3 (continued)

		Asian	Hispanic	Middle Atlantic	E. North Central	W. North Central	South Atlantic	E. South Central	W. South Central	Mountain	Pacific	Population size	Republican	Conservative	Bible-believer
W. South Central	Pearson Correlation	-.038	.069**	-.135**	-.155**	-.085**	-.180**	-.076**	1	-.098**	-.141**	-.018	-.014	.026	.113**
	Sig. (2-tailed)	.087	.002	.000	.000	.000	.000	.001		.000	.000	.422	.527	.256	.000
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
Mountain	Pearson Correlation	-.044*	-.003	-.114**	-.131**	-.072**	-.152**	-.064**	-.098**	1	-.119**	-.043	.010	.033	-.044*
	Sig. (2-tailed)	.047	.895	.000	.000	.001	.000	.004	.000		.000	.051	.651	.146	.049
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
Pacific	Pearson Correlation	.161**	.099**	-.164**	-.189**	-.104**	-.219**	-.093**	-.141**	-.119**	1	.007	-.021	-.026	-.094**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000		.759	.341	.261	.000
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
Population size	Pearson Correlation	.072**	.058**	.340**	-.044*	-.061**	-.123**	-.049*	-.018	-.043	.007	1	-.068**	-.027	-.001
	Sig. (2-tailed)	.001	.009	.000	.048	.006	.000	.027	.422	.051	.759		.003	.241	.978
	N	2005	2012	2023	2023	2023	2023	2023	2023	2023	2023	2023	1972	1933	1987
Republican	Pearson Correlation	-.011	-.082**	-.019	.015	-.012	.026	.029	-.014	.010	-.021	-.068**	1	.368**	.135**
	Sig. (2-tailed)	.623	.000	.397	.501	.590	.256	.194	.527	.651	.341	.003		.000	.000
	N	1955	1962	1972	1972	1972	1972	1972	1972	1972	1972	1972	1972	1890	1940
Conservative	Pearson Correlation	-.016	-.038	-.060**	.011	-.004	.035	.034	.026	.033	-.026	-.027	.368**	1	.128**
	Sig. (2-tailed)	.480	.099	.008	.619	.869	.127	.133	.256	.146	.261	.241	.000		.000
	N	1917	1924	1933	1933	1933	1933	1933	1933	1933	1933	1933	1890	1933	1903
Bible believer	Pearson Correlation	-.020	-.016	-.039	.013	-.055*	.059**	.084**	.113**	-.044*	-.094**	-.001	.135**	.128**	1
	Sig. (2-tailed)	.365	.485	.079	.560	.014	.009	.000	.000	.049	.000	.978	.000	.000	
	N	1970	1977	1987	1987	1987	1987	1987	1987	1987	1987	1987	1940	1903	1987

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4

Quadratic Model Regression Coefficients

Model	B (Std. Error)	t	Sig.	VIF Statistics
(Constant)	37.220 (3.459)	10.761	.000***	
Baby Boomer	7.121 (1.582)	4.503	.000***	2.173
Generation X	8.976 (1.685)	5.329	.000***	2.132
Generation Y	12.558 (2.037)	6.166	.000***	1.745
Male	7.283 (1.076)	6.766	.000***	1.044
Married	-.669 (1.226)	-.546	.585	1.354
Low income	2.152 (1.640)	1.312	.190	1.770
Moderate income	6.376 (1.845)	3.456	.001***	1.762
High income	7.987 (1.830))	4.363	.000***	2.267
Very high income	10.551 (2.235)	4.722	.000***	2.010
high school diploma	11.283 (1.780)	6.339	.000***	2.847
junior college degree	18.605 (2.420)	7.689	.000***	1.734
bachelor degree	26.210 (2.179)	12.026	.000***	2.484
graduate degree	29.776 (2.659)	11.196	.000***	1.926
Black	-16.323 (1.601)	-10.197	.000***	1.284

Table 4 (continued)

Model	B (Std. Error)	t	Sig.	VIF Statistics
American Indian	-9.472 (4.176)	-2.268	.024**	1.060
Asian	-6.347 (3.157)	-2.011	.045**	1.113
Hispanic	-13.078 (2.903)	-4.506	.000***	1.167
Middle Atlantic	1.564 (3.053)	.512	.609	3.071
E. North Central	2.201 (2.863)	.769	.442	3.879
W. North Central	.578 (3.266)	.177	.860	2.342
South Atlantic	1.232 (2.749)	.448	.654	5.294
E. South Central	-.837 (3.393)	-.247	.805	2.194
W. South Central	-3.412 (2.987)	-1.142	.254	3.342
Mountain	3.560 (3.150)	1.130	.259	2.599
Pacific	1.145 (2.994)	.382	.702	3.301
Population size	.003 (.002)	1.783	.075*	9.062
Population size squared	-5.171E-7 (.000)	-1.927	.054*	9.001
Republican	-1.817 (1.402)	-1.296	.195	1.335
Conservative	.971 (1.438)	.675	.500	1.188

Table 4 (continued)

Model	B (Std. Error)	t	Sig.	VIF Statistics
Bible believer	-5.331 (1.446)	-3.686	.000***	1.176

Dependent variable: Percentage of correct responses

*significant at .10; **significant at .05; ***significant at .01 R-squared = .497

Table 5

Ninety Percent Confidence Intervals for Statistically Significant Coefficients

Model	B (Std. Error)	90.0% Confidence Interval for B	
		Lower Bound	Upper Bound
graduate degree	29.776 (2.659)	25.397	34.155
bachelor degree	26.210 (2.179)	22.622	29.799
junior college degree	18.605 (2.420)	14.620	22.589
Generation Y	12.558 (2.037)	9.204	15.911
high school diploma	11.283 (1.780)	8.352	14.214
Very high income	10.551 (2.235)	6.872	14.231
Generation X	8.976 (1.685)	6.202	11.750
High income	7.987 (1.830)	4.973	11.001
Male	7.283 (1.076)	5.510	9.055
Baby Boomer	7.121 (1.582)	4.517	9.726
Moderate income	6.376 (1.845)	3.338	9.413
Bible believer	-5.331 (1.446)	-7.713	-2.950
Asian	-6.347 (3.157)	-11.545	-1.149
American Indian	-9.472 (4.176)	-16.349	-2.596

Table 5 (continued)

Model	B (Std. Error)	90.0% Confidence Interval for B	
		Lower Bound	Upper Bound
Hispanic	-13.078 (2.903)	-17.858	-8.298
Black	-16.323 (1.601)	-18.958	-13.687
Population size*	.003 (.002)	.000	.006
Population size squared*	-5.171E-7 (.000)	.000	.000

*These are the only continuous variables, all others are dummies.

Table 6

Worst-case and Best-case Scenario

Factors	Worst	Best
Constant	37.2	37.2
Generation	0 Traditionalist	12.5 Generation Y
Gender	0 female	7.2 male
Income	0 very low income	10.5 very high income
Education	0 less than High school	29.7 graduate degree
Ethnicity	-16.3 Black	0 White
Religion	-5.3 Bible believer	0 Bible is book of fables
Population size	.003 (population~1000)	4.5 (population ~3 million)
Total	15.6	101.6

The numbers in the table are the truncated values of the mid-point estimates of statistically significant regression coefficients that fall within a 90% confidence interval. Note that the total for the best-case scenario is slightly greater than 100.

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