Determinants of Science Policy Change and the
Need for Reform in Congressional Decision-Making

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Abstract
Science impacts nearly all aspects of American society. However, the extent
of this impact depends on favorable legislation. Given the key role Congress
plays in policymaking, it is necessary to determine what factors cause
legislators to change science policy so that researchers can determine more
successful ways of producing meaningful science policy outputs. I therefore
measure the influence of eleven political variables on policy change in science
and four other issue areas during thirty-one congressional terms. Results
reveal that scholars need to identify a more effective method Congress can use
to contemplate science policy change, which I propose needs to incorporate
both expertise and citizen participation.

Introduction

"The relationship between science and politics can be described as a recursive coupling of two interdependent developments—the scientification of politics and the politicization of science" (Weingart, 2002, p. 2). Through case study analysis, science policy theorists argue that extensive use of scientific expertise in political processes weakens democracy by distancing citizens from technically driven policy decisions and simultaneously delegitimizes science by introducing political bias into the work of researchers (Jasanoff, 1987; Weingart, 2002; Jasanoff, 2004; Mooney, 2005; Brown, 2006). However, in order to determine the role experts should play in politics, it is necessary to first realistically quantify their impact on policy decisions. Because aforementioned scholars rely on anecdotal evidence and do not discuss other political determinants that might be involved, existing research fails to adequately measure the influence expertise has on science policy change over time, an insufficiency this paper seeks to resolve.

Consequently, this paper asks the question: what political factors cause meaningful change in congressional science policy and how do these dynamics similarly influence change in other major issue areas, namely health, transportation, education, and community development & housing (hereinafter CD&H)? When investigating general congressional behavior, scholars suggest that partisan dynamics and external support from the president and public largely influences policy outcomes, due to pressure from party leaders and a need to secure future votes from constituents. Although minimally, academics also note that the size of the federal budget plays a role in shaping policy outcomes by clarifying the feasibility of policy goals.

I expect that these determinants of general congressional policy change will influence some, if not all, of the issue areas in this study. Specifically, I hypothesize that expertise will have the largest effect on science policy change, with external support, partisan characteristics, and size of the federal budget having minimal impacts. Furthermore, I anticipate that explanatory variables for science will correspond highly with those for health and education since subtopics in these areas often interrelate. Because transportation and CD&H are less prioritized, I predict these areas will depend mostly on the federal budget.

I test these hypotheses by examining *Congressional Quarterly Almanac* coverage of 1,224 laws passed between the 80th and 111th Congresses, or between 1947 and 2010. By comparing highly differing trends in policy change across the five issue areas, I conclude that congressmen's unique and substantial reliance on expertise for science explains its relatively small policy output relative to other issue areas.

Why Congressional Science Policy?

Both the executive and judicial branches can act as important sources of policy change; however, as the legislative branch of the United States, Congress undoubtedly plays the most direct and formative role in shaping American law. Scholars agree that Congress is in a "privileged position" to

produce tangible "outputs" in health policy, foreign policy and other key issue areas (Adler & Lapinski, 2006) since the Constitution grants the Legislature direct lawmaking powers. While they admit that other governmental actors, such as the president, participate in policymaking, political scientists conclude that the outcomes of actions put forth by other branches heavily depend upon congressional behavior.

For instance, presidential success in Congress is contingent upon congressional perception of public support for the president and party composition of Congress (Rivers & Rose, 1985; Cohen, 2012). Congress can deduce the extent of public support for the president from his electoral margin since it quantifies how much the public preferred the president to the losing candidate in his election. Notably, George W. Bush won the 2000 election with a margin of only five electoral votes, the lowest margin achieved within all of the sixty-two years examined in this study (Leip, 2015). It is thus not surprising that President Bush accomplished minimal legislative success during the beginning of his administration. Even when Bush gained agenda-setting power in security- and defense-related policy after the September 11th terrorist attacks in 2001, he still rarely saw his other policy proposals come to fruition in Congress during 2003 and 2004, due to his still relatively low public support (Babington, 2004).

Since presidential and judicial lawmaking capabilities are both limited, Congress is necessarily the "institution where the collective choice of the nation is forged into outcomes" (Adler & Lapinski, 2006, p. 3). In turn, understanding the factors that influence congressional decision-making is crucial to understanding legislation both broadly and for specific issue areas.

Quantification of Policy Change

Given the key role of Congress in promoting scientific progress, it is essential to quantify and explain congressional science policy change over time, in relation to other topic areas. Adler and Wilkerson (2009) clarify that policy is a culmination of many laws, distinct from lawmaking, which focuses more on discrete legislative acts. It is clear that policy change is important for understanding congressional behavior and legislative patterns, as many scholars have conducted research in this area (Adler & Wilkerson, 2009; Kingdon, 1995; Baumgartner & Jones, 1993; Birkland, 1997).

Some scholars have attempted to quantify policy change with equations, such as the one shown below (Cohen, 2006).

$$\frac{(Number\ of\ issue\ area\ additions + Number\ of\ issue\ area\ deletions)}{Number\ of\ issue\ areas\ retained\ from\ previous\ Congress} \times 100$$

Although this type of measure decently describes changes in the size of policy agendas, it fails to capture meaningful changes in policy content. For instance, Congress could pass less science policies than did the previous Congress, but these new policies might have much more significant effects on scientific research. This type of scenario occurs between the 109th and 111th

congressional terms. The 109th Congress passed a higher number of laws related to health research than did the 111th Congress, but the latter Congress increased funding for the National Institutes of Health by 5.1% since the previous term, while the former increased such funding by only 3.5% (NIH, 2016; PAP, 2014).

Adler and Wilkerson (2009; 2012) use a more effective method, which quantifies the degree of meaningful policy change in a topic as the amount of *Congressional Quarterly Almanac* (hereinafter CQ) coverage for that issue area. The authors explain that CQ's team of non-partisan journalists and researchers provides "policymakers, lobbyists, academics, and other congressional observers" with consequential legislation that "mattered most in a given year," thereby focusing on significant policy (Adler & Wilkerson, 2009, p. 6; CQ Press, 2016). Using the CQ dataset that Policy Agendas Project (PAP) provides, the scholars define policy change as "the sum of CQ article lines devoted to a given [topic] during a given congressional term" (Adler & Wilkerson, 2009, p. 6).

The scholars justify use of this measure by citing other studies that equate CQ lines of coverage to policy significance (Anderson, Box-Steffensmeier, & Sinclair-Chapman, 2003; Edwards, Barrett, & Peake, 1997; Carson, Finocchiaro, & Rohde, 2010; Mayhew, 1991; Sinclair, 1995; and Stimson, MacKuen & Erickson, 1995). They further validate this measure by finding that the most important laws according to CQ coverage highly coincide with those found in the Mayhew (1991) "list of 'most innovative and consequential' laws," as well as those emerging from the policy significance scores Clinton and Lapinski (2006) use to identify meaningful legislation (Adler & Wilkerson, 2012, p. 173-174).

While the authors admit there is not a perfect standard to validate CQ coverage as a measure of significant policy change, they argue based on the aforementioned evidence that CQ coverage sufficiently describes policy substance and that a change in the amount of coverage represents meaningful policy change within issue areas. This paper thus makes the same assumption and uses fluctuations in CQ coverage between 1947 and 2010 as a measure of policy change in science and the other four analyzed topic areas.

Trends in Science Policy and its Comparison to Other Topic Areas
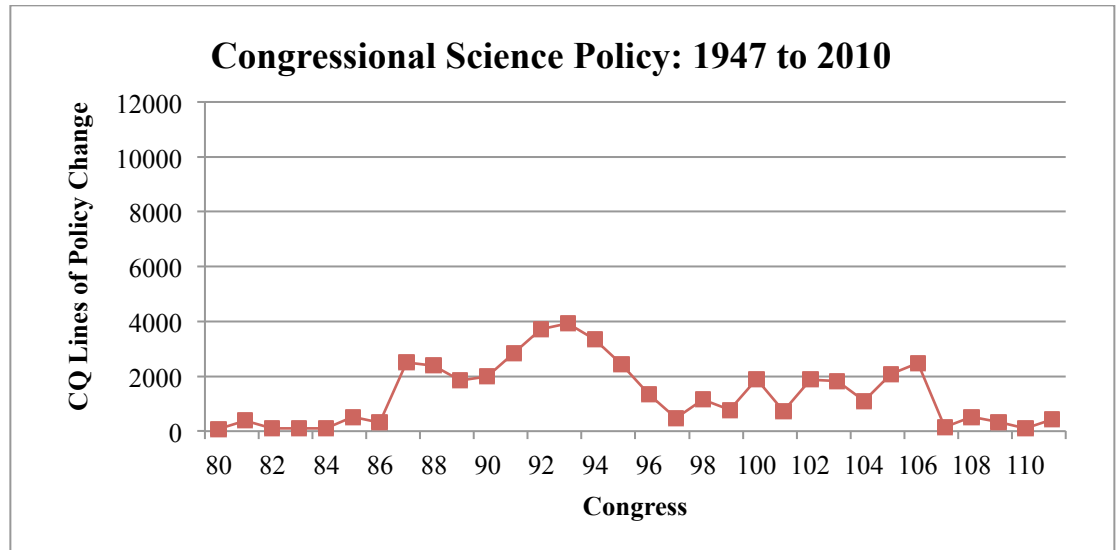

FIGURE 1: Total Number of CQ Column Lines per Congress Discussing Passed Science Laws. Data is taken from Policy Agendas Project Congressional Quarterly Almanac dataset.
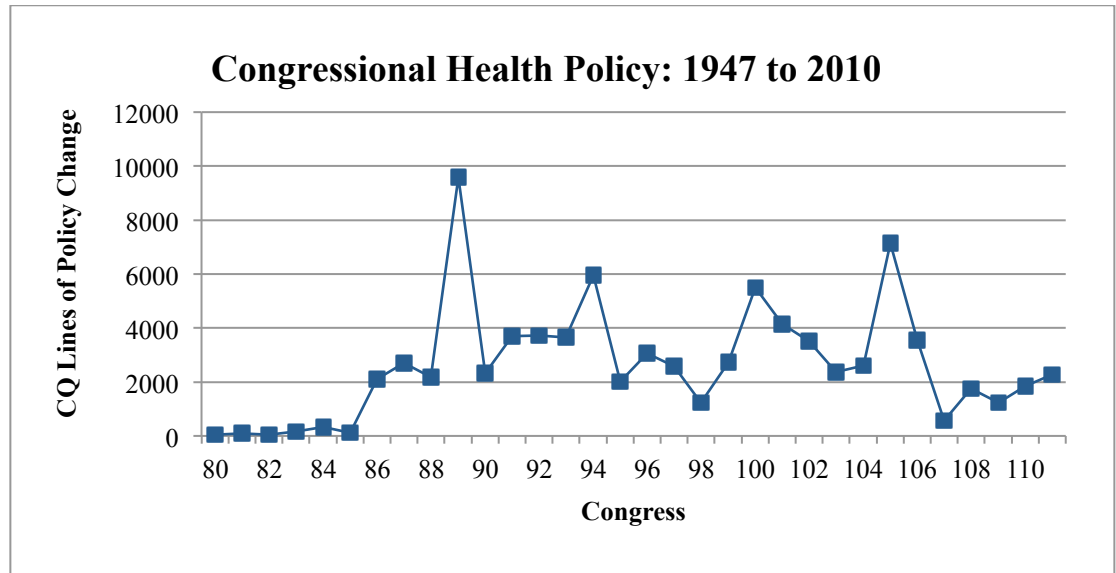

FIGURE 2: Total Number of CQ Column Lines per Congress Discussing Passed Health Laws. Data is taken from Policy Agendas Project Congressional Quarterly Almanac dataset.

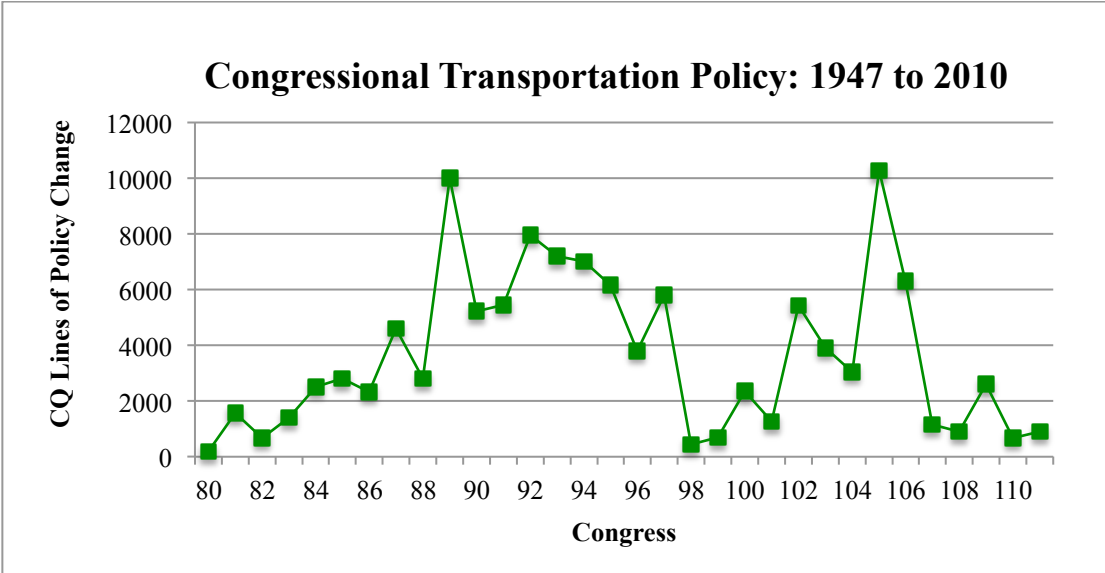**Congressional Transportation Policy: 1947 to 2010**

FIGURE 3: Total Number of CQ Column Lines per Congress Discussing Passed Transportation Laws. Data is taken from Policy Agendas Project Congressional Quarterly Almanac dataset.

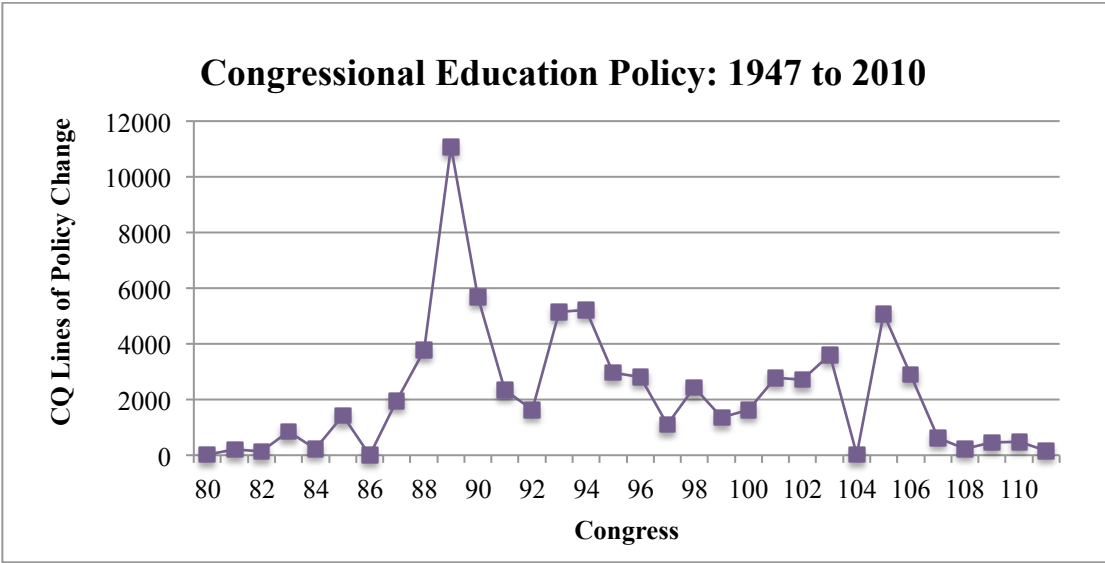**Congressional Education Policy: 1947 to 2010**

FIGURE 4: Total Number of CQ Column Lines per Congress Discussing Passed Education Laws. Data is taken from Policy Agendas Project Congressional Quarterly Almanac dataset.
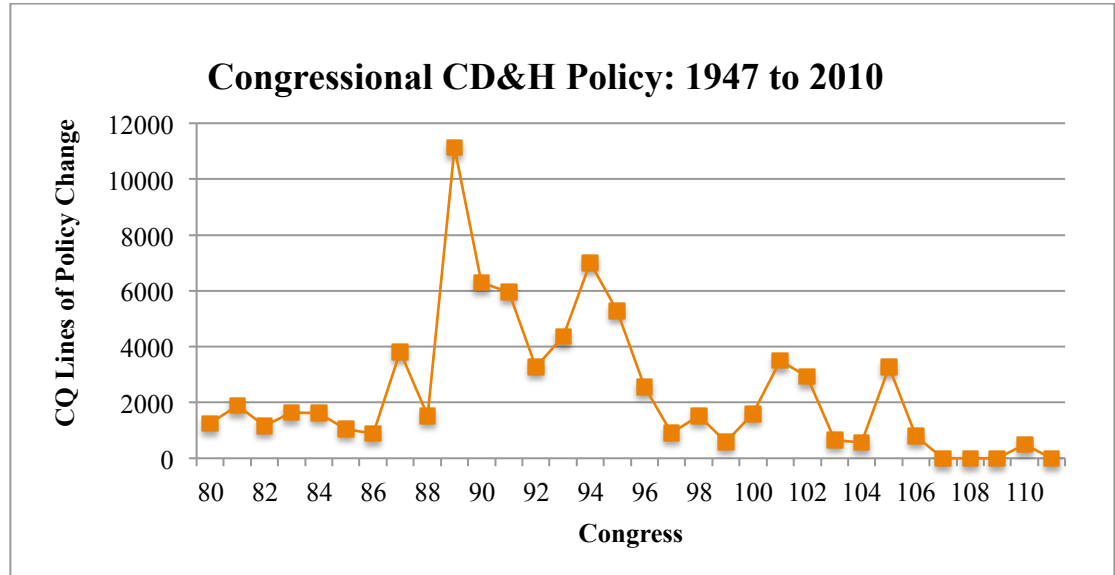
FIGURE 5: Total Number of CQ Column Lines per Congress Discussing Passed CD&H Laws. Data is taken from Policy Agendas Project Congressional Quarterly Almanac dataset.

As society continues to face environmental threats, complex diseases, innovations in enemy warfare, and other worrisome issues, it is clear that science is needed both to explain and find solutions for these problems. Weingart (2002) notes that "the more results [scientists] produce…the more questions arise," so "the frontiers of science are indeed endless" (p. 1). Since the role of science in society is inevitably growing (Weingart, 2002; Price, 1971), one would expect that science policy is correspondingly expanding over time. However, Congress has actually passed a decreasing amount of meaningful science legislation over the last sixty-two years (Figure 1). The largest and virtually singular development in science policy occurred between the 87th and 94th Congresses, or during the 1960s and early 1970s, and has steadily declined thereafter. Also noteworthy, the Congresses serving between 2001 and 2010 troublingly returned to the almost nonexistent levels of science legislation during the 1950s Legislatures, a decade during which the apparent role of science in society had barely begun to emerge in America (Rossiter, 1985).

Although these trends in science are seemingly disappointing, they are not entirely unique. The volume of significant transportation, education, and CD&H legislation has similarly decreased but at even faster rates (Figures 3, 4, and 5). Notwithstanding a minor increase in transportation policy during the 109th Congress (2005-2007), these issue areas also experienced a similar return to 1950s legislative trends in the final decade examined. One might wonder if the decline in science policy therefore simply represents diminishing legislative behavior overall; however, Figure 2 suggests otherwise. Passage of significant health policy has increased at a relatively

rapid rate, even during the latest decade, thereby suggesting policy change does vary in magnitude and direction between issue areas.

Further demonstrating this variation, there are important characteristics unique to science policy change. Most notably, the amount of CQ science coverage ranges between 0 and 4,000 lines of law, while the other four areas experience ranges between 0 and at least 10,000. In fact, the other issue areas receive, on average, between 2,200 and 3,700 CQ lines of coverage per year, while science receives only 1,370 lines of coverage on average per year (PAP, 2014). Not only does science experience generally smaller outputs of meaningful policy, but it also remains highly constant, while the other areas experience drastic spikes of growth and decline. For instance, the other four topics all radically increase in policy during the 89th Congress, while science actually declines. Similarly, science policy experiences its largest growth between the 91st and 93rd Congresses, when three of the other four issue areas either decrease in significant policy outcomes or remain constant.

Because science policy changes in these distinct ways, it is clear that the factors influencing policy in other issue areas likely have different or absent effects on science policy. One should wonder what influences science policy and why legislative action in this area is so minimal compared to that in the rest.

Congressional Science Policy: the Weakness of Existing Theories

In the rare occasions scholars study science policy, they primarily examine either policy solutions for scientific issues (Schneider, 1989; Jones, 2010) or how science policy benefits the economy (Smith, 1990; OECD, 2000), national security, and health (Richter, 1995). Scholars thus usually focus on the effects, rather than the causes of science policies. The few scholars who do evaluate the factors influencing science policy choices often concentrate on the Cold War as a causal factor (Leslie, 1993; Rossiter, 1985). This research fails to explain science policy trends beyond the Cold War, as well as instances when science policy did not adequately reflect the war's conditions. For example, large increases in significant science policy during the 87th Congress occur immediately after the Cuban Missile Crisis, which many consider to be the height of the Cold War, but also more appreciably between the 91st and 93rd Congresses when the US embraced *détente*, or relaxation of tensions (Figure 1). Therefore, research needs to develop more timeless, encompassing theories to explain changes in science policy.

A small subset of research investigates the process of science policymaking. However, these investigations advocate political processes theorists believe would produce the best science policy outcomes, such as citizen panels that combine expertise with public deliberation, while barely describing the science policymaking process as it actually exists in reality (Jasanoff, 1987; Weingart, 2002; Jasanoff, 2004; Mooney, 2005; Brown, 2006). Nevertheless, these scholars analyze some cases, such as those related to carcinogen regulation and genetically modified food, and agree that "it has become common practice for…politics [to] request special scientific

expertise," because "scientific knowledge has been [historically] regarded as superior and of higher value than popular knowledge or 'common sense'" (Weingart, 2002, p. 2). The researchers suggest that scientists not only give advice to politicians, but they can also set the science policy agenda. For example, environmental issues and technology controversies did not arise as political issues until scientists found pesticides in the food chain and released findings on the potential harms technology can cause (Weingart, 2002; 1991). While these studies highlight a probable trend in politics, they do not control for other possible causal factors. To assess the validity of this consensus that political "decision-making [has become] more technical and expert-driven," it is necessary to use a much larger number of policy cases and measure the effect of expertise on policy change over time (Dauvergne, 2005, p. 369).

Quantifying Issue Specialization

One way to measure the influence of expertise on meaningful policy change is to investigate committee activity. According to Joseph Cooper, an expert in congressional committees, the committee system emerged "to make legislative specialization [or expertise] possible" (Cooper, 1970; Gilligan & Krehbiel, 1990, p. 536). Gilligan and Krehbiel (1990) likewise argue that committees provide "informational efficiency," since committee members become specialists, by "obtain[ing] superior information about the consequences of various legislative alternatives" (p. 536). By obtaining "superior" information, committees allow "Congress to accomplish more with its limited manpower," given that Congress is not capable of becoming experts in all policy initiatives unless there is a division of labor (Adler & Wilkerson, 2012, p. 60; Talbert, Jones, & Baumgartner, 1995).

A staff member from the Senate Labor and Human Resources Committee explained that committees acquire a reputation for being experts on particular issues, because they get a referral for a particular bill, hold investigative hearings in which they invite expert witnesses to testify, and consequently obtain future jurisdiction over similar bills (Talbert, Jones, & Baumgartner, 1995). Legislative hearings, which investigate the implications of bills that were referred to the committee of jurisdiction, especially tend to invite experts who are both supporters and dissenters, thereby theoretically allowing committee members to gain balanced information about the relevant issue (Talbert, Jones, & Baumgartner, 1995). Given committees' clear role as issue experts in Congress, the level of committee activity is a valid proxy for issue specialization, since members obtain relevant bill information from field experts during hearings.

Although science policy literature suggests a unique role of expertise in science policy outcomes, the efficiency that committees provide makes it possible that committee activity is a key determinant of policy change for other topic areas, as well. Increased committee activity, by expanding the amount of information Congress can acquire, should result in more policy change. In fact, scholars find that committees "control the pace and direction of policy change within their jurisdiction" (Adler & Lapinski, 2009; Deering

& Smith, 1997; Fenno, 1973; Weingast & Marshall, 1988). Therefore, committee activity is a likely indicator of policy change within specific topic areas.

Papers discussing the relationship between experts and science policy do not control for other possible causal factors, making it necessary to measure the effect of additional political variables. In turn, I test how well theories of general congressional behavior specifically apply to science policy. Such theories recognize many predictors of general policy change, which I will categorize broadly as: partisan characteristics of government, external mood and support, and size of the federal budget.

Methodology
Operationalizing the Dependent Variable
In order to quantify meaningful policy change in a given topic area, this study uses the aforementioned method of measuring CQ topic coverage (Adler & Wilkerson, 2012). Specifically, the total number of CQ article column lines per Congress discussing laws passed in a given topic represents meaningful legislation in that issue area. This measure is derived from the Policy Agendas Project *Congressional Quarterly Almanac* dataset, which computes "ArticleSize" as the "length in column lines of the article" (PAP, 2014). Although the dataset includes articles discussing both failed and successful legislation, I only define topic coverage as the number of lines discussing bills that became public law. I exclude failed bills, because reputable scholars measuring policy change, significance, and success likewise only include successful enactments in their quantifications, thereby defining policy as a culmination of public laws or the bills that pass (Adler & Wilkerson, 2012; Clinton & Lapinski, 2006; Mayhew, 1991). In accordance with this established definition of policy, this paper applies the same restriction.

One should note that the Policy Agendas Project accounts for format changes of articles over time. Because the average number of words per column line in early Almanac years is half as much as that of later years, the Project halves the number of column lines counted per article in these early years, specifically from 1948 to 1958. This variable is therefore a consistent measure over time (PAP, 2014).

Defining Topic Areas
The Policy Agendas Project 2014 *Topics Codebook* defines 20 major topic areas and 220 subtopic areas by numerical code. All datasets used in this analysis have categorized legislation according to these major and subtopic codes. Adler and Wilkerson (2012) also use Policy Agendas Project topic and subtopic codes to define the issue legislation they include in their study.

Science legislation includes laws with eight of the ten "Space, Science, Technology and Communication" codes. The two excluded codes are "Telephone and Telecommunication Regulation" and "Broadcast Industry Regulation," since these two refer to communication legislation, rather than science policy. An example of a law coded within these included science

categories is the "National Aeronautics and Space Administration Authorization Act of 2005," which provided NASA with funding and permission for "missions to Mars and the Moon, repair to the Hubble Space Telescope, and the retirement of old shuttle fleets" (PAP, 2015).

Stine (2009) clarifies that science policy is involved in the following additional issue areas: health, environment, energy, transportation, defense, and education, through research and development efforts. Accordingly, I also define science as having the "research and development" codes under the first five of these six topic areas. For example, Congress in 1992 passed into law a bill coded as health research and development that provided funding for increased Alzheimer's disease research (PAP, 2015). Lastly, I include legislation with the "Education Excellence" code, only if the bill refers to science-related education. One such law is the 1984 Math-Science bill, which "authorized a program to bolster the quality of mathematics and science education" in the U.S. (PAP, 2015).

Health, transportation, education, and CD&H legislation include public laws with all the codes listed under these major topic areas, except the research and development codes that are being defined as science. Using these codes for both science and one of the other issue areas would not be an accurate measure of policy change in a given topic area, as there would be issue overlap. To clarify these distinctions, the law passed in 2000 that increased highway construction is considered transportation policy, while the laws passed in the early 1970s to provide funding for the research and development of high-speed ground transportation technology is considered science policy within this study. The latter directly funds scientific research to improve transportation, while the former lacks this element.

Independent Variables
1. Issue Specialization
As previously discussed, committees allow legislators to gain specialized knowledge in specific issue areas. Therefore, committee activity acts as a proxy variable for expert knowledge and issue specialization. I use the PAP Congressional Hearings dataset, which records each US congressional hearing from 1946 to 2013 and codes them by PAP topic areas. I thus measure committee activity as the total number of days per Congress committees hold referral hearings in each topic area. I exclude non-referral committees, as these focus on "issues for which [the committee has] not received a bill referral" and therefore do not directly "shape the fate of bills" (Baumgartner & Jones, 2002, p. 99).

2. Partisan Characteristics
Partisan characteristics include: the party composition of the legislature, the extent of divided government, and the party of the president. To measure the effect of congressional party composition on policy change, this study uses the percentage of seats per Congress occupied by Democrats (History, Art & Archives, U.S. House of Representatives, 2015; Senate Historical Office,

2015). The Republican percentage of Congress is not included as a variable, because it would provide the same measure but in the reverse direction.

Divided government occurs when the party controlling the executive branch is different from the party controlling at least one chamber in Congress (Bessette & Pitney, 2013). Because the dummy variable cannot gauge the extent of divided government, but simply indicates its presence, the percentage of seats in Congress occupied by a member of the president's political party is also used to measure divided government (Light, 1982). The political party of the president during each Congress and the presence of divided government are both made into dummy variables (0 = Democrat, 1 = Republican; 0 = undivided, 1 = divided).

3. External Mood and Support
As review of literature indicates, both the president and the public likely influence congressional policy decisions in specific issue areas. Gelman *et al.* (2015) assembled a dataset of unique presidential policy proposals between 1947 and 2008, constructed from the *Public Papers of the President* and coded according to the PAP codebook. Using the coding definitions described earlier, I select the total number of presidential policy proposals in each issue area per Congress to quantify the president's legislative issue agendas, such as his science legislative agenda. I also use the total number of presidential policy proposals in all issue areas per Congress to measure the president's overall legislative activity.

I also include electoral margin, or the difference between electoral votes the president won in his election and those of the losing presidential candidate as a measure of public support for the president, which likely influences congressional responses to presidential policy proposals (Gelman *et al.*, 2015; Leip, 2015). For years during which presidents came to office due to presidential death or impeachment, I use the electoral margin earned by the previous president.

Using Stimson and Coggins' (2014) Policy Moods dataset and custom series application, I aggregate mood scores for each topic into an average general score per Congress between 1947 and 2010. This score estimates broad public support for overall congressional policy activity. I also measure the effects of removing general mood score or replacing it with issue-specific mood score, but note that issue-specific data is often only available starting in the 1970s and is therefore less useful for this study.

Religiosity is an indirect measure of public support for certain issue areas, such as health and education (Koopman, 2009). Consequently, I include the average percentage per Congress of Americans who "would say religion is [very important] in [their] life" as a measure of public religiosity (Gallup, 2015).

4. Federal Budget

Lastly, the study includes the size of the federal budget, by recording the average federal surplus/deficit in millions of dollars during each Congress between 1947 and 2010 (Federal Reserve Bank of St. Louis, 2014).

Statistical Models

I use multiple regression models to determine the effects of these independent variables on topic-specific policy change. For each issue area (science, health, transportation, education and CD&H), I develop a model with CQ topic coverage as the dependent variable, by examining 1,224 CQ records of public law. Each CQ record discusses only one public law, since the Policy Agendas Project separates articles containing multiple laws into unique records. I include the eleven aforementioned independent variables and identify significant predictor variables for each topic, based on a significance threshold requiring the p-value to be below 0.05.

Although social scientists occasionally use lagged dependent variables in time series analyses, I choose to exclude this variable from the model. I do so, because scholars increasingly contend that "the lagged dependent variable specification is too problematic for use in most situations," as it underestimates the effects of explanatory variables, while overestimating its own effect (Keele, 2005, p.1). Achen (2001) argues that lagged investigations of the federal budget and nuclear arms race, for example, have produced artificial and inaccurate results. In turn, I omit the lagged dependent variable, because it would likely underestimate the explicatory power of the independent variables, making the results unreliable.

Results

Independent Variable	Science	Health	Transportation	Education	CD&H
Committee Activity (Referral Hearings)	14.05*	1.22	7.87	8.38	8.62
Democrat Percentage of Congress	1896.00	4987.00	7139.00	11890*	10930.00
Divided Government	-311.0	-337.4	-336.8	-242.8	-182.9
Presidential Party Congressional Seats Percentage	-3864.00	-15720.00	-9028.00	-4185.00	-4704.00
Presidential Party	39.87	-681.50	-391.60	-290.40	-1618.00
Total Presidential Proposals	-0.38	12.30	22.46**	-3.67	10.68
Topic-Specific Presidential Proposals	16.86	-7.06	177.6*	71.23*	-64.91
Mood Score	-89.79	84.39	307.10	-73.86	-205.60
Religion	-10030.00	-56170**	-59210*	-38900**	-17810.00
Electoral Margin	-0.38	7.33	7.27	4.40	7.81
Federal Surplus/Deficit	0.00	0.01	0.01	0.007501*	0.00
Multiple R-squared	0.61	0.68	0.68	0.70	0.72
Adjusted R-squared	0.38	0.43	0.44	0.47	0.49
N	31	31	31	31	31

Significance Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
N = observations (number of congressional terms)

TABLE 1: Predictors of Topic-Specific Policy Change between the 80th and 111th Congress

Explanatory Variables of Science Policy Change
Results reveal that only committee activity, or the amount of days Congress dedicates to science referral hearings, significantly correlates with CQ coverage of science laws. Controlling for all other variables, meaningful science policy increases when committee activity increases, thereby confirming original expectations and substantiating existing science policy theories arguing that Congress depends on expert knowledge for science policy decisions. Contrary to the original hypothesis, partisan characteristics, external support, and the federal budget lack any appreciable impact on science policy change.

Comparison of Science Indicators to Those for Other Issues
Committee activity uniquely shape science policy, rather than any of the other four issue areas. However, explanatory variables also differ for all examined topics. Unlike original predictions, even science, health and education are determined by different factors, despite the seeming overlap of subtopics. Health policy negatively and significantly correlates with public religiosity alone. Committee activity, partisan characteristics, budget size and other measures of external support all fail to explain health policy change.

The sizes of the president's general policy agenda and transportation-specific policy agenda significantly and positively correlate with transportation policy change, while American religiosity negatively and significantly correlates. All other factors are insignificant. While the president's policy agenda is an expected indicator, religion does not have an apparent causal relationship with transportation policy and is thus likely reflecting the effect of another factor not included in this study.

Education policy change requires the most congressional consideration of political environment, as measures of partisan dynamics, external support, and the federal budget all play a significant role. Specifically, the increased percentage of Democrats in Congress amplifies education legislation. Likewise, presidential support of education and larger federal budgets additionally increase education policy initiatives. Similar to health and transportation policy, public religiosity negatively correlates with education policy, suggesting that congressmen will not forego support from religious constituents for education that threatens their beliefs.

Community development and housing policy is the only issue area for which none of these independent variables are significant. In turn, specialized knowledge, partisan dynamics, external support, and size of the federal budget all fail to explain this topic. It is thus likely that environmental events, such as housing crises, provide the most impact on this topic.

The only overlap between issue areas occurs when religion negatively correlates with health, transportation, and education, suggesting that American religiosity plays a broader role in policymaking. However, congressional behavior is almost entirely unique for each issue area.

Discussion
Unlike other examined issue areas, Congress relies significantly and uniquely on specialized knowledge when making science policy decisions and more minimally upon pressures from party leaders, the president, and the public. Policymakers likely justify this behavior by acknowledging that science is too technical for average citizens, or even themselves, to understand properly without the aid of experts. This trend validates the concern of policy theorists that "as decision-making [grows] more technical and expert-driven, citizens [are] progressively distanced from the process…that form[s] the backbone of…[policy] decisions" (Jasanoff, 2005, p. 386). One might intuitively wonder why Congress has not produced more laws that beneficially expand

scientific efforts if scientific knowledge seemingly determines policy decisions in this area. Weingart (2002) explains that "the demand for scientific expertise" in politics diminishes the legitimacy of science as an objective, disinterested field by introducing political pressures into their work (p.704). Scientists heavily involved in making policy decisions may shape their scientific findings in a way that supports political goals, thus resulting in irrational policy decisions.

An infamous example of such delegitimizing of science is the tobacco industry's enduring effort to thwart anti-smoking laws. During the 1950s and 1960s, the link between smoking and lung cancer was becoming evident to scientists. However, tobacco companies employed expert scientists to deny the link between smoking and disease and funded staged scientific research to demonstrate the falsity of this casual connection (Mooney, 2005). These paid experts created doubt among the public and were often able to delay anti-smoking policies. In fact, many key anti-smoking laws did not pass until the 1980s, such as the "Comprehensive Smoking Education Act of 1984" and indoor smoking bans, even though the effects of smoking were established decades earlier (CDC, 2015).

Despite the negative side effects, it is clear that the involvement of expert knowledge in politics increases science policy outputs, given the positive correlation between the two. One would therefore be amiss to eliminate expert opinions from policy decisions, and this type of knowledge is of course valuable. However, science policy is distinctive from most of the other issue areas in that it does not appreciably culminate from conventional democratic pressures, such as public opinion or presidential support that either shapes or reflects that opinion (Gelman *et al.*, 2015). Perhaps this distancing of citizens from science policy decisions explains the narrow range of science policy change compared to that of the other issue areas (Figures 1-5). In fact, the results demonstrate that pressures from the public, the president, political parties, or a combination of all three shape health, transportation, and education policy, which have more than double the amount of maximal policy change than science does and higher averages of policy change per Congress.

Conceivably, these conventional policy actors refrain from advocating science policy action because they lack the knowledge to support their claims as well as the experts upon whom Congress so faithfully relies. If party leaders, the president, or the public were encouraged to participate more in science policy promotion and to give those with specialized knowledge a less authoritarian role, there would seemingly be a larger impetus for policy change, simply because there is strength in numbers. One might attempt to counter this claim by observing that CD&H has larger outputs than science but also seems to ignore these same pressures. However, various environmental circumstances, such as housing crises, force legislators to act immediately in this issue area, and legislators can produce housing policies that affect their constituents directly. On the other hand, conditions surrounding science are ostensibly less urgent. A familiar example of the immediacy of housing policy is the "Housing and Economic Recovery Act of

2008," which aimed to "help at least 400,000 families save their homes from foreclosure," and which passed soon after it was clear that the subprime mortgage crisis of 2008 was occurring (HUD, 2008, p.1). This law was a response to a circumstantial event and had the potential to quickly affect thousands of citizens.

Unlike housing policy, most circumstances that require scientific assistance, such as global warming, appear less urgent to Congress because effects are more long-term in their exposure. Furthermore, congressmen seeking to gain support from their constituents are unlikely to attempt to do so by improving science, because effects are less direct and immediate. A bill to provide increased funding for spinal cord injury research, for example, will affect scientists studying this topic, but will have little to no effect on most citizens until this research results in a cure years later.

Therefore, Congress has fewer reasons to produce large policy outputs in science unless the public asks for them. It is necessary for Congress to make science policy deliberations less technical, so that such decisions are not only expert-reliant but also involve citizens who can advocate for science. While policymakers certainly need to continue receiving technical advice from experts, it is important that this information is comprehensible to the public, thereby enabling non-expert citizens to participate in the process as well. Such a practice would allow lawmakers to still make decisions based on expert knowledge; however, the public would be more involved and thus more demanding of science policy change.

Some scholars have already proposed certain methods to diminish the gap between expert and citizen knowledge of science and to consequently increase demand for science policy change. Beck (1979) promotes citizen science, which theoretically informs the public by allowing non-experts to participate in scientific research. For example, an ordinary citizen, Lois Gibbs, discovered in 1978 that her neighborhood rested on top of 21,000 tons of toxic waste, inspiring her to form and lead the Love Canal Homeowners Association, which reported epidemiologic findings that eventually led the EPA to advocate for three different policies that would address this issue (Beck, 1979). Brown (2006) describes a correspondingly prudent method of using citizen panels, whereby temporary advisory groups made up of non-expert citizens collectively deliberate about a policy issue after hearing from diverse experts who educate them about the topic. In this case, the experts are still involved in informing policies, but informed citizens acting similarly to juries can supplement their knowledge with broader advocacy and support.

Although the effectiveness of these approaches has not sufficiently been tested, their goal of combining expertise and citizen engagement is a seemingly promising way to promote meaningful changes in science policy. It is thus necessary for scholars to continue developing similar proposals and to test their efficacy, so that society can start using these mechanisms to stimulate important changes in science policy that will address the wide array of issues we face and that only science can solve.

Conclusion

This paper has demonstrated the importance of investigating issue-specific trends in congressional behavior by revealing that the factors influencing change in each topic vary not only with those shaping general policymaking, but also with those influencing other issue areas. Results also validate concerns of science policy theorists, who argue that science policy processes have become too complex and consequently exclude conventional democratic pressures. This finding simultaneously provides an enduring theory of science policy change in response to the shortage of existing explanations.

By highlighting Congress's unique and significant dependence upon specialized knowledge when contemplating science policy change, the analysis emphasizes the need to reform the way lawmakers decide on science policy. Specifically, researchers must identify methods that combine expertise with citizen involvement, so that advocacy for science policy increases and compels Congress to produce more substantial science policy changes. While scientific knowledge is always valuable, some form of citizen, presidential, or party participation is essential for significant policy change in a democratic society.

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