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DEFINING POLICY ISSUES: THE DYNAMICS OF INFORMATION PROCESSING AND ISSUE DEFINITIONS

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Abstract

This dissertation examines how information is translated into issue definitions. Issue definitions—the way that policy issues are understood—have long been noted to be important for policy choices. In this project, I develop a model of issue definitions where issues are understood as a function of the various dimensions of the issue weighted by the importance of each dimension. I then incorporate this model into the theory of information processing developed by Jones and Baumgartner (2005). The theory of information processing posits that information can be understood as signals in the policymaking environment, and information processing is the collection and prioritizing of those signals. In this dissertation, I model these information signals as the salience of each dimension of an issue.

Using the case of used nuclear fuel (UNF) management, this dissertation test hypotheses about the nature of issue definitions and policy change, institutions, and policy actors. Specifically, I estimate the dimensions of the UNF issue using latent Dirichlet allocation, a type of quantitative text analysis. Following the development of the UNF dimensions, I test hypotheses about how the salience of these dimensions are related to policy change, how institutional structures influence dimension salience, and how policy actors systematically highlight some dimensions over others.

Chapter 1

Issue Definitions, Information Processing, and Policymaking

In February 2010 the Obama Administration asked the Department of Energy to withdraw the license application for Yucca Mountain that had previously been submitted to the Nuclear Regulatory Commission. This action seems to have sealed the fate of Yucca Mountain, the place that had been designated as the sole repository for the country's used nuclear fuel (UNF). The selection and consideration of Yucca Mountain as the solution to the nation's problem of the increasing amount of radioactive material gathering at various nuclear power facilities, was a nearly four decade process. While policy development has occurred, the basic policy dilemma remains; what should be done with this material?

The examination of the issue of used nuclear material allows important insights into the policymaking process, particularly within policy areas that are steeped in scientific and technical information, controversial, and possess a long time horizon.[1] Scholars of the policy process have long noted the importance of how issues are understood, and how these issue definitions can shape policy choices (Stone, 1989; Rochefort and Cobb, 1993; Baumgartner and Jones, 1993). In addition, scholars have noted the importance of information for the development of policy issues

[1] Indeed, the Environmental Protection Agency is required to develop exposure regulations that stretch out to 1 million years.

(Krehbiel, 1991; Sabatier and Jenkins-Smith, 1993; Jones and Baumgartner, 2005; Workman, Jones and Jochim, 2009). Less attention has been paid however, to how information is translated into issue definitions. Given the long time frame and complexities of handling used nuclear material, that issue is an ideal one for examining the importance of information and the process by which information shapes how issues are understood. In this dissertation, I posit that issue definitions are based on how the dimensions of a policy issue are weighted by policy actors and institutions and that these weights shape the information available to policy makers. In addition, I examine how issue definitions shift and evolve over time both leading to and following policy change.

In short, the dissertation will examine how information is refracted through actors and institutions to produce issue definitions and how those issue definitions evolve over time. I use the issue of UNF management to test hypotheses about the role of actors, institutions, and policy change in shaping how issues are understood. This first chapter briefly describes the nature of the research about the policy process, and describes the model of issue definitions that I develop. Following that discussion, I describe the theoretical framework I use to understand how information is used to define policy issues. Next, I give a brief background on UNF management. Finally, I provide a broad overview of the subsequent chapters.

1.1 Understanding the Policy Process

From the outside, the policymaking process can seem to be either largely idiosyncratic or driven by partisanship and political ambition. However, scholars have been able to draw out many systematic patterns within the policymaking process and these patterns have formed the basis of multiple frameworks and theories about such topics as policy change, policy learning, and information processing. Some of the early attempts to systematically characterize the policy process included

Table 1.1: Policy Process and the Levels of Analysis

Level	Constituent Parts	Description
Macro	Policymaking Institutions	The formal policy making institutions
	Policy Regimes/Linked Subsystems	Issues or problems that span multiple subsystems
Meso	Subsystem	A set of actors engaged in a bounded substantive issue area
	Coalitions	Collection of allied groups/individuals that share policy core beliefs and preferences
Micro	Individuals	Individual units within a coalition; could include a single organization or group, or individuals such as members of Congress, policy entrepreneurs, or public managers

Lowi's typologies (Lowi, 1972) and the policy stages model or "heuristic" (Brewer and deLeon, 1983; Jones, 1984; deLeon, 1999). Both Lowi's typology and the stages model were found to lack the theoretical and empirical rigor to be classified as proper theories, largely due to a lack of properly specified causal mechanisms (Sabatier, 1991). As a result, a wide array of frameworks and theories of the policy process began to proliferate and continue to be developed (Sabatier, 2007; Nowlin, 2011).

The various frameworks and theories differ from each other by the levels of analysis and the levels of abstraction in which they focus. Levels of analysis refers to the level or levels (macro, meso, micro) in which policy action is taking place (Redford, 1969). Policy scholars focus on the most pertinent level for the specific question(s) they are addressing. Each of the varying levels contain different aggregations of institutions and actors and focus on different decision processes. The various levels, their parts, and a brief description are shown in Table 1.1.

At the macro level, scholars tend to focus on the large policymaking institutions such as Congress, the Executive, and the Judiciary. Scholars at the macro level are often focused on questions of institutional adjustment and response across a wide range of policy issues (Jones and Baumgartner, 2005; Workman, 2009). Nested between the macro and meso levels are policy issues that span multiple policy subsystems, but are linked by common actors, institutions, or arguments. Examples of these types of issues include climate change and homeland security (Jones and Jenkins-Smith, 2009; May, Jochim and Sapotichne, 2011). The meso level includes the subsystem, which is the set of actors and institutions concerned with a particular policy issue, and coalitions, a collection of actors bound by shared beliefs and policy preferences within a subsystem. Finally, the micro level is focused on particular groups or individuals active on a policy issue.[2]

Apart from levels of analysis, policy theories also vary by level of abstraction. At the highest level of abstraction are frameworks, which "bound inquiry" and "direct the attention" of scholars (Schlager, 2007, 293). Frameworks can "provide anything from a skeletal set of variables (or variables sets) to something as extensive as a paradigm"(Sabatier 2007, 322). Once a framework is established, theories can be put forward based on the concepts identified as important in the framework. For example, within the Advocacy Coalition Framework (ACF) is a theory of policy learning (Sabatier and Weible, 2007). Theories identify and "place values" on variables, they also "posit relationships among the variables" and they "make predictions about likely outcomes" (Schlager 2007, 296). Models are developed and used to "test specific parts of theories by fixing a limited number of variables at specific settings and exploring the outcomes produced" (Schlager 2007, 294). Hypotheses are then generated from a model and test specific cause and effect relationships among variables. Moving from a framework to a theory and from there to a model and finally to set of hypotheses implies logically coherent

[2]Several of the prominent policy frameworks, including the Institutional Analysis and Development Framework (IAD) (Ostrom, 2007), the Advocacy Coalition Framework (ACF) (Sabatier and Weible, 2007), and the Narrative Policy Framework (NPF) (Shanahan, Jones and McBeth, 2011) touch on each of the three levels.

relationships that become increasing specific and more narrow in scope (Sabatier 2007, 323).

This dissertation develops and tests a model of issue definitions. Policy scholars have long noted the importance of how policy issues are defined. The way that issues are understood, either as "policy images" (Baumgartner and Jones, 1993), "problem definitions" (Rochefort and Cobb, 1993), "social constructions" (Schneider and Ingram, 1993), "policy narratives" (Jones and McBeth, 2010), or "frames" (Baumgartner and Mahoney, 2008) can have profound impacts on the politics of the issue and on ultimate policy choices. Despite the use of these various terms, each are connected to the same underlying phenomenon; the way that issues are understood by elite policy actors and the mass public. The major focus of this dissertation is develop an approach to better understand how issues come to be defined. As noted, this concept is an important component within many of the policy process theories, therefore finding a way to better model how issues are defined allows for empirical tests of multiple theories. The next section describes the theoretical approach to modeling issue definitions, and Chapter 2 will discuss the empirical modeling of issue dimensions and definitions.

1.2 Modeling Issue Definitions

Policy scholars have long been concerned with how policy issues are understood and the implications of those understandings for both policy designs (Schneider and Ingram, 1993), and the politics surrounding the issue (Lowi, 1972). Traditionally in the literature issue definitions have largely been conflated with problem definitions, and have largely focused on questions of agenda setting. How do "conditions" that exist in the world become "problems" on the policymaking agenda (Kingdon, 1984; Stone, 1989; Rochefort and Cobb, 1993; Baumgartner and Jones, 1993; Wood and Doan, 2003). Stone (1989) argued that conditions become problems once a causal story is developed that can attribute blame for the problem on the actions of some individuals or groups. Once a causal story is in place, the condition is more likely to be seen as something that can be effectively dealt with and is therefore more likely to be placed on the agenda. Wood and Doan (2003) develop a threshold model of problem definitions and argue that conditions become problems once those conditions pass a certain threshold among a critical mass of individuals, thereby forcing institutions into action.

Beyond problem definitions and agenda setting, other scholars have noted other ways that issue definitions can impact policy processes. Punctuated Equilibrium Theory (PET) notes the important role that policy images play in facilitating policy change. In particular, changing policy images interact with policy venues to produce large-scale "punctuated" policy changes (Baumgartner and Jones, 1993). For example, the nuclear energy subsystem experienced rapid shifts as the policy image changed from positive to negative and attracted new policy actors across new policy venues.

More recent work argues that policies can be characterized (i.e., defined) by their relevant attributes and the salience (i.e., importance) assigned to those attributes (Jones and Baumgartner, 2005). This policy characterization approach is based on an attribute-based understanding of information processing (Jones, 1996; Jones, Talbert and Potoski, 2003). Attributes, or dimensions, of policy issues are the underlying characteristics of the issue that serve as the basis of policy choices. These attributes make up a multi-attribute problem space of attributes and salience weights that changes over time. While the problem space is multi-dimensional, the separate choice space, where issue attributes are combined and arrayed, is uni-dimensional (Jones, 1994*b*; Jones, Talbert and Potoski, 2003). Policymaking institutions reduce the multidimensional issue space to a uni-dimensional choice space (Talbert and Potoski, 2002). Often this uni-dimensional choice space aligns with liberal and conservative ideology (Poole and Rosenthal, 1997).

The model of issue definitions that I propose builds on this past work, but is intended to be more generalized. In essence the model attempts to explain how issues are understood. The basic assumption of the model is that issues are complex and contain multiple attributes that exist in a multidimensional issue space. These dimensions can include problem indicators (e.g., unemployment rate, amount of greenhouse gas in the atmosphere), problem causation or origin, and possible solutions (Rochefort and Cobb, 1993). A somewhat semantic, but important point of departure in the approach I propose from the policy characterization approach of Jones and Baumgartner (2005) is how I deal with the question of separate problem and choice spaces. In brief, I propose an *issue* space which can contain dimensions related to both problems and solutions. While a long line of policy scholars, most notably Kingdon (1984), have noted that policy problems and solutions can develop separately and independently, I am most interested in how issues are constructed though a process of combining and weighting the various dimensions—both problem and solution—of the issue. This is important because, depending on the weight assigned to it, the proposed policy solution can have significant impact in the way the entire issue is understood. For example, recent work dealing with climate change policy solutions has shown that altering the proposed solution by advocating for increased use of nuclear energy (Kahan et al., 2007) or geo-engineering (Kahan et al., 2012) can alter the views that individuals have of the climate change issue. In particular, those that are likely to assign less risk to climate change and be more supportive of nuclear energy or geo-engineering, can be compelled to assign greater risk to climate change when nuclear energy or geo-engineering is offered as a solution. So, attaching a dimension that is salient to an issue can alter the issue space, and therefore redefine the issue.

A second assumption is that policy actors, particularly in conflictual policy areas, will have differing issue definitions. Indeed, these varying definitions are what structure the conflict. Therefore, modeling the various issue definitions can provide insight into the nature of policy conflict and resolution. A third and final assumption is that issue definitions are dynamic and change or evolve over time.

The issue definition model (IDM) is intended to provide a generalizable model of how policy issues are understood. It assumes a multidimensional issue space, policy actors that vary in their definition of the issue, and definitions are dynamic. By assuming that actors define issues differently, I mean that policy actors vary in the salience that they attach to each dimension of the issue. Salience is defined as the importance of a particular dimension and the centrality of a dimension for understanding the policy issue. Therefore, a dimension that is considered highly salient is seen as a) important and b) central to how the issue is understood. The model can be expressed more formally as:

$$ID_a = \sum_{i=1}^{n} s_i$$

where s_i is the salience of dimension i for issue a.

This simply means that issue definitions can be theoretically modeled as a function of the sum of each dimension weighted by its salience. Note that the model above is expressed as static, or the issue definition at time t. However, the salience of dimensions can vary over time making issue definitions dynamic. The dynamic element of issue definitions is a function of the changing salience s_i that results from the competition between policy actors over time. The sum assigned to the issue definition would be arbitrary, but the relative distance could be measured in a Euclidean space, similar to the way in which political scientists calculate spatial models. However, in the empirical model, discussed in detail in Chapter 2, I measure the salience attached to each dimension by measuring the proportion of verbal Congressional testimony that is about each dimension. In this approach each dimension is assigned a proportion for each witness statement, and these proportions sum to one. As a result, the empirical model estimates the salience that each actor attaches to each dimension, but does not provide a summation.

The IDM could be used to test hypotheses across a variety of the policy process theories, however in this dissertation I leverage the IDM to better understand how policy information is created by and filtered through competitive policy actors and institutions to construct issue definitions. Therefore, I build on insights offered by the theory of information processing developed by Bryan Jones and his colleagues (Jones and Baumgartner, 2005; Workman, Jones and Jochim, 2009). The next section describes the theoretical framework I apply in the dissertation.

1.3 Information Processing and Issue Definitions

Policy scholars have long noted the importance of information to the policy process. Information can include objective indicators (Wood and Doan, 2003), science and technical information (Sabatier and Jenkins-Smith, 1993), policy analysis (Weiss, 1977; Jenkins-Smith, 1990), and public opinion (Burstein, 2003). Traditional understandings of information in the policymaking process treated information as costly for policymakers to acquire, thereby causing information to be *under-supplied* (e.g., Niskanen, 1971). However, more recently scholars have argued that information is in fact *oversupplied* and that costs are associated with how to prioritize this information (Jones and Baumgartner, 2005; Workman, Jones and Jochim, 2009). The amount of information that is supplied likely varies across policy issues (Boswell, 2012) and over time, with mature subsystems likely having a richer information environment than nascent subsystems.

In an environment where information is oversupplied, policymakers are constantly bombarded with information that is generated by multiple sources including interest groups, Congressional committees, federal agencies, and the media. Policymakers must then decide what pieces of information are most important. In this context, information is defined as "signals" from the environment, and information processing consists of the "collecting, assembling, interpreting, and prioritizing" of those signals (Jones and Baumgartner, 2005, 7). The information that is generated varies, not only by source, by also by substance. Drawing from communications theory, Jones, Baumgartner and de la Mare (2005) argues that an information signal (i.e., message) is passed from a source to a receiver. This can be illustrated as:

$$\textit{Source} \rightarrow \textit{Message (Information Signal)} \rightarrow \textit{Receiver}$$

An information signal moves from a source to a receiver, and the receiver subsequently processes the signal.

The receiver is this scenario are policymaking institutions, and these institutions subsequently process—collect, assemble, interpret, and prioritize—the multitude of information signals. But these institutions, much like individuals, are "boundedly rational" and have a limited ability to effectively process all of the incoming signals (Jones, 2001). Institutions are largely path dependent and these dependencies can create institutional friction that can slow the recognition of new and important information in the environment. This friction also leads to disproportionate information processing, where some information is weighted heavily and other information ignored. Policy decisions are made following the processing of information, and this process can lead to decisions that are either incremental, reflecting small changes, or punctuated reflecting large changes (Jones and Baumgartner, 2005). The nature, including the amount and quality, of the information likely plays a role in whether changes are incremental or punctuated, with punctuations being more likely in policy areas that with sparse information (Boswell, 2012). Figure 1.1 illustrates this process, where the thick arrow from information

Figure 1.1: Information Processing

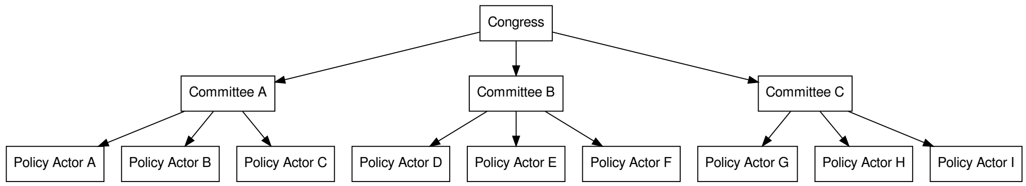
to institutions represents the large quantity of information signals that is directed at policymaking institutions, and the thinner arrow from institutions to decision reflects how information is filtered, or managed, by the institutions prior to a policy decision being made.

While the approach discussed above contains important insights into how information and institutions operate at the macro level, it is not as clear in explaining how information is translated into issue definitions—which is a critical step in moving from information processing to policy choices—at the meso, or subsystem level. The central question of this dissertation can be stated as: *Given what we know about the importance of how issues are defined and given what we know about the role of information in the policy process, how does information lead to issue definitions?* To answer this question, I examine how information is generated and processed by the multiple policymaking institutions and actors that operate within policy subsystems. Specifically, to integrate the issue definition model into the information processing framework outlined above, I operationalize the information signal as being the dimension that is most salient (i.e., important) to the source. Such that:

$$\textit{Source} \rightarrow \textit{Salient Dimension} \rightarrow \textit{Receiver}$$

It is likely that there are differences among the various sources about which di-

Figure 1.2: The Structure of Information Competition



mensions should be most salient, and these differences likely vary in systematic and predictable ways. Furthermore, these differences create competition among sources in determining how an issue comes to be defined. These dynamics are explored in the subsequent chapters, and the sources of information I examine include the various Congressional committees and policy actors involved in the UNF subsystem.

In brief, I argue that issues are defined within policy subsystems, where institutional sub-units and policy actors specialize in particular issues and attempt to define those issues by signaling the salient dimension to policymakers. However, the multidimensional nature of many policy issues create large information costs for policymakers. These costs are associated with searching for information when it is under-supplied, or processing information when it is oversupplied. To reduce these costs, policymakers within an institution (e.g., Congress) delegate to sub-units within the institution (e.g., Congressional committees), and these sub-units further delegate to other actors outside the institution. This process is illustrated in Figure 1.2.

As shown, Congress delegates information gathering and processing to various committees, and these committees draw on other policy actors to signal the salient dimensions of an issue. As a result, competition occurs between committees within Congress and between policy actors appearing before committees, and policy issues are defined (and/or redefined) through this competitive process. I examine this competitive process within the used nuclear fuel (UNF) subsystem, and the next section provides a brief background on the UNF issue.[3]

1.4 Used Nuclear Fuel Management

Used nuclear fuel (UNF) [4] is the radioactive material that remains following the production of nuclear energy. Nuclear energy currently provides about 20% of the electricity used in the United States. To produce electricity, nuclear reactors make use of the energy that is released through the process of nuclear fission—splitting uranium atoms—in a controlled setting. The overall process of producing nuclear energy—the nuclear fuel cycle—involves the mining, enrichment, and fabrication of uranium into ceramic pellets. These pellets are placed within fuel rods that are loaded into fuel assemblies and placed into the reactor. The fission process occurs within each of these fuel rods. Once removed from the reactor, the fuel rods are stored in large cooling pools and current practice is to store the rods on-site at nuclear reactors. At a majority of sites the cooling pools have filled and the spent fuel rods have been moved into large concrete casks. The Nuclear Regulatory Commission (NRC) estimates that, as of 2009, nearly 63,000 metric tons of waste exist at different sites around the country.[5]

What to do with the used nuclear material has been a difficult policy issue for several decades. When nuclear energy was first developed, initial plans were to reprocess this material. Reprocessing entails extracting material from the uranium pellets in the fuel rods and using this material again. Due to concerns of nuclear proliferation, reprocessing was halted by the Ford administration in 1976 (Walker,

[3] A more detailed discussion occurs in Chapter 3.

[4] Used nuclear material is known by various terms including nuclear waste, high-level waste, spent nuclear fuel, and used nuclear fuel. I use the term used nuclear fuel (UNF).

[5] http://www.nrc.gov/waste/spent-fuel-storage/faqs.html

2009). The ban on reprocessing was continued by the Carter administrated, but was rescinded under Reagan. However, reprocessing has not been adopted in the United States, likely due to the low-cost of uranium (Walker, 2009). Once reprocessing was abandoned, proper storage of this material became a central policy question. Scientific consensus centered on deep geologic disposal as the preferred storage medium, and Congress and the Carter administration begin working to structure a process of site selection for two storage sites, one in the eastern half of the United States and one in the western half (Carter, 1987). This culminated in the Nuclear Waste Policy Act of 1982 which stated that the Department of Energy (DOE) shall characterize three sites as scientifically and technically feasible to store the used nuclear material. The President would then choose one site from the three, and the DOE would submit a license application to the Nuclear Regulatory Commission (NRC) (Vandenbosch and Vandenbosch, 2007). This process was short-circuited however, by the Nuclear Waste Policy Amendments Act of 1987, which designated Yucca Mountain in Nevada as the only site to be considered for long-term storage. Yucca Mountain was approved by the Bush administration in 2002, and the DOE submitted a license to the NRC in the summer of 2008. In 2010, however the Obama administration withdrew the license application and put in a place a Blue Ribbon Commission of experts to advise the administration and Congress on next steps for dealing with civilian nuclear material. The BRC submitted its report in early 2012.[6]

The issue of how to handle UNF provides an interesting case to examine how information is transformed into issue definitions. I explore how this issue came to be defined through the use of original data of all the Congressional hearings about UNF from 1975 to 2012. I use quantitative text analysis to examine the opening statements of each witness appearing at these hearings. These opening statements

[6]The BRC website can be found at brc.gov

are used to determine the dimensions of the UNF policy debate. The next section provides a brief overview of the following chapters of the dissertation.

1.5 Overview of the Dissertation

In brief, this dissertation can be summed up in four major points, which will be explored in the following chapters:

- Issue definitions are a function of the weighting of the various dimensions of the issue
- These salience weights can act as signals in an information processing framework
- Dimensions vary in salience over time, and this variation is associated with policy change
- Institutions and actors within policy subsystems vary in the attention they pay (i.e., the signals they send) to the various dimensions

1.5.1 Chapter 2: Modeling Issue Definitions

Chapter 2 outlines the empirical approach used to estimate the dimensions of the UNF issue. It describes, in detail, the data collection and analysis process. Data for the dissertation comes from 1,271 witnesses statements from the 140 Congressional hearings regarding UNF that occurred from 1975—2012. These statements were analyzed using Latent Dirichlet Allocation (LDA), a specific type of quantitative text analysis. The LDA process uncovered seven dimensions of UNF policy; programmatic, safety/regulation, Yucca Mountain, site selection, science/technical, storage, and transportation. These dimensions act as the dependent variables in the subsequent chapters.

1.5.2 Chapter 3: Policy Evolution and Issue Complexity

Policy change is often seen as the ultimate result of the policy process, even though change is difficult to conceptualize and measure (Capano, 2009). The various policy process frameworks and theories offer different drivers of policy change. For example, PET argues that change occurs as a result of changed policy images interacting with changed policy venues, and the ACF argues that change occurs as a result of changed policy beliefs of the major policy actors involved in the subsystem. In a similar fashion, it is possible that policy change occurs after an issue has been redefined. However, it is also likely that policy change creates conditions for issues to be redefined by altering the salient dimensions of an issue. In Chapter 3, I examine the dynamic nature of issue definitions and how those definitions shape and are shaped by policy change. First, I detail the evolution of UNF policy, and discuss the four major policy eras of UNF policy development. Next, I posit hypotheses about which of the seven dimensions will be most salient within each policy era. I test these hypotheses using a Bayesian Poisson changepoint model, which examines shifts in salience for each of the dimensions. I then develop hypotheses about policy evolution and issue complexity, and test these hypotheses using the Herfindahl index.

1.5.3 Chapter 4: Institutions and Information

The theory of information processing argues that institutions process information by organizing and prioritizing the signals (i.e., information) in the environment. Individuals are "boundedly rational" and thereby limited in their ability to process the multiple signals that exist with regard to one complex policy issue, let alone the multiple issues and conditions that may require attention (Simon, 1997). Institutions allow for such information to be processed in a parallel fashion, meaning that many issues and many dimensions of issues can be processed simultaneously. This parallel processing occurs through multiple policy subsystems and/or through the multiple organizational layers of particular policymaking institutions. For example, committees in Congress allow for specialization within certain policy domains and this specialization allows committee to development expertise and provide valuable information to the floor (Krehbiel, 1991). In addition to expertise, parallel processing also implies variation in the jurisdictional boundaries of Congressional committees. These two factors, expertise and jurisdictional scope, combine to create the dynamics of expertise-based jurisdictional competition, in which committees try to gain access to a subsystem by leveraging their expertise on a salient dimension. Using the hearing data and the dimensions outlined in Chapter 2, Chapter 4 develops and tests two hypotheses based on the assumption of expertise based competition among committees.

1.5.4 Chapter 5: Policy Actors and Information

Apart from institutions, policy actors play a major role in defining policy issues. Policy actors, such as executive agencies, elected officials, and interest groups, are defined as individuals or groups with an interest, expertise, and sustained involvement in policymaking. Many of these actors are motivated to participate by interests, including but not limited to some material gain, and by core beliefs and values (Sabatier and Jenkins-Smith, 1993; Sabatier and Weible, 2007). Both of these factors work to shape the policy preferences of the various actors involved in the issue. In addition to being motivated, policy actors are also strategic. They attempt to definition issues to in a way that they can "win" (Riker, 1986); defined as achieving their particular policy goal. Given this desire to define issues on their terms, policy actors will vary in the attention they pay to particular dimensions of an issue. In Chapter 5, I posit a set of hypotheses about which dimensions the policy actors active in the UNF subsystem will highlight in their Congressional testimony.

1.5.5 Chapter 6: Conclusion

In Chapter 6, I conclude by summarizing the findings and their implications and discussing ideas for future research using the issue definition model.

Chapter 2

Modeling Issue Definitions using Quantitative Text Analysis

The issue definition model, outlined in Chapter 1, assumes that issue definitions are comprised of the various dimensions of the issue weighted by the salience of those dimensions. Determining the particular dimensions however, presents a methodological challenge. This is because issues are often defined by debate and argument, and determining the nature of debate requires reliable and valid ways to measure "text as data." The approach I adopt in this dissertation is topic modeling, a type of quantitative text analysis. Specifically, I use Latent Dirichlet Allocation (LDA) which is an "unsupervised" (i.e., requiring no prior coding of documents) way to quantify the content of text documents. The text documents I analyze are the verbal opening statements of 1,271 witnesses that appeared at Congressional hearings about UNF between 1975 and 2012. Using this approach, I discern seven dimensions within the UNF issue.

This chapter outlines the methodological approach taken to develop an empirical estimate of the dimensions of the UNF issue, and to measure the salience of those dimensions. The next section briefly describes text analysis broadly and then offers a detailed discuss of LDA modeling. Following that, I examine the dimensions that make up the UNF issue. Finally, I evaluate the validity of the approach and the seven dimensions.

2.1 Quantitative Text Analysis

The analysis of text data is a growing area of interest in political science and public policy research. More scholars are moving toward quantitative methods to examine the growing amount of text data that is becoming widely available through social media, "Big Data", and the increasing digitization of historical documents (Hopkins and King, 2010). Quantitative text analysis seeks to systematically categorize and draw inferences from texts. There are multiple ways and methods to "quantify" text, and each approach contains strengths, weaknesses, and trade-offs (Quinn et al., 2010). Broadly speaking, quantitative text analysis techniques are used for either the *classification* or *scaling* of texts (Grimmer and Stewart, 2012). Classification places text into one of several possible categories, and scaling locates actors in a policy space, typically along a liberal—conservative dimension. My interest is in classification—specifically categorizing texts by issue dimension—therefore I will focus on those techniques.[1] The various classification techniques include human coding, dictionary based approaches, supervised learning, and topic modeling. In the next sections I briefly describe each approach before moving on to a more in-depth discussion of Latent Dirichlet Allocation, the type of topic modeling that I adopt to characterize the dimensions of the UNF issue.

2.1.1 Classification Techniques

Human Coding: Human coding approaches involve the hand-coding of documents by multiple coders. In addition, categories are determined prior to the analysis and are assumed to be unchanging. Coders then assign text to one of the categories, often following a codebook developed prior to the analysis.[2] For example, some of the early work on the ACF used hand coded Congressional testimony to deter-

[1] For more on scaling see Laver, Benoit and Garry (2003); Lowe (2008); Lowe et al. (2011)

[2] Although the codebook can be adjusted in an iterative process during the analysis phase.

mine the policy beliefs and coalition affiliations of policy actors (Jenkins-Smith, Clair and Woods, 1991; Jenkins-Smith and Clair, 1993). In another example, the Policy Agendas Project[3] codes Congressional hearings, executive orders, State of the Union speeches, Supreme Court cases, and other policy documents as being about 1 of 19 major topics and 225 sub-topics. More recently, scholars have developed ways to discern the major elements of policy designs by coding policies according to a rubric based on a Grammar of Institutions developed by Crawford and Ostrom (1995) (these studies include Basurto et al., 2010; Siddiki et al., 2011; Siddiki, Basurto and Weible, 2012). Human coding, particularly when multiple coders are used, can be a valid and reliable approach to code texts. This is true, in part, because multiple coders permit various reliability tests. However, they are often cost prohibitive due to the resources needed to develop a codebook and to train and pay coders. In addition, the categories, or the other item(s) to be coded, need to be clearly defined and well understood by each coder. As a result of the challenges inherent in human coding, several computer assisted approaches have been developed. It should be noted that these approaches do not supplant careful reading and understanding of the texts being studied, rather they augment and enhance the ability of humans to classify a large volume of texts across multiple categories.

Dictionaries: One automated approach is dictionary based classification. Dictionary based coding uses dictionaries of keywords or phrases, that are developed prior to the analysis, to classify documents by comparing the terms in the set of documents to the terms in the dictionaries. One of the more popular dictionary based approaches is sentiment analysis (Nasukawa and Yi, 2003; Hu and Liu, 2004; Liu, Hu and Cheng, 2005; Liu, 2012). The dictionaries used for sentiment analysis are comprised of a set of words with *positive* connotation such as, “amaze”,

[3] http://www.policyagendas.org/

"flexible", "influential", "low-risk", and "sincere" or *negative* connotation such as, "assault", "dread", "loath", "malice", and "unproven". Sentiment analysis of this type has been used to compare sentiment expressed through Twitter to consumer confidence and presidential approval polls (OConnor et al., 2010) and the tone of *New York Times* coverage across three policy domains, environment, foreign affairs, and crime (Young and Soroka, 2012). The largest cost of dictionary based approaches involves, much like human coding, the initial development of the dictionary. While some publicly available dictionaries exist, particularly for sentiment analysis, it is not clear that these dictionaries can be easily portable across different contexts, therefore caution is needed when using these dictionaries (Grimmer and Stewart, 2012).

Supervised Learning: Supervised learning combines human coding and automated approaches. A subset of the texts are hand coded, typically placed into categories, and then the remaining texts are categorized using a machine-learning algorithm (Collingwood and Wilkerson, 2012). The hand coded texts constitutes the "training" data and the excluded texts are the "test" data. Often the idea behind this approach is to get a sense of the overall proportion of documents that belong in a particular category (Hopkins and King, 2010; Grimmer and King, 2011). This approach has been used to categorize the activity of bureaucratic agencies into the Policy Agendas coding scheme (Workman, 2009). There are a growing number of software applications, based in the `R` statistical programming language, that use this type of approach. These include *ReadMe*[4] and *RTextTools*.[5]

Topic Modeling: While supervised learning methods require the use of some precoded data, unsupervised methods, such as topic modeling, are fully automated

[4]http://gking.harvard.edu/readme
[5]http://www.rtexttools.com/

approaches requiring no prior analysis or setting of categories. Probabilistic topic models involve the automated processing of a large corpus of texts to determine underlying latent themes or topics (Steyvers and Griffiths, 2007; Blei, 2012). In short, "Topic modeling algorithms are statistical methods that analyze the words of the original texts to discover the themes that run through them, how those themes are connected to each other, and how they change over time" (Blei, 2012, 77-78). Topic modeling has been used to examine Senate press releases (Grimmer, 2010) and floor speeches in Congress (Quinn et al., 2010). The approach I adopt in this dissertation is Latent Dirichlet Allocation (LDA) modeling, which is a type of topic model. LDA is explained in detail in the next section.

2.1.2 Latent Dirichlet Allocation

The issue definition model posits that issue are defined by the dimensions of the policy issue weighted by the salience of those dimensions. In order to empirically determine the issue dimensions, I use LDA. The core assumption of LDA is that a single document can contain multiple latent topics (Blei, Ng and Jordan, 2003), where a topic is determined by the co-occurrence of words (Blei, 2012). Therefore, LDA models are an ideal modeling approach for the issue definition model given that it is important to be able to assume that policy issues exist in a multidimensional space and that policy actors will touch on more than a single dimension in their testimony before Congress. In brief, LDA assumes a hierarchical structure where a corpus is a collection of documents, documents are a collection of topics, and topics are a collection of words (Steyvers and Griffiths, 2007). As such, LDA models are structured hierarchically as;

$$Corpus \rightarrow Documents \rightarrow Topics \rightarrow Words$$

Similarly, the issue definition model to be estimated using Congressional testimony, where the documents are statements and the topics are dimensions, is structured as;

$$\textit{Statements} \rightarrow \textit{Dimensions} \rightarrow \textit{Words}$$

An additional assumption of LDA is that the documents and the words are observed, but a latent, or hidden, structure of topics, topic distributions per documents, and word distributions per topic exists. Therefore, LDA can be thought of as a dimension reduction approach where multiple words are placed within a few latent topics. The model estimates words within topics and topics within documents simultaneously, with the goal of inferring the latent structure of topic proportions within documents. In more formal terms, LDA is a generative model based on *observed* variables (words) and *hidden* variables (topics) that defines a joint probability distribution. The joint probability distribution is then used to calculate, though Bayes' rule, a conditional or posterior distribution of the hidden variables given the observed variables (Blei, 2012, 79-80).

Using formal notation adopted from Blei, Ng and Jordan (2003), a *word* is denoted w, and a *document* is a collection of N words, $\mathbf{w} = (w_1, w_2, ..., w_n)$, where w_n is the nth word in the document. Note the word ordering is not important and that LDA assumes a "bag of words" approach, where co-occurrences of terms and not the order of terms are used to determine underlying topics. Finally, a *corpus* is a collection of M documents denoted $\mathbf{D} = (\mathbf{w}_1, \mathbf{w}_2, ..., \mathbf{w}_M)$. Following this notation, the generative process, that is the assumed process that generated the documents, topics, and words, can be described as follows (Blei, Ng and Jordan, 2003, 996):

1. Choose $N \sim \text{Poisson}(\xi)$
2. Choose $\theta \sim \text{Dir}(\alpha)$
3. For each of the N words w_n

(a) Choose a topic $z_n \sim \text{Multinomial}(\theta)$

(b) Choose a word w_n from $p(w_n|z_n, \beta)$, a multinomial probability conditioned on the topic z_n.

Topic proportions, denoted θ, are the sum of the probabilities for each topic in the dth document. These proportions are assumed to be drawn from a Dirichlet prior, $\theta \sim \text{Dir}(\alpha)$ where α is the Dirichlet distribution's shape parameters. The number of topics K, and by extension the dimensionality of $\text{Dir}(\alpha)$ and the topic variable z, is assumed a priori and is also assumed as fixed. The Dirichlet prior of α is $50/K$ (Griffiths and Steyvers, 2004). Finally, the distribution of words is parameterized by β.

As noted, the observed and latent variables form a joint distribution that given the parameters α and β, topic mixture θ, a set of N topics $\mathbf{z}$, and a set of N words $\mathbf{w}$ can be expressed as:

$$p(\theta, \mathbf{z}, \mathbf{w}|\alpha, \beta) = p(\theta|\alpha) \prod_{n=1}^{N} p(z_n|\theta) p(w_n|z_n, \beta)$$

This joint distribution is used to calculate a posterior distribution of topic probabilities for each document, expressed as:

$$p(\theta, \mathbf{z}|\mathbf{w}, \alpha, \beta) = \frac{p(\theta, \mathbf{z}, \mathbf{w}|\alpha, \beta)}{p(\mathbf{w}|\alpha, \beta)}$$

The numerator is the joint distribution of all random variables, and the denominator is the probability of obtaining the observed corpus under any topic model (Blei, 2012, 81). These probabilities could be summed over all possible topic structures, however given the large number of possible topic structures this becomes "intractable to compute" (Blei, 2012, 81). Therefore, this total needs to be approximated using either sampling based or variational approximations (Blei, 2012). I use Gibbs sampling to estimate the posterior distribution (Griffiths and Steyvers, 2004).

In less formal terms, LDA is a data reduction technique (e.g., factor analysis) that assumes that a text document has a mixture of latent topics. Words that co-occur repeatedly across documents are assigned to a topic. Then, based on the array of words in a document, LDA estimates the proportion of each document that refers to each topic. The next section describes the data collection process, and the topics present during Congressional hearings with regard to UNF.

2.2 Defining Used Nuclear Fuel

Data for the analysis came from 140 Congressional hearings, drawn from the Congressional Universe database about used nuclear fuel between the years 1975 and 2012. The hearings were found using the search terms "nuclear waste", "spent nuclear fuel", "used nuclear fuel", and "Yucca Mountain." The hearings were coded by Congress, year, chamber, committee, sub-committee, witnesses, and witness affiliation.[6] Hearing transcripts, in PDF format, were available for each hearing. Overall, these hearings included a total of 1,322 witnesses, of which 1,271 gave opening statements and the remainder were either silent or only answered questions. More details about the witnesses will be discussed in Chapter 5. The verbal opening statements of each of these witnesses were extracted from the hearing transcript, each statement became a separate document, and these documents were combined into a corpus.[7] The next section describes the analysis and results.

[6] Appropriation hearings were excluded from the subsequent analysis because participation in those hearings is limited, therefore they are not considered representative of overall participation.

[7] Some previous work has coded the written statements of witnesses (e.g., Esterling, 2011), however I chose to use the verbal statements because witnesses, do to time constraints, are likely to express the most salient points in the verbal statement. In addition, only the opening statements were used and not the question and answer portions of the hearings, so that only those dimensions that the witness thought salient, and not the questioner, would be determined.

2.2.1 Document Preprocessing

Prior to modeling, the text documents require some preprocessing. The first steps involved removing numbers and punctuation and placing terms in lowercase. The next step was to remove all standard stop-words (e.g., and, for, in, is, it, the) from the corpus. An additional number of stop-words unique to the policy issue (e.g., nuclear, waste, spent, fuel) and unique to the context of Congressional hearings (e.g., chairman, committee, thank, testimony) were also removed. These stop-words are removed because they are common to nearly every witness and therefore provide no valuable information.[8] While it is important to remove words that are extremely common, it is just as important to remove words that are rarely used, or used by only a few witnesses. This is important because rarely used words are not likely to be associated with any topic, thereby introducing unwanted noise into the model. Thus, I removed all terms that were not in at least 1% of the documents. Next, I use the Porter algorithm (Porter, 1980) to stem the remaining terms. Stemming refers to the process of removing the suffix of terms to equate similar terms while reducing the overall number of terms. For example, the stem word `decis` stands for decision or decisions. Finally, I created a document-term matrix where rows represent the documents, the columns represent the terms, and the cells contain the number of times each term appears in each document. This matrix contained the 1,271 documents as the rows and the 2,941 terms.[9]

2.2.2 Model Selection

There are not, as of yet, agreed upon quantitative measures to asses or compare the model fit of topic models (Blei, 2012). Compared to supervised approaches where the onus is on the researcher to develop categories *prior* to analysis, unsupervised

[8] This is standard practice when doing this type of text analysis (see Grimmer, 2010; Quinn et al., 2010).

[9] For more detail on the steps discussed above see Feinerer, Hornik and Meyer (2008).

approaches, such as topic models, place the burden on the researcher to ensure that the categories derived by the model have semantic validity (Quinn et al., 2010; Grimmer and Stewart, 2012). Semantic validity means that each topic has a clear and coherent meaning that can be discerned by the association of terms to that topic (Krippendorff, 2003). Since the K number of topics are assumed prior to modeling, which is a common feature of cluster algorithms (Grimmer and King, 2011), care must be taken when assigning the number of topics. Given this, I used an iterative process of modeling with varying topic numbers including 2, 4, 5, 6, 7, 8, 10, 20, 50, and 100. The criteria used to evaluate the results of models using different numbers of topics were largely substantive and conceptual (much like Quinn et al., 2010, 216).[10] The ideal number of topics should have semantic validity and represent dimensions that are likely to exist throughout the time period being examined. With $K \leq 6$ several terms overlapped making topics less clearly differentiated, and $K \geq 8$ I judged the topics to be too narrow and time-bound. Given these results seven topics were chosen as the best fitting number of dimensions. The next section describes the dimensions of the UNF issue. Following that I examine the predictive validity—"the extent to which the measure corresponds correctly to external events" (Quinn et al., 2010, 216)—by predicting the mean proportion of each dimension following two major policy changes; the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987.

2.2.3 Used Nuclear Fuel Dimensions

To determine the distribution of dimensions at Congressional hearings regarding used nuclear fuel, I used LDA on the opening statements of witnesses appearing

[10] As noted, automated techniques augments human understanding and does not replace it. Therefore, the importance of substantive knowledge about the policy area begin examined cannot be overstated.

at those hearings. Opening statements were collected and preprocessed into a 1,271 X 2,941 document-term matrix. The rows of this matrix represent the 1,271 opening statements, the columns represent the 2,941 unique terms, and the cells are the count of terms per document. As noted, LDA assumes a proportion per document of latent topics based on the distribution of terms, where terms that co-occur frequently are understood as belonging to the same topic. The observed data (terms) are used to estimate the unobserved topics. In other words, the model finds the parameters α and β that maximize the log-likelihood of the data in the 1,271 X 2,941 matrix (Blei, Ng and Jordan, 2003). For my purposes, topics are assumed to be synonymous with issue dimensions. The results of the LDA process are shown in Table 2.1.

Table 2.1 lists the 30 terms that were most closely associated with each dimension.[11] As is evident in Table 2.1, terms tended to cluster into seven discernible dimensions; programmatic, safety/regulation, Yucca Mountain, site selection, scientific/technical, storage, and transportation. Below I briefly describe each of the seven dimensions.

> *Programmatic*: The programmatic dimension deals largely with the development and implementation of programs related to the selection and characterization of a suitable site for waste disposal. This is evidenced by terms such as "site", "program", "review", "plan", and "process."
>
> *Safety/Regulation*: The safety/regulation dimension deals with the development and implementation of proper regulatory standards for dealing with used nuclear fuel. This can be seen by the importance of such terms as "radioact", "dispos", "standard", and "manag."
>
> *Yucca Mountain*: This dimension deals with Yucca Mountain in Nevada, the site ultimately chosen for disposal, as evidenced by terms such as

[11] Note that a term can be associated with more than one topic.

Table 2.1: Dimensions of Used Nuclear Fuel and the Terms Most Associated with each Dimension

Dimensions	**Terms**
Programmatic	site, program, DOE, repositori, act, process, review, plan, licens, NRC, polici, issu, public, character, decis, propos, provid, recommend, technic, requir, commiss, depart, concern, comment, develop, environment, particip, final, manag, feder
Safety/Regulation	radioact, dispos, highlevel, EPA, environment, standard, lowlevel, develop, materi, program, manag, radiat, protect, level, oper, dump, research, public, erda, contain, ocean, product, uranium, futur, intern, agenc, activ, unit, regul, requir
Yucca Mountain	DOE, program, mountain, yucca, fund, nevada, project, repositori, depart, issu, energi, cost, board, continu, billion, scientif, act, report, court, site, current, million, util, begin, secretari, applic, nation, polici, manag, meet
Site Selection	site, nation, senat, energi, time, process, concern, polit, feel, depart, repres, hear, bill, tri, countri, legisl, governor, issu, nevada, citizen, reason, land, simpli, decis, happen, suggest, hope, govern, serious, talk
Scientific/Technical	repositiori, site, geolog, studi, test, time, data, system, technic, develop, water, salt, dispos, evalu, design, potenti, rock, form, isol, requir, program, perform, activ, investig, result, process, environ, concept, research, suitabl
Storage	storag, facil, reactor, manag, dispos, feder, power, plant, oper, reprocess, util, govern, energi, cost, interim, provid, industri, commerci, perman, capac, polici, develop, licens, nation, technolog, electr, time, generat, store, administr
Transportation	transport, materi, local, shipment, respons, safeti, regul, feder, radioact, citi, cask, counti, hazard, accid, public, health, rout, govern, risk, depart, nrc, requir, communiti, york, ship, propos, concern, impact, emerg, involv

"mountain", "yucca", and "nevada."

Site Selection: Site selection is largely about the *politics* surrounding the process of choosing possible site locations to store used nuclear fuel. Important terms include "site", "nation", "concern", and "polit." The term `polit` is the stem for terms like *politics* and *political*.

Scientific/Technical: The scientific/technical dimension deals with the science of used fuel storage (e.g., "studi", "test", "data") and the type of natural medium that could be used "salt", "geolog", "rock" for storage.

Storage: This dimension deals with questions about storage (e.g., "storag") and waste management, but largely centers on concerns about on-site storage at nuclear power plants vs. off-site storage of waste. This is evidenced by terms like "facil", "reactor", "capac."

Transportation: The transportation dimensions deals with transportation of spent nuclear fuel from production site to storage site (e.g., "transport", "shipment", "rout").

Table 2.2 provides descriptive statistics for each dimension. As noted, each opening statement has an estimated topic proportion for each of the seven dimensions, and Table 2.2 displays the overall mean, standard deviation, and minimum and maximum values for each dimension.

The programmatic dimension has a mean of 0.20, which indicates that the average proportion of the programmatic dimension across all the statements is 0.20. The programmatic dimension also has the highest mean, which indicates that it was the most salient (i.e., most talked about) dimension over the full span of hearings. Site selection had the next highest mean at 0.17, followed by Yucca Mountain and storage at 0.14, then science/technical at 0.13, and finally safety/regulation and

Table 2.2: Descriptive Statistics of Dimensions

Dimension	**Mean**	**sd**	**Min**	**Max**
Programmatic	0.20	0.15	0.01	0.80
Safety/Regulation	0.11	0.11	0.01	0.75
Yucca Mountain	0.14	0.12	0.01	0.74
Site Selection	0.17	0.12	0.01	0.59
Science/Technical	0.13	0.11	0.01	0.82
Storage	0.14	0.12	0.01	0.71
Transportation	0.11	0.12	0.01	0.74

transportation each had a mean proportion of 0.11. However, the high standard deviations of each dimension indicate a sizable amount of variation around the mean. This is also seen in the min and max values that range from 0.01 to 0.82. A min value of 0.01, which is near zero, indicates that the dimension was not discussed much in at least one statement and a higher max value, such as 0.82, means that an estimated 82% of at least one statement was about that particular dimension. The dimension with the lowest max value was site selection at 0.59, whereas the dimension with the highest was scientific and technical at 0.82. Site selection had the lowest "peak" proportion (0.59) but the second highest mean proportion (0.17), indicating that this issue dimension was rarely the sole topic addressed by any particular witness, but was frequently discussed in tandem with other dimensions.

Table 2.3 show the correlations between each dimension. As shown, the strongest correlation is -0.29 between the safety/regulation dimension and the Yucca Mountain dimension.[12] This is likely a result of the fact that, as shown in Figure 2.1 and will be discussed in greater detail in Chapter 3, the safety/regulation dimension was more salient in the early phase of the UNF subsystem and the Yucca Mountain dimension was more salient in the later phases.

[12]If there was a strong correlation between the dimensions, than a Correlated Topic Model (CTM) would have been more appropriate. However, using a CTM produced very similar results.

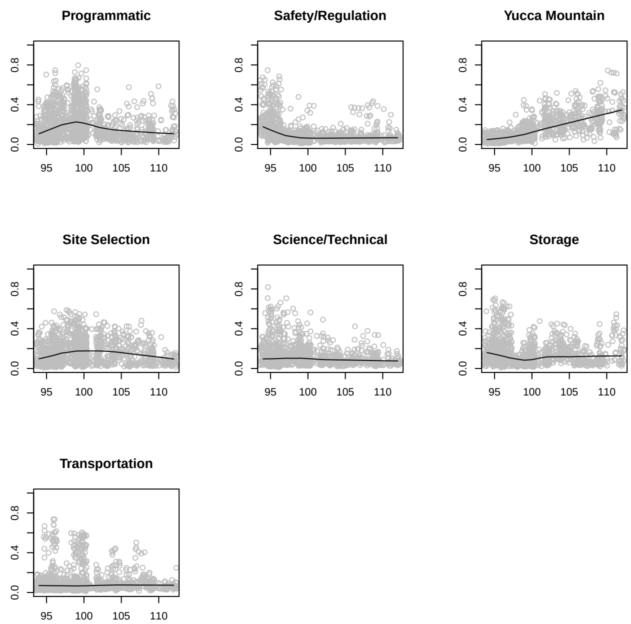
Table 2.3: Correlations of Dimensions

	Program	Safe	Yucca	Site	Sci/Tech	Storage	Trans
Program	1.00	-0.27	-0.15	-0.26	-0.10	-0.26	-0.26
Safe	-0.27	1.00	-0.29	-0.20	0.09	-0.05	-0.12
Yucca	-0.15	-0.29	1.00	-0.07	-0.22	-0.07	-0.16
Site	-0.26	-0.20	-0.07	1.00	-0.19	-0.20	-0.03
Sci/Tech	-0.10	0.09	-0.22	-0.19	1.00	-0.21	-0.24
Storage	-0.26	-0.05	-0.07	-0.20	-0.21	1.00	-0.18
Trans	-0.26	-0.12	-0.16	-0.03	-0.24	-0.18	1.00

Figure 2.1 shows how the proportion of attention paid to the different dimensions tended to vary over the period from 1975-2012. The panels within Figure 2.1 show a scatterplot of the proportion of each dimension for each statement by Congress. Each scatterplot contains a lowess line, a non-parametric measure of fit, for each dimension showing a non-linear characterization of the proportion of discussion devoted to that dimension over time.

As can be seen, the dimensions vary over time in their salience by Congress. The programmatic dimension seems to have risen for each Congress and peaked around the 99th Congress, or around 1985-1986. This is as expected given that is it the period after the Nuclear Waste Policy Act (NWPA) of 1982 and just prior to the Amendments Act of 1987 (NWPAA), which designated Yucca Mountain as the only site to be considered. The safety/regulation dimension was more salient in earlier Congresses as opposed to later years, because this was when Congress was first examining how to deal with used nuclear fuel. Yucca Mountain became increasing salient following the NWPAA, over which period the Yucca site was the focus of UNF disposal policy. Site selection seems to have been most prominent following the 97th Congress, which passed the NWPA, and then starts to slowly taper off. The science and technical dimension seems to have remained relatively flat, however it seems to have much more variation in the earlier Congresses than in later ones. The storage dimension seems to have declined from the 94th Congress

Figure 2.1: Dimension Proportions by Congress



until rising again after the 100th and then staying at that level. Finally, transportation seems to have remained relatively flat over the entire period, although with periods of more variability.

Overall, the salience of each dimension seems to rise and fall as we would expect given the policy developments occurring within the various Congresses. This pattern of variation within dimensions provides some evidence for the validity of these dimensions, suggesting that they capture the nature of the debate concerning UNF policy over the 1975-2012 period. The next section more closely examines the validity of the dimensions by using OLS to model the dimensions following two major exogenous events; the passage of the NWPA and the passage of the NWPAA.

2.2.4 Predictive Validity Check

Predictive validity refers to whether the measure(s) correspond with exogenous events as we would expect. Quinn et al. (2010) found that their categorization of Congressional floor speeches matched with important events in expected ways. For example, speeches about national defense and the use of force increased in 1999 during the bombing of Kosovo, in 2001 following September 11th and the lead-up to the war in Afghanistan, and most notably in 2002 during the lead-up to the war in Iraq. Along a similar line, I examine the impact of two major pieces of legislation on the salience of each of the dimensions.

The Nuclear Waste Policy Act of 1982 (NWPA) was the first major piece of legislation that dealt directly with used nuclear fuel. Among its provisions, it required the Department of Energy (DOE) to study five potential sites and recommend three to the President by 1985; allowed a veto for the potential host state, however this veto could be overridden by Congress; and established away-from-reactor storage once storage capacity at a plant site had been met (CQ Almanac, 1982). The second major piece of legislation, the Nuclear Waste Policy Amendments Act of 1987 (NWPAA), designated Yucca Mountain in Nevada, as the only site to considered for a used nuclear fuel repository.

Knowing a little bit about these major policy changes and about the dimensions, we can derive some expectations about the behavior of the dimensions following each major change. For example, we expect that the salience of the programmatic dimension would increase following the NWPA, since the programmatic dimension is largely focused on the development and implementation of the programs that are called for in the NWPA. We would also expect that site selection would become more salient after the passage of NWPA, since that legislation initiated the process of studying various potential sites. Finally, we would expect that the Yucca Mountain dimension would become more salient after the passage of the

NWPAA.

To examine these salience changes, I used OLS to model the salience of each dimension following each of the two major policy changes.[13] The dependent variable is the mean proportion for the predicted dimension aggregated by year. This gives an N of 38, for the 38 years in the dataset (1975-2012). The two independent variables are dummy variables that represent the two policy changes. The NWPA variable has a value of 0 for 1975 to 1981 and 1987 to 2012, and a value of 1 for 1982 to 1986. The NWPA was superseded by the NWPAA, which is why it has zero values from 1987 to 2012. The NWPAA variable has a value of 0 for 1975 to 1986 and a value of 1 for 1987 to 2012. Table 2.4 presents the results.

Table 2.4: Salience of the Dimensions following Policy Change

	Program	Safety	Yucca	Site	Sci/Tech	Storage	Trans
(Intercept)	0.18***	0.19***	0.06*	0.13***	0.15***	0.19***	0.10***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)
NWPA	0.11**	−0.12***	0.04	0.08*	−0.00	−0.12*	0.00
	(0.04)	(0.03)	(0.05)	(0.03)	(0.02)	(0.05)	(0.04)
NWPAA	−0.04	−0.11***	0.21***	0.00	−0.05**	−0.03	0.01
	(0.03)	(0.02)	(0.03)	(0.02)	(0.01)	(0.03)	(0.03)
N	38	38	38	38	38	38	38
adj. R^2	0.36	0.46	0.55	0.15	0.25	0.10	−0.05
Resid. sd	0.06	0.05	0.08	0.06	0.04	0.08	0.07

Standard errors in parentheses
† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

As shown in Table 2.4, the programmatic dimension, as expected, became more salient following the passage of the NWPA, but showed no significant change following the NWPAA. The safety/regulation dimension became less salient following each major change. This may be because questions of the proper safeguards of this material were technical questions that were addressed early in the process. Also as expected, the Yucca Mountain dimension became significantly more salient following the NWPAA. The site selection dimension, as expected, became more salient following the NWPA. The scientific and technical dimension became less salient

[13] The focus here is only to see if some evidence of validity of the dimension measures can be gained by examining their relationship with two major pieces of legislation. In the next chapter, Chapter 3, I will use more sophisticated time series techniques and examine the relationship between the dimensions and policy change in much more depth.

following the NWPAA, perhaps because the focused shifted to Yucca Mountain and away from broader technical questions. The storage dimension declined following the NWPA, likely because the NWPA settled the question of away-from-reactor storage. Although, away-from-reactor storage remains a highly controversial aspect of the used nuclear fuel debate. Finally, neither policy change had any significant impact on the transportation dimension. Overall, the dimension measures seemed to perform as expected, with *a priori* expectations about the programmatic, site selection, and Yucca Mountain dimensions being met and the other dimensions performing in ways that quite plausible given the history of the UNF debate.

Summary

This chapter set out to empirically measure the dimensions of the used nuclear fuel issue. This is the first step toward measuring the the issue definition model presented in Chapter 1. One of the major challenges of measuring issue dimensions is that they are often expressed in oral and/or written debates, thereby making empirical measurement more difficult. However, scholars have developed a number of approaches to quantify texts, and this chapter surveyed the options before settling on Latent Dirichlet Allocation (LDA) as the appropriate modeling approach. Following a detailed discussion of LDA, I briefly described the seven dimensions of used nuclear fuel management that I discerned using LDA. These dimensions were then determined to have both semantic validity, having a coherent meaning that was evident by the clustering of terms, and predictive validity by corresponding with external events as expected. The next three chapters of this dissertation will use these measures to determine the role of policy change, institutions, and actors in determining how issues are defined.

Chapter 3

Policy Evolution, Complexity, and Issue Definitions

Policy change is of major importance to policy scholars. Indeed, much of the work on policy process theories is geared toward explaining the necessary conditions and processes required for policy change to occur. One of the conditions often considered necessary for policy change are external shocks coming from outside the subsystem. These shocks include "changes in socioeconomic conditions, regime change, outputs from other subsystems, or disaster" (Sabatier and Weible, 2007, 198-199), and they can shift coalitions, open policy windows, and compel punctuations. Other possible avenues are those that are internal to the subsystem such as policy-oriented learning, shifts in policy images, changing policy venues, and shifts in attention to different dimensions of the issue (Baumgartner and Jones, 1993; Sabatier and Jenkins-Smith, 1993; Jones, 1994*a*; Jones and Baumgartner, 2005). In this chapter I focus on how shifts in attention (i.e., shifts in salience) across issue dimensions is related to policy change over a period of nearly four decades. I also examine the complexity—the number of dimensions of an issue under consideration—of UNF management and how it varies following major policy change.

3.1 Policy Change and Policy Evolution

The study of long term policy change requires a time horizon of at least ten years (Sabatier and Weible, 2007). In this chapter I examine, what I term, the policy *evolution* of the UNF issue. For purposes of this chapter, policy evolution is defined simply as policy change over time. I examine changes in the UNF issue over a period of 38 years, from 1978 to 2012, and this period covers two major policy changes; the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987.

Policy change is often associated with shifts in the salience of the dimensions underlying the policy issue space, and this association extends to policy evolution. However, these linkages are dynamic, meaning that salience shifts are a *cause* and *effect* of policy change. In other words, policy change can occur because one or more dimensions became more salient, yet policy change itself can shift the salience of the underlying issue dimensions. To examine these relationships, I begin by providing a brief background on the UNF subsystem. Once this background is established, and coupled with the dimensions discussed in Chapter 2, I derive hypotheses about which dimensions will be more salient *prior* to major policy change and which will be more salient *following* major policy change. To test these hypotheses, I use a Bayesian changepoint model that estimates both the points in time and the number of salience shifts for each dimension.

Policy evolution is closely related to shifts in dimension salience, and it may also be related to the complexity of the issue. Many (perhaps most) policy issues are multidimensional, and this dimensionality increases the complexity of the issue. A large body of work argues that political institutions help structure complex and multidimensional issues into a single dimension (e.g., Poole and Rosenthal, 1997). For example, Talbert and Potoski (2002) and Jones, Talbert and Potoski (2003) argue that when bills are introduced in Congress they contain multiple dimensions, but these dimensions are reduced by the time the bill is voted on by the entire chamber. This reduction in complexity from bill introduction to floor vote follows a period of debate and committee consideration. The debate and information gathering that occurs through the committee process works to reduce the number of salient dimensions, thereby reducing the complexity of the issue. Conversely however, the debate and consideration process may increase complexity by producing more information about the policy issue under consideration (Jones, Baumgartner and de la Mare, 2005; Breunig and Workman, 2010). In addition, other work has noted that when issues are multidimensional it can allow strategic policy actors to alter the issue space by adding dimensions that are salient to them (Riker, 1986, 1990). This sets up competing hypotheses about the nature of policy evolution and issue complexity. On the one hand, policy evolution may work to decrease complexity by reducing the number of salient dimensions. This reduction occurs because following policy change some dimensions could be considered "settled", no longer controversial, and therefore no longer salient. However, on the other hand, policy evolution can increase complexity by highlighting different dimensions and/or allowing policy actors needed time to reframe the issue. I examine these hypotheses using the Herfindahl index, which measures the concentration of issue dimensions. Specifically, I compare values of the Herfindahl index across the four major "eras" of UNF policy evolution; prior to the Nuclear Waste Policy Act of 1982 (NWPA), after the NWPA, after the Nuclear Waste Policy Amendments Act of 1987 (NWPAA), and after the withdrawal of the Yucca Mountain license application. The next section provides background on the development of the UNF subsystem and each of these eras.

3.2 The Development of the Used Nuclear Fuel Subsystem

Policy subsystems have been the major unit of analysis for scholars of the policy process (see McCool, 1998, for a review). Subsystems are the foci of policymaking activity and they include the relevant Congressional committees, bureaucratic institutions, interest groups, and other interested policy actors. In addition, subsystems are seen as semi-independent or semi-autonomous from the larger political environment. Indeed, the dominant actors within in the subsystem often work to exclude participation of other actors and venues (Baumgartner and Jones, 1993, 2002). However, the delineation of subsystems can be difficult in practice. This delineation is further complicated by nested or overlapping subsystems (Sabatier and Weible, 2007), and policy issues, like climate change or national security, that span multiple subsystems. As a result, a growing body of work is moving beyond the subsystem as the unit of analysis and examining trans-subsystem dynamics (Jones and Jenkins-Smith, 2009) and policy regimes. A policy regime is focused on "boundary-spanning" policy issues with institutional features that are shared across multiple subsystems (Jochim and May, 2010; May, Jochim and Sapotichne, 2011). For analytical clarity, I treat UNF management as its own distinct subsystem, however it is clearly nested within the larger nuclear energy policy regime.

UNF management initially evolved as a dimension of the nuclear energy subsystem, however UNF begin to development as a distinct policy issue following several changes in the nuclear energy subsystem. In the 1940s and 1950s the nuclear energy subsystem was the quintessential iron triangle with a dominant coalition of energy companies, members of the Joint Committee on Atomic Energy in Congress (JCAE), and bureaucrats within the Atomic Energy Commission (AEC) (Baumgartner and Jones, 1993; Duffy, 1997). Baumgartner and Jones (1993), argue that the disruption of the nuclear energy subsystem, that began in the 1960s and followed through the 1970s, was precipitated by the interaction of policy images and political institutions. As the policy image of nuclear energy began to shift, from positive to negative, opponents of nuclear energy were able to successfully apply pressure to other policy institutions (e.g., various congressional committees, the courts) to claim jurisdiction on elements of nuclear energy. The claiming of jurisdiction by multiple institutions, split the previously dominant coalition. While no single event marks the demise of the nuclear energy subsystem, major change was initiated with the Energy Reorganization Act of 1974 (ERA). The ERA split the AEC into the Energy Research and Development Administration (later the Department of Energy) and the Nuclear Regulatory Commission (NRC). These shifting dynamics also weakened the once powerful JCAE, and it was disbanded in 1977. These two changes altered the institutional foundation of the nuclear energy subsystem, and laid the groundwork for the development of a distinct UNF subsystem. The next section provides a brief history of the development of UNF policy in Congress.

3.2.1 The Policy Evolution of Used Nuclear Fuel Management

The shifting policy images of nuclear energy and changing institutional foundations of the nuclear energy subsystem set the stage for UNF management to emerge as its own issue with distinct attributes or dimensions. Using Congressional testimony, Chapter 2 outlined the seven dimensions of UNF policy and below I describe the evolution of the UNF subsystem, including major events and legislation associated with UNF. Table 3.1 outlines four policy eras, based on the policy evolution of used nuclear materials management. Specifically, these periods are delineated by the three major UNF policy changes. The first era includes the years prior the passage of the Nuclear Waste Policy Act (NWPA) (1975-1982), the second era includes the years following the NWPA but before the Nuclear Waste Policy Amendments

Act (NWPAA) (1983-1987), the third era includes the years following the NWPAA (1988-2009), and the fourth era are the years following the withdrawal of the Yucca Mountain license application (2010-). In addition, Table 3.1 also presents the significant legislative and/or executive actions that occurred during those periods. Following Table 3.1, I briefly describe each of the four eras.

Table 3.1: Development of Used Nuclear Fuel Policy

Policy Eras (Years)	Events
Pre-NWPA (1975-1982)	JCAE Abolished (1977) Interagency Review Group (1978) *Nuclear Waste Policy Act* (1982)
Post-NWPA (1983-1987)	DOE formally recommends three sites for consideration; one each in Washington, Texas, and Nevada (1986) *Nuclear Waste Policy Amendments Act* (1987)
Yucca Mountain (1988-2009)	*Energy Policy Act* (1992) Clinton Veto of Nuclear Waste Policy Act of 2000 (2000) *Yucca Mountain Approval* (2002) License Submitted (2008)
Post-Yucca Mountain (2010-)	License Withdrawn (2010) Blue Ribbon Commission (2012)

Legislation in italics

Pre-Nuclear Waste Policy Act (1975-1982)

In this early period, the management of UNF was not considered to be consequential in the development of civilian nuclear energy (Walker, 2009). During the early phases of nuclear energy development it was planned that UNF would be reprocessed to recover uranium and plutonium and these recovered materials could then be used to produce fresh nuclear fuel for the production of more energy. However, some highly radioactive material remains even after reprocessing, but the safe disposal of those remains were considered at the time to be a "solvable problem" (Walker, 2009). In the mid 1950's the National Academy of Sciences (NAS) issued a report that recommended deep geologic disposal of used nuclear materials

(Vandenbosch and Vandenbosch, 2007). In particular, the NAS recommended salt as the geologic medium for disposal. Following this recommendation, the Atomic Energy Commission (AEC) began to examine possible sites for the permanent disposal of nuclear materials. One site that was considered in the early 1970's was the salt deposits near Lyons, Kansas. However, this site was abandoned due to scientific and technical concerns over the impact of boreholes, created when exploring for oil and gas, on the structural integrity of the site. In addition, there were political concerns expressed by state and local officials in Kansas (for more on the Lyons case see Carter, 1987; Vandenbosch and Vandenbosch, 2007; Walker, 2009).

As noted, in the early phases of nuclear energy development it was planned that nuclear fuel would be reprocessed and the recovered uranium and plutonium would be used as an additional source of fuel. However, due to nuclear proliferation concerns—the plutonium that resulted from reprocessing could be used to make nuclear weapons—reprocessing was officially abandoned by the Ford administration in 1976. This policy was carried forward by President Carter, and was reversed by President Reagan. Even though Reagan eliminated the ban on reprocessing, commercial reprocessing of UNF has not yet become viable due to the low price of uranium relative to the cost of developing reprocessing technology (CQ Researcher, 2011). Following the abandonment of reprocessing, the management of used nuclear material became less of a "solvable problem."

In 1978 the Carter administration formed an Interagency working group to examine the scientific and technical issues surrounding the management of UNF. This working group released a report in 1979 that concluded:

- The responsibility for resolving military and civilian waste management problems should not be deferred to future generations.
- The most promising technology for permanent disposal of high-

level nuclear waste is geologic disposal.

- The search for repository sites should consider a number of locations in a variety of geologic environments leading to the option of having at least two repositories, preferably in different regions of the country.
- Interim storage should not be a substitute for progress on opening the first repositories

(Vandenbosch and Vandenbosch, 2007, 53)

The recommendation that multiple geologic media, apart from salt as recommended by the NAS in the 1950s, be considered opened up possibilities for many other sites. Following the working group's report, several pieces of UNF management legislation were introduced in the 96th and 97th Congresses based on the report, proposals by the Carter administration, and work done by the Senate Energy Committee. Legislation passed both the House and Senate in the 96th Congress, but the conference committee was unable to reconcile the bills. However, the 97th Congress passed the Nuclear Waste Policy Act and it was signed into law by President Reagan in January 1983 (CQ Almanac, 1982).

> *The Nuclear Waste Policy Act of 1982 (NWPA)*: The NWPA was the first piece of legislation that dealt specifically with the management of UNF, and outlined the role the federal government would play in UNF management. It established the Office of Civilian Radioactive Waste Management (OCRWM) within the Department of Energy (DOE). The NWPA adopted geological disposal as the preferred type of disposal, but it also allowed Monitored Retrievable Storage (MRS) to be considered as an option. It required the DOE to nominate five sites for consideration as appropriate for geological storage and required the

Secretary of Energy to recommend one site to the President. It stated that the Department of Energy (DOE) must receive a license from the Nuclear Regulatory Commission (NRC) for both the construction of the repository and for the receipt of UNF. This licensing process mirrored the process of a utility obtaining a license for a nuclear power plant. The NWPA also limited the quantity of waste to be placed in the repository to 70,000 metric tons. It also allowed for a second repository to be built, presumably, in the eastern U.S. Once a site was chosen, the potential host state was allowed to veto the facility, however this veto could be overridden by Congress. The NWPA set a deadline of 1998 for the DOE to take possession of UNF. Finally, it established the Nuclear Waste Fund to pay the cost of UNF storage. The fund collects money by placing a fee of 0.1 cents per kilowatt hour on consumers of nuclear energy (CQ Almanac, 1982; Carter, 1987; Clary, 1991; Vandenbosch and Vandenbosch, 2007; Walker, 2009).

Post-Nuclear Waste Policy Act (1983-1987)

The NWPA compelled the DOE to characterize five possible sites for the disposal of UNF. Five sites were proposed in late 1984, and they were located in Hanford, Washington; Yucca Mountain, Nevada; Deaf Smith County, Texas; Davis Canyon, Utah; and Richton Dome, Mississippi. The evaluation of these sites lead the DOE, in their Draft Environmental Assessments, to rank (in alphabetical order) Deaf Smith, Hanford, and Yucca Mountain as the top three choices (Vandenbosch and Vandenbosch, 2007, 62-63). However, in 1986 the DOE released a "Multi-Attribute Utility Analysis" that ranked (in order) Yucca Mountain, Richton Dome, Davis Canyon, and Hanford as the preferred sites based on "minimizing health and safety impacts, and construction, and transportation costs" (Vandenbosch and Vandenbosch, 2007, 63). Based on these reports, in 1986 the DOE limited consideration to three possible sites; the Hanford site in Washington state, Deaf Smith County in Texas, and Yucca Mountain in Nevada. While these three sites matched those of the earlier environmental assessments, it did not match those of the later utility analysis. This lead many in the potential host states to begin to accuse the DOE of deciding on political rather than scientific or technical grounds, and this began to erode trust in the DOE (Clary and Kraft, 1988; Kraft, 1991; Vandenbosch and Vandenbosch, 2007). As a result of the increasing political controversy, Senator Bennett Johnson moved to have Yucca Mountain, which had ranked the highest in the 1986 analysis, selected as the only repository site to be considered. Yucca Mountain was chosen in a House and Senate conference committee in December of 1987 and "hitched a ride" on the Omnibus Budget Reconciliation Act of 1987. This large bill was signed by President Reagan on December 22nd 1987 (CQ Almanac, 1987).

> *The Nuclear Waste Policy Amendment Act of 1987 (NWPAA)*: The NWPAA, though initially intended to build on the NWPA of 1982, made major changes to UNF policy. The most prominent was designating Yucca Mountain in Nevada as the only site to be considered for a repository. This change shifted the dynamics of the subsystem, and has since been the basis of contention within the subsystem. Other changes included postponement of the second repository in the eastern United States, stating that the MRS option can only be used after a permanent repository is licensed, and establishing the Nuclear Waste Technical Review Board to provide additional oversight for the scientific and technical work being done by the DOE (Walker, 2009).

Yucca Mountain (1988-2009)

The selection of Yucca Mountain, far from settling the question of UNF disposal, ratcheted up the intensity of the political controversy. This was in large part because of the political nature of how Yucca Mountain was chosen, in a conference committee "behind closed doors" (Vandenbosch and Vandenbosch, 2007). Indeed, the legislation is often referred to (by opponents) as the "screw Nevada" bill. The controversy showed no signs of abating over time as Yucca Mountain has been opposed by every member of Nevada's Congressional delegation, both Republican and Democrat. Members of Congress from Nevada have expressed their opposition in several ways over the years including "voting against the designation of Yucca Mountain for the nation's repository, cutting the Yucca Mountain budget both in committee and on floor votes, filibusters in the Senate, and holding up nominations" (Vandenbosch and Vandenbosch, 2007, 89).

Despite the resulting delays in implementing the legislation, the DOE continued to perform site characterization at Yucca Mountain and Congress continued to debate and make policies regarding UNF. The first piece of UNF related legislation passed after the NWPAA was the Energy Policy Act of 1992 (EnPA).

> *The Energy Policy Act of 1992 (EnPA)*: The EnPA was not exclusively intended to address the UNF issue, but it included one section important to Yucca Mountain. It directed the Environmental Protection Agency (EPA) to issue radiation exposure standards for Yucca Mountain. The EnPA also required the EPA to contract with the National Academy of Sciences (NAS) to establish these standards The resulting NAS report, issued in 1995, made three recommendations.[1] First, it recommended that a standard to be set to limit health risks to the individual. Second, it recommended that standards be set for peak risk,

[1]The NAS report can be found here http://www.nap.edu/openbook.php?isbn=0309052890

which could extend past 10,000 years. Finally, since the probability of future human intrusion is difficult estimate, risk-calculations should not require inclusion of the assumption of future human intrusion (Vandenbosch and Vandenbosch, 2007).

The requirement that the EPA follow the guidelines set by the NAS and the fact that the NAS noted that "peak risk" might occur past 10,000 years, set the stage for a contentious legal battle in federal court. In 2001 the EPA issued regulations regarding radiation exposure at Yucca Mountain based on the 10,000 year standard. The EPA was subsequently sued by Nevada and Natural Resources Defense Council (NRDC) for not following the recommendations of the NAS report which had noted peak risk could extend beyond 10,000 years. The Federal D.C. Court of Appeals ruled in July 2004 that EPA regulation should indeed extend beyond 10,000 years, based on the EnPA requirement that the EPA follow NAS guidelines (Vandenbosch and Vandenbosch, 2007). In 2008, the EPA issued revised standards that include a maximum exposure of 15 millirem for the first 10,000 years of operation at Yucca Mountain and maximum exposure of 100 millirem from 10,000 to one million years.[2]

The NWPA mandated that the federal government, DOE in particular, take possession of the UNF currently stored on-site at the various nuclear power plants around the country by 1998. However, it seemed clear by the early mid 1990s that DOE was not going to meet that obligation, so as a result several bills were put forward to establish a temporary storage site at Yucca Mountain. Having a temporary site at Yucca Mountain could satisfy this requirement however, these attempts were unsuccessful. The 106th Congress passed the Nuclear Waste Policy Act of 2000, which was vetoed by President Clinton in April of 2000 (CQ Almanac, 2000). This bill would have established temporary storage of UNF at Yucca Moun-

[2]On average, a person living in the U.S. is exposed to 360 millirems of radiation a year.

tain during the time in which the DOE was submitting a construction license to the NRC for a permanent repository (Vandenbosch and Vandenbosch, 2007). Clinton's veto was sustained in the Senate by one vote (CQ Almanac, 2000). As a result of not meeting the 1998 deadline, utilities companies have successfully sued to recoup a portion of the funds placed in the Nuclear Waste Fund (CQ Researcher, 2011).

Policy change is often a result of exogenous changes in the macro policy environment. One such change are elections, and two elections in particular proved to be consequential to UNF policy; the 2000 election of George W. Bush and the 2008 election of Barack Obama. The Presidency of George W. Bush helped eased the recommendation and approval of Yucca Mountain as a UNF repository.

> *Yucca Mountain Approval*: On January 10th, 2002 then Secretary of Energy Spencer Abraham notified the state of Nevada that he intended to recommend Yucca Mountain as a permanent repository to President Bush. Secretary Abraham made his recommendation to President Bush on February 14th, 2002 and President Bush approved Yucca Mountain the next day. Following the procedures laid out in the NWPA, the state of Nevada vetoed the approval on April 8th, 2002 but that veto was overridden by Congress on May 8th, 2002 (CQ Almanac, 2002).

Once Yucca Mountain was formally approved, the next step involved the DOE submitting a license application to the NRC. The DOE originally planned to submit this license in 2004 (CQ Almanac, 2002), yet it was not submitted until the summer of 2008.

Post-Yucca Mountain (2010-)

The NRC had begun consideration of the license application soon after it was submitted however, the Obama administration's FY 2010 budget, submitted in 2009, drastically cut funding for the NRC's license review process. In 2010 the DOE formally withdrew the license application and in its FY 2011 budget requested no funds at all for the Yucca Mountain project (CQ Researcher, 2011). These events effectively canceled Yucca Mountain, fulfilling a campaign pledge that President Obama made in 2008. During the campaign Obama stated that in terms of UNF, "it is time to start exploring new alternatives for safe, long-term solutions based on sound science" (CQ Researcher, 2011, 75). When announcing the license withdrawal, President Obama called for a Presidential commission to examine options for the storage of UNF.

The Blue Ribbon Commission for America's Nuclear Future released their final report in January 2012. The report made several recommendations including a the use of a "consent-based" approach to the siting of a UNF repository, a new quasi-governmental organization that would oversee all aspects of UNF management, "prompt efforts" to develop a geologic site for UNF disposal, and "prompt efforts" to develop temporary storage facilities in multiple locations (BRC, 2012).

3.3 Policy Evolution and Issue Dimensions

The discussion above outlined the major policy debates and legislation regarding UNF policy and management. Using quantitative text analysis of Congressional testimony, Chapter 2 described the major topics associated with UNF. More formally, Chapter 2 determined the set of dimensions of the issue space that constitute the UNF issue domain. Knowing about the major policy debates and about the dimensions, I can derive some expectations about how the salience of dimensions might shift leading into and following each major change. In this chapter, I examine the shifts in the salience of each dimension using Bayesian changepoint analysis to determine the year and number of salience shifts. Following that, I use the Herfindahl Index to examine competing hypotheses about policy evolution and issue complexity.

3.3.1 Salience Shifts and Issue Complexity

As seen in Figure 2.1 from Chapter 2, the salience (i.e., attention) of the UNF dimensions seemed to vary over time by Congress. Policy change can often be a result of shifts in the salience of one or more of the underlying dimensions of the issue (Baumgartner and Jones, 1993; Jones, 1994*b*; Jones and Baumgartner, 2005). However, policy change itself can shift the salience of dimensions, thereby making some dimensions more/less salient than they were prior to the policy change. For example, recent health-care reform requires all U.S. citizens to have health insurance, and provides government subsidies for low-income Americans to purchase health insurance. This major change likely makes questions of access to health insurance less salient, yet will likely make questions of public costs more salient. Below I posit several hypotheses about the evolution of UNF policy and the salience of the various dimensions.[3]

Apart from salience shifts, policy evolution can also influence the complexity of an issue. Complexity, as defined here, is based on the number of dimensions being discussed in a given time period. An issue is considered highly complex if multiple dimensions are being considered simultaneously, and conversely it is considered less complex if only one or a few dimensions are being considered. Policy evolution could either increase or reduce the number of dimensions that are being considered. Therefore, below I posit two competing hypotheses about policy evolution and issue complexity.

[3]Given the short time frame of the post-Yucca era, I do not posit any hypotheses about the salient dimensions during that span of time.

Pre-NWPA 1975-1982

Much of the discussion within Congress prior to the passage of the NWPA centered around storage options once reprocessing was abandoned. At the heart of these debates were questions about the proper regulatory safeguards and the scientific and technical aspects of UNF management. Those questions were central to discussions of the proper geologic medium (e.g., salt versus granite or shale), as discussed by the 1978 Interagency Working Group. In addition, these dimensions shaped the policy design inherent within the NWPA. As a result, the safety/regulation, science/technical and storage dimensions are likely more salient prior to the NWPA, compared to the post-NWPA, Yucca Mountain, post-Yucca policy eras. Therefore, I posit the following hypotheses:

> *H1: The safety/regulation, science/technical, and storage dimensions were more salient prior to the Nuclear Waste Policy Act of 1982, relative to the other eras*

Post-NWPA 1983-1987

The NWPA outlined the procedures for the DOE to select and characterize a suitable site for a UNF repository. As a result, the focus was shifted from scientific and technical questions to questions about program development and site selection. Given these shifts, I posit that:

> *H2: The programmatic and site selection dimensions were more salient following the Nuclear Waste Policy Act of 1982, relative to the other eras*

Yucca Mountain 1988-2009

Following the NWPAA, which designated Yucca Mountain as the only site to be considered as a UNF repository, it became clear that the adequacy and appropriateness of the Yucca Mountain site would be the dominant dimension.

> *H3: The Yucca Mountain dimension was more salient following the Nuclear Waste Policy Amendments Act of 1987, relative to the other periods*

Issue Complexity

As discussed above, policy evolution—policy change over time—can influence the complexity of a policy issue in one of two ways. First, it can reduce through the number of salient dimensions through the debate and information processing that occurs over time. Second, and conversely, information processing can increase complexity over time. Theoretically, I can derive no directional expectations about the effect of the evolution of UNF policy on issue complexity, but I can nevertheless posit two competing hypotheses:

> *H4a: The used nuclear fuel issue will become* ***less*** *complex over the four policy eras*
>
> *H4b: The used nuclear fuel issue will become* ***more*** *complex over the four policy eras*

3.4 Data and Methods

The data for this chapter come from the verbal opening statements of a total of 1,271 witnesses from 140 Congressional hearings about UNF. To examine the shifts in dimension salience over time, I use the LDA analysis from Chapter 2 to determine the most salient dimension (i.e., the dimension with the highest topic proportion) for each witness statement. For example, if a statement has estimated topic proportions of 0.40 for the programmatic dimension, 0.10 for safety, 0.20 for Yucca Mountain, 0.10 for site selection, 0.05 for storage, and 0.15 for transportation, than that statement would be coded as being about the programmatic dimension. This produces a count variable based on the number of statements that give primary weight to each dimension in each year.[4] Table 3.2 shows the number and percent of statements where each dimension was the most salient, pooled across the years 1975 to 2012. As shown, the programmatic dimension is the most salient over all, with 26% of statements giving greatest weight to that dimension. This is followed by site selection at 21%; Yucca Mountain and storage at 13%; transportation at 10%; science/technical at 9%; and finally safety/regulation at 8%.[5]

Table 3.2: Dimension Salience Pooled by Years (1975-2012)

Dimension	Count (Percent)
Programmatic	330 (26%)
Safety/Regulation	105 (8%)
Yucca Mountain	169 (13%)
Site Selection	265 (21%)
Science/Technical	110 (9%)
Storage	167 (13%)
Transportation	125 (10%)

To examine the nature of salience shifts and when changes in salience are likely to occur, I use a Bayesian changepoint model (Chib, 1998). A Bayesian changepoint model allows estimation of endogenous shifts in time-series data. Specifically, it estimates a changepoint parameter, which is the probability of significant changes in the mean value of a series at a point in time (Western and Kleykamp,

[4]Year is being used as opposed to Congress to increase the n size for the time-series analysis.
[5]These results closely match the mean topic proportions presented in Table 2.2 in Chapter 2.

2004). Traditionally, intervention analysis was used in time-series analysis to determine whether a significant change occurs following some exogenous event (e.g, Enders and Sandler, 1993). However, with this type of analysis it is more difficult to examine the dynamic nature of the relationship between dimension shifts and policy change. Using changepoint analysis I can examine the salience shifts of each dimension of UNF management both before and after policy change.

Given the count nature of the data, I use a Bayesian Poisson changepoint model (Spirling, 2007; Brandt and Sandler, 2010; Park, 2010; Santifort, Sandler and Brandt, 2013). The Poisson form of the model can be expressed as:

$$y_t \sim Poisson(\mu_t)$$

$$\mu_t = x_t' \beta_m, \quad m = 1, \ldots, M$$

where μ_t indicates a count at time t, and M is the total number of states. A state is a period of time in which the mean of the time-series is constant. The β_m parameter is the changepoint estimate for M number of states. A changepoint occurs when the series changes states (i.e., the mean of the series shifts).

As noted, the changepoint model will estimate the probability of the series shifting from one state to another. In addition, model fit measures can be compared to examine the number of states M that exist in the series. In other words, the changepoint model will estimate the location and number of significant shifts in means for the time-series data. Using this approach, I can estimate how many times and when salience shifts—a significant change in the mean number of statements with a given dimension as its highest proportion—occurred within each of the seven UNF dimensions. Models are estimated by varying the number of M states and using the Bayes factor to determine best model fit.[6]

[6]The Bayes factor is the posterior odds ratio between the odds of one model relative to other models (see Kass and Raftery, 1995; Gill, 2002, 201). The model with the largest natural log of

3.5 Results

3.5.1 Issue Dimensions and Policy Change

I posited several hypotheses about the salience of dimensions both prior to and following the NWPA and the NWPAA. Using changepoint models, I estimate the number and location of changepoints for each dimension across nearly four decades (1975-2012). To test these hypotheses using the changepoint models I a) find the highest mean number of statements for each dimension and the associated time period (i.e., M state) and b) examine which era (pre-NWPA, post-NWPA, and post-NWPAA) that time period, or M state, occurred. For example, *H1* posited that the safety/regulation dimension would be more salient pre-NWPA, relative to the other policy eras. Evidence for this hypothesis would be if the highest mean for the safety/regulation dimension occurred between 1975 to 1982. The results of the changepoint models are presented in Figures 3.1 and 3.2. The vertical dashed lines in Figures 3.1 and 3.2 represent the changepoints for each particular dimension. Following the figures, I discuss the changepoints and dimension shifts within each policy era. Then I conclude by performing an ANOVA to test the statistical significance of the differences in dimension means across each policy era.

The first hypothesis posited that the safety/regulation, science/technical, and storage dimensions would be most salient prior to the NWPA, as compared to the other periods. As the third column in Table 3.3 shows, the safety/regulation dimension was most salient (i.e., had its highest mean) from 1976-1980, prior to the NWPA, consistent with the expectations of *H1*. From 1976-1980, the estimated mean number of statements about the safety/regulation dimension was just over 13. The science and technical dimension was most salient from 1976 to 1985, which leads into and follows the NWPA. Storage shifted in salience five times,

the Bayes factor relative to the other models is considered to have the best fit.

Figure 3.1: Dimension Salience and Changepoints:
Programmatic, Safety, Yucca, Site

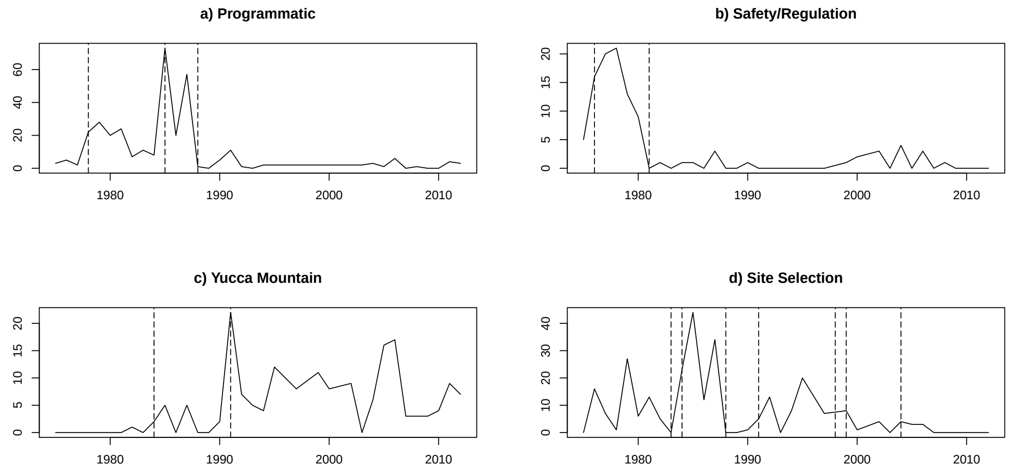


Figure 3.2: Dimension Salience and Changepoints:
Sci/Tech, Storage, Transportation

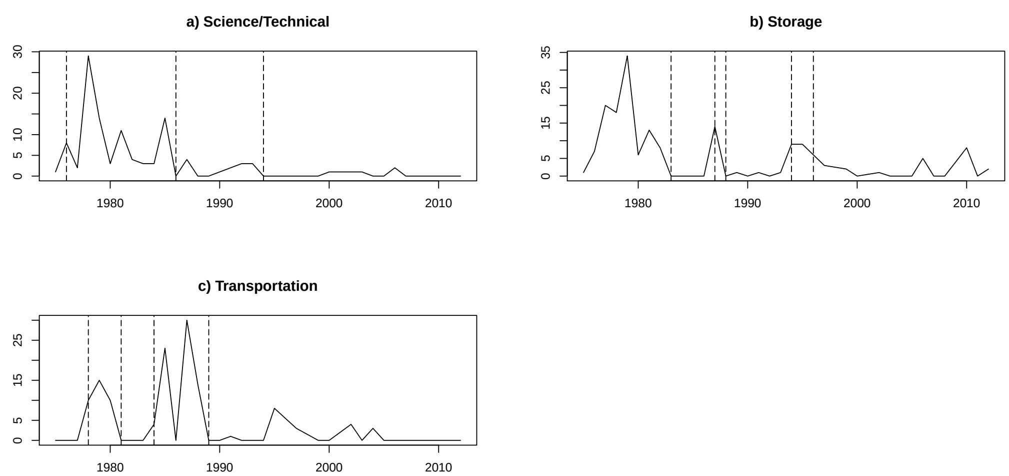


Table 3.3: Issue Dimensions, Changepoints, and Policy Eras

Dimension	Change Point	Mean Count (Years)	Policy Era
Programmatic		2.772 (1975-1977)	Pre-NWPA
	1978 (+)	15.218 (1978-1984)	Pre/Post NWPA
	1985 (+)	**37.727 (1985-1987)**	*Post-NWPA*
	1988 (−)	2.225 (1988-2012)	Yucca Mountain
Safety/Regulation		3.0617 (1975)	Pre-NWPA
	1976 (+)	**13.3499 (1976-1980)**	*Pre-NWPA*
	1981 (−)	0.7388 (1981-2012)	All
Yucca Mountain		0.1933 (1975-1983)	Pre/Post NWPA
	1984 (+)	1.724 (1984-1990)	Post-NWPA/Yucca
	1991 (+)	**7.717 (1991-2012)**	*Yucca Mountain*
Site Selection		8.453 (1975-1982)	Pre-NWPA
	1983 (−)	0.507 (1983)	Post-NWPA
	1984 (+)	**22.751 (1984-1987)**	*Post-NWPA*
	1988 (−)	0.505 (1988-1990)	Yucca Mountain
	1991 (+)	7.630 (1991-1997)	Yucca Mountain
	1998 (−)	1.454 (1998)	Yucca Mountain
	1999 (+)	1.940 (1999-2003)	Yucca Mountain
	2004 (−)	0.165 (2004-2012)	Yucca Mountain
Science/Technical		1.018 (1975)	Pre-NWPA
	1976 (+)	**8.387 (1976-1985)**	*Pre/Post NWPA*
	1986 (−)	1.331 (1986-1993)	Post-NWPA/Yucca
	1994 (−)	0.418 (1994-2012)	Yucca Mountain
Storage		**11.946 (1975-1982)**	*Pre-NWPA*
	1983 (−)	0.202 (1983-1986)	Post-NWPA
	1987 (+)	7.457 (1987)	Post-NWPA
	1988 (−)	0.553 (1988-1993)	Yucca Mountain
	1994 (+)	5.776 (1994-1995)	Yucca Mountain
	1996 (−)	1.706 (1996-2012)	Yucca Mountain
Transportation		0.249 (1975-1977)	Pre-NWPA
	1978 (+)	9.037 (1978-1980)	Pre-NWPA
	1981 (−)	0.495 (1981-1983)	Pre/Post NWPA
	1984 (+)	**12.546 (1984-1988)**	*Post-NWPA/Yucca*
	1989 (−)	0.916 (1989-2012)	Yucca Mountain

Highest mean in bold

but, as expected, was most salient from 1975 to 1982. These results are consistent with my expectations about the salience of the safety/regulation, science/technical, and storage dimensions prior to the NWPA vis a vis the other time periods. The salience of the science/technical dimension did not shift until 1985, three years after the NWPA. This shift is likely because 1985 was just prior to the recommendation by the DOE that only three candidate sites—Nevada, Washington, and Texas—be chosen for characterization.

Hypothesis *H2* posited that the programmatic and site selection would be most salient following the NWPA. As shown in Table 3.3 and Figure 3.1, the programmatic dimension was most salient between 1985 and 1987, when an estimated 38 statements were mostly about that dimension. This result is consistent with *H2*. Also as expected, the site selection dimension was most salient from 1984 to 1987, the years following the NWPA; the DOE environmental assessments and multi-attribute analysis; and prior to the NWPAA of 1987.

Finally, the third hypothesis posited that the Yucca Mountain dimension would be most salient following the NWPAA. The results were consistent with this expectation, with an estimated number of just under 8 statements giving greatest weight to the Yucca Mountain dimension from 1991-2012. The Yucca Mountain dimension also experienced a salience shift much earlier, in 1984, as the DOE was considering it (along with other sites) to host a potential repository. The second shift in salience is estimated to be in 1991, just prior to the EnPA.[7]

In general, this analysis confirms my hypotheses about the nature of shifting dimensional salience. Looking at the estimated mean number of statements for each dimension and the years in which that mean was relatively constant, allowed for the comparison of salience across the UNF policy eras. As shown, these means tended to be highest in the years that were expected, based on my historical anal-

[7]The four year lag is likely a result of the fact that only four hearings occurred from 1988 to 1990.

ysis of UNF policy in the U.S. While the changepoint models estimated the mean for each state, the probability of a changepoint, and the number of changepoints, it does not test the statistical significance of the difference in those estimated means. To test for statistical differences in the means of each dimension across each policy era, I use an ANOVA test. The means for each era represent that average number of documents that gave the greatest weight to each respective dimension. The results of the ANOVA tests are shown in Table 3.4.

Table 3.4: Mean Dimension Salience by Policy Eras

Era	Program	Safe	Yucca	Site	Sci/Tech	Storage	Trans
Pre-NWPA	13.88	**10.63**	0.13	9.38	**9**	**13.38**	4.38
Post-NWPA	**33.8**	1	2.4	**22.6**	4.8	2.8	**11.4**
Yucca	2.15	0.75	**7**	3.85	0.7	2.2	1.65
Post-Yucca	3.5	*na*	8	*na*	*na*	1	*na*
F Test	10.06***	12.35***	4.58**	6.95**	5.975**	7.165***	3.247*

The results, presented in Table 3.4, show that the mean differences are statistically significant. In the Pre-NWPA era, the safety/regulation, science/technical, and storage dimensions were all significantly more salient, meeting my expectations. The programmatic and site selection dimensions were, as expected, more salient in the post-NWPA era, relative to the the other eras. In addition, the transportation dimension was also more salient during this time. This is likely because transportation was a significant concern for the potential host states. The Yucca Mountain dimension has its highest mean in the post-Yucca era, however this mean was not statistically significant.[8] However, the mean of 7 is significantly different than both the pre-NWPA and post-NWPA policy eras. The post-Yucca period consists of only 5 hearings with 24 total witnesses. These hearings are largely about the withdrawal of the Yucca Mountain license application, therefore Yucca Mountain is still the most salient dimensions even in the post-Yucca period.

[8]This lack of statistical significance is a result of the high variance associated with the low sample size of 24 witnesses for the 112th Congress.

Apart from estimating the means for each state in the time-series, the changepoint models also estimate the year of the changepoint and the number of changepoints for each dimension. These dynamics are worth examining to evaluate how salience shifts precede and follow policy change. The full results are shown in Table 3.3, and below I discuss each dimension in turn.

- The *programmatic* dimension had an estimated increase in salience in both 1978 and 1985, and an estimated decline in salience in 1988. The programmatic dimension increased in salience in 1978 leading up to the NWPA, as the initial legislation was being discussed and increased again following the NWPA.

- The *safety/regulation* dimension experienced two estimated salience shifts; an increase in 1976 and a decrease in 1981. Although the safety/regulation dimension was most salient prior to the NPWA, both of these shifts occurred within that period.

- *Yucca Mountain* became somewhat more salient in 1984, following the DOE's environmental assessment and leading into the NWPAA. But, as expected, it was most salient from 1991 to 2012, after the NWPAA.

- The *site selection* dimension seems to be the most volatile; experiencing the most shifts with seven. This dimension was most salient from 1984 to 1987, the years following the NWPA and prior to the NWPAA of 1987. However, it increased in salience in 1991, and from 1991 to 1997, the estimated mean number of statements about about site selection was 7.63. During this period, there were several bills introduced in Congress about establishing a temporary MRS site (Vandenbosch and Vandenbosch, 2007).

- The *science/technical* dimension had three shifts, and was most salient from

1976 to 1985. This time period covers the development of the NWPA and the narrowing of the sites to be considered to host a UNF repository.

- The *storage* dimension experienced five salience shifts, yet was most salient from 1975 to 1982. This dimension increased in salience in 1987, just prior to the NWPAA, and increased again in 1994 as temporary storage sites began to be considered.

- The *transportation* dimension was most salient from 1984 to 1988. This was during the period that DOE was narrowing down the number of sites to be considered, and transportation to and from the potential site was an important consideration.

The pattern of shifts in the salience of issue dimensions helps define the primary eras in the evolution of the UNF policy domain over the decades under consideration. In the early development of the UNF subsystem, prior to the NWPA, the most salient dimensions were those that focused on development of programs to address UNF (programmatic), the needed safe guards and standards (safety/regulation), questions concerning the different geologic medium (science/technical) and the need for away-from-reactor storage following the decision not to reprocess UNF (storage). These dimensions defined the issue at that time and were addressed in the NWPA. Following the passage of the NWPA, questions shifted to the governments role in developing and implementing the programs called for in the NWPA (programmatic). In addition, concern began to grow, particularly within potential host states, about the process the DOE was using to determine which site should be selected (site selection). This started to generate intense political controversy and disagreement between states and the federal government. The UNF issue became defined at this time as one of political controversy over the process of selecting a site to be studied. This growing political controversy, the high ranking of

Yucca Mountain in the DOE's analysis, and the relatively weak political position of Nevada lead directly into the NWPAA, which chose Yucca Mountain as the only site to be considered.

The above analysis illustrates that the issue space underlying the UNF issue is multidimensional, and that those dimensions shift in importance as the policy issue evolves. In the next section I turn to the related matter of changing issue complexity. Specifically, I address whether the multiple dimensions of UNF tend be considered in more or less equal proportions, making the issue more complex, or whether the shifts in salience discussed above lead to a focus on only a few dimensions. In addition, I discuss whether the UNF issue became more or less complex as the issue evolved.

3.5.2 Issue Dimensions and Issue Complexity

As noted above, policy evolution can either serve to increase or decrease issue complexity, where complexity is defined as a function of the number of dimensions being discussed. To test these competing hypotheses, I use the Herfindahl index. The Herfindahl index originated as measure of market concentration of firms, but has since been used to measure the jurisdictional diversity of Congressional committees (Hardin, 1998; Baumgartner, Jones and MacLeod, 2000), the interplay between the media and Congress (Jones and Wolfe, 2010), and the diversity of terrorists attacks (Santifort, Sandler and Brandt, 2013). For my purposes, I use the Herfindahl index to measure the diversity of the dimensions being discussed, both overall and aggregated across the 19 Congresses in the dataset. The index can be expressed as:

$$1 - \sum_{i}^{n}(p(d_i))^2$$

where $p(d_i)$ is the proportion of total statements where dimension d_i was the most salient. The index ranges from 0 to 1, with values closer to 1 indicating more complexity—numerous dimensions being discussed in similar proportions—and a value closer to 0 indicating less complexity, which means fewer dimensions being discussed.[9] A maximum complexity value of 1 would be obtained if each dimension had the same proportion of total statements. In my analysis, that would occur if each dimension was most salient in ~14.25% of the statements. If all dimensions had been discussed equally, this would indicate a highly complex issue that can't be defined along only one or a few dimensions. A complexity value close to 0, on the other hand, would indicate that nearly all the statements focused on the same dimension. Table 3.5 shows the overall complexity score for the entire period and the count and percent of statements for each of the seven dimensions.

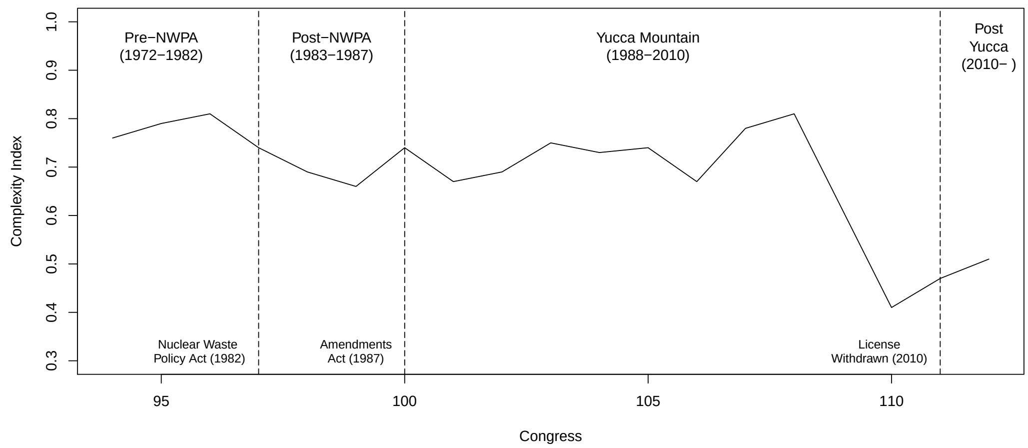
Table 3.5: Overall Complexity and Issue Dimensions

	Complexity	Dimensions (Count\Percent)
All Policy Eras(1975-2012)	0.83	Programmatic (330\26%) Site Selection (265\21%) Yucca Mountain (169\13%) Storage (167\13%) Transportation (125\10%) Science/Technical (110\9%) Safety/Regulation (105\8%)

As seen in Table 3.5, the overall complexity of the UNF issue is 0.83, which indicates a high degree of complexity. Overall, the programmatic dimension was the most salient, accounting for just over a fourth (26%) of all statements. This is followed closely by the site selection dimension at 21%, whereas the remaining five dimensions seem to be clustered more closely, ranging from 13 to 9 percent of all statements. These results are evidence that the UNF issue is highly complex with

[9] The Herfindahl index was originally scaled so that a smaller value indicated a more diffuse, or less concentrated, activity. However, for ease of interpretation I use $1 - H$ which allows a higher value to indicate increased complexity.

Figure 3.3: Issue Complexity by Congress and Policy Eras



multiple dimensions being considered.

Hypotheses *H4a* and *H4b* were competing hypotheses about the relative complexity of the UNF issue, following major policy changes. *H4a* posited that policy issues become less complex as they evolve, whereas *H4b* posit that issues become more complex. The null hypothesis in either case would be no significant change in complexity over time. To test these hypotheses, I calculated a complexity score for each of the 19 Congresses, the 94th through the 112th, within the period of study. Figure 3.3 plots the complexity index for each Congress, and the vertical lines indicate the significant policy changes that demarcated each of the four policy eras.

As can be seen, the issue of UNF management was highly complex from the 94th to the 108th Congress, or 1975 through 2004. However, a relatively steep decline in complexity occurred in the mid 2000s. The complexity index in the 108th Congress was 0.81, yet that fell to 0.61 in the 109th and fell again to 0.41 in the 110th Congress. This period follows the formal approval of Yucca Mountain in 2002 by the Bush administration and the 107th Congress. Following the approval of Yucca Mountain, the 108th Congress (2003-2004) held four hearings dealing with UNF issues. These hearings touched on several dimensions of the UNF issue, thereby increasing complexity even though the discusses were largely in the context of Yucca Mountain. For example, the Senate Appropriations subcommittee on Energy and Water Development Appropriations (with Harry Reid from Nevada as ranking member) held hearings on possible silica exposure of workers at the Yucca Mountain site. Breathing in silica dust can lead to silicosis, which can be dangerous and causes inflammation and scarring of the lungs. Therefore, apart from Yucca Mountain, this hearing touched on the safety/regulation dimension. A second hearing was about the proposed transportation routes to and from the Yucca Mountain site. Both of these examples illustrate how the issue of UNF remained so complex for so long. However, the decrease in complexity that began in the 109th Congress, likely comes as a result of a shift of focus to Yucca Mountain as the DOE prepared, and subsequently submitted, the license application to the NRC. Following the withdrawal of the license application, an increase in complexity can be seen. It is likely that the debates about UNF management will continue to become more complex as they continue.

Overall, the UNF issue remained highly complex and showed no signs of decreasing as the policy debate evolved. This seems to indicate that policy change had no impact on the complexity of the UNF issue. To formally test hypotheses *H4a* and *H4b*, I compared, using an ANOVA test, the mean score of the complexity measure across each of the four policy eras. The results are shown in Table 3.6.

As can be seen in Table 3.6, the mean complexity score decreased from the pre-NWPA to the post-Yucca period, however these differences are not statistically significant. This finding indicates that some issues, such as UNF, remain highly complex even following major policy changes.

Table 3.6: Issue Complexity and Policy Eras

Era	Mean of Complexity Index
Pre-NWPA	0.78
Post-NWPAA	0.70
Yucca	0.67
Post-Yucca	0.51
F Test	2.047^{ns}

3.6 Summary

This chapter examined the policy evolution of the UNF issue. Specifically, it provided a background on the development of the UNF subsystem. This background included a summary discussion of the debates and major policy events that occurred in the UNF subsystem from 1975 to 2012. Following this background and the dimensions outlined in Chapter 2, I posited several hypotheses about the shifting salience of the various policy dimensions prior to and following policy change. Using Bayesian changepoint analysis, I showed that the salience of UNF dimensions is related to policy evolution in systematic and predictable ways. In addition, using ANOVA tests I found these difference to be statistically significant. Next I tested two competing hypotheses about policy evolution and the complexity of the UNF issue. The results indicated that as the UNF subsystem evolved, it became less complex, however the reduction in the complexity measure was not statistically significant. Over, the UNF issue remained quite complex in each policy era. In sum, the issue of UNF management is inherently complex and multidimensional, which presents unique challenges to policymakers dealing with this issue.

Chapter 4

Institutions, Information Processing, and Issue Definitions

The study of institutions has long played a key role in understanding the policy process (Smith and Larimer, 2009). Early political science was built around careful studies of the major policymaking institutions like Congress and the bureaucracy. Institutions provide structure, through rules, norms, and procedures, in the political and policymaking process, thereby reducing the costs associated with making collective decisions. Absent this institutional structure, consensus in a majoritarian system where policy choices are made along multiple dimensions is extremely difficult to achieve (see Shepsle, 1989). In this chapter, I examine how institutions work to shape issue definitions through specialization and expertise. Specifically, I examine how committees in Congress structure the dimensions of the UNF policy debate.

4.1 Institutions and Information Processing

Many policy issues are complex and multidimensional and, as shown in Chapter 3, the issue of UNF is no exception. The large number of such issues that policymakers must address feeds into the broader complexity of the policymaking environment. In brief, the policymaking environment can be characterized as filled with complex issues and awash in information signals about those issues. In such an environment the central question becomes how do policymakers make policy choices? Social choice theorists have noted that in complex environments, where preferences are multidimensional, reaching an equilibrium point can at best be difficult and at worst impossible (Riker, 1988). Without such equilibrium, there exists no theoretical basis for expecting stability. However, stability, punctuated by change, seems to be a central feature of the policy process (Tullock, 1981; Baumgartner and Jones, 1993). One of the major reasons for this stability is the role played by the various policymaking institutions (Shepsle, 1979).

Stability is imposed on the chaos of the policymaking environment through institutions and institutional arrangements that bring order to the chaos through rules. Institutions are defined here as a "set of individuals acting according to common rules resulting in collective outcomes" (Jones and Baumgartner, 2005, 151). These common rules provide structure in the policy process by organizing and restricting conflict (Shepsle and Weingast, 1981); and by reducing the costs associated with decision-making in a complex environment. These types of costs can include decision costs (costs of coming to a decision), transaction costs (costs of taking an action), information costs (costs of gathering and processing information), and cognitive costs (costs associated with limited cognitive capacity) (Jones and Baumgartner, 2005, 151-152). While institutions can work to lower each of these kinds of costs for policymakers, I will focus my attention on the role of institutions in the reduction of information costs. Information costs have often been considered equivalent to search costs, where costs are associated with finding information relevant to the decision at hand. Traditionally, information for policymaking was considered costly because it was under-supplied, and often kept hidden for strategic purposes. Costs are then incurred by policymakers wishing to obtain this information, often through costly monitoring of the environment and oversight of bureaucratic agencies (see Niskanen, 1971; Lupia and McCubbins, 1994; Epstein and O'Halloran, 1999; Huber and Shipan, 2000). A second component of information costs are the costs associated with the processing of information. Processing costs are a result of the oversupply of information, and are incurred by the organizing and prioritizing of information (Jones and Baumgartner, 2005). Institutions can lower processing costs by "winnowing" the number of items (i.e., legislation) (Krutz, 2005) or dimensions (Talbert and Potoski, 2002; Jones, Talbert and Potoski, 2003) being considered.[1]

Institutions work to lower information costs (i.e., search costs and processing costs) through parallel processing and the specialization that results. As noted, policymakers are faced with a multitude of issues at any given time, and were they only able to process them in a serial fashion (one at a time) it is likely few policy actions would be taken. Institutions however allow for the processing of multiple issues at once (Jones, 1994*b*; Workman, Jones and Jochim, 2009). Parallel processing within institutions is largely accomplished through multiple sub-units within the larger institutions. These sub-units focus and specialize on particular issues, or dimensions of issues. A prime example is the committee structure in Congress. Another example is the various sub-units within bureaucratic organizations, like the (former) Office of Civilian Radioactive Waste Management within the Department of Energy. Yet another example, at a different scale, is policy subsystems, which are anchored in institutional arrangements and focused on a specific policy area or issue.

As noted above, the focus of this chapter is how institutions reduce information costs and structure multidimensional policy issues by highlighting certain dimensions of the issue over others. Specifically, I examine Congress and how it

[1]It should be noted that institutional structure can also raise processing costs by producing more information that needs to be considered. Indeed, the growth of information produced from Congressional committees is associated with the growth of bureaucratic agencies (Jones, Baumgartner and de la Mare, 2005). However, my focus is on the ways in which committees use expertise to highlight some dimensions over others. By making some dimensions more salient than others committees provide a signal about which dimensions should be most prominent, thereby reducing processing costs for the policymaker.

structures the dimensions of UNF management through expert committees with jurisdictional authority within a policy subsystem. (Shepsle and Weingast, 1987; Krehbiel, 1991).

4.2 Committees and Issue Dimensions

The role that committees play in defining policy issues is closely linked to their role in anchoring policy subsystems. Policy subsystems are sets of institutional arrangements, nested within the larger policymaking environment, that are organized around particular policy areas or issues. Subsystems are anchored by the sub-units within the policymaking institutions, like Congressional committees and smaller units within bureaucracies (e.g., OCRWM within DOE), that have policy decision or implementation authority in that domain. The committees role in a subsystem is based on the committee's expertise and jurisdictional span.

Committee expertise is developed through the specialization that occurs as a result of the parallel processing of information. In an expertise based understanding of committees, committees are seen as agents to the larger institution of Congress (Maltzman, 1998). The Congress delegates information gathering and processing to committees to reduce policy uncertainty (Gilligan and Krehbiel, 1990; Krehbiel, 1991). Often this uncertainty is characterized as uncertainty about the relationship between public policy and outcomes (Krehbiel, 1991; Esterling, 2004), however I characterize uncertainty as uncertainty regarding which dimensions of an issue are or should be most salient. Committees reduce this type of uncertainty by signaling certain dimensions, through the hearing process, to the full body.[2] There is likely to be significant variation in the dimensions that committees find salient, and therefore signal to the full Congress. This variation is in part a function of their

[2]Committees function to assist members of Congress in achieving multiple goals (Fenno, 1973), however my focus is on the information processing purpose of committees.

expertise. Any one committee cannot be expert on all issues or even all dimensions of a issue, due to high information costs. Developing expertise on any one issue is costly, both in terms of time and energy, but also in terms of opportunity costs. Opportunity costs are high because becoming expert on one issue(s) negates the ability to become expert on another issue(s). Due to the nature of the costs of expertise and the technical nature of the UNF issue, it is likely that only a few committees will be active in the UNF subsystem.

In addition to expertise, a committee's role in a subsystem is dictated by their jurisdictional span. Some committees, such as the Energy and Commerce committee in the House, are active across multiple issues and subsystems, whereas other committees are more limited in scope (Baumgartner, Jones and MacLeod, 2000; Sheingate, 2006). The jurisdictional structure in Congress is dynamic and features competition between committees attempting to exert influence over particular issues (Talbert, Jones and Baumgartner, 1995; King, 1997; Baumgartner, Jones and MacLeod, 2000; Sheingate, 2006). A key feature of policy subsystems is that actors that perceive themselves to be at an advantage attempt to keep issues contained within the subsystem to avoid the large scale disruptions that might result from the increased involvement of other policy actors and institutions (Baumgartner and Jones, 1993; Worsham, 1998; Baumgartner and Jones, 2002). In a similar fashion, committees seek to protect their jurisdictional turf from abrupt changes and/or other committees seeking to expand their jurisdiction (King, 1997).

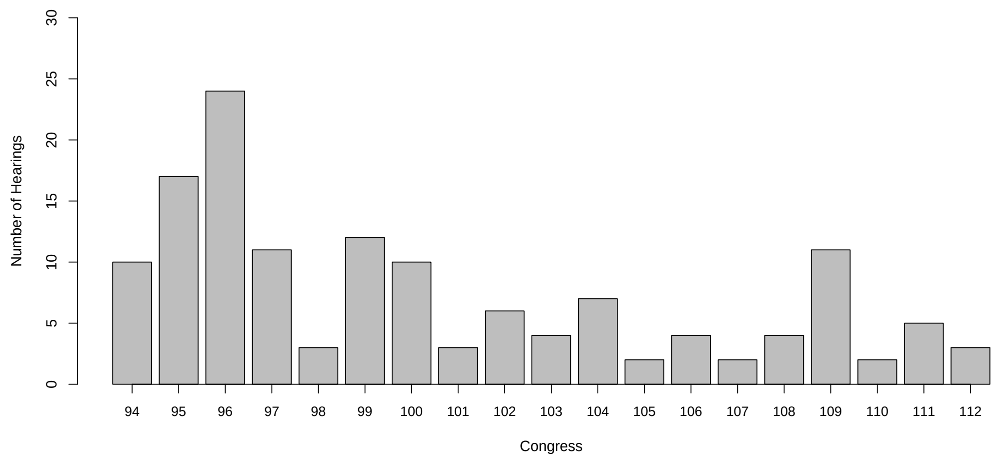
In brief, committees anchor subsystems through the expertise and jurisdictional authority they development as a result of the parallel processing of policy issues. However, committees often try to expand their influence into other subsystems. Giving the costs associated with the development of expertise, it is likely that committees attempt to leverage their expertise when competing for jurisdictional control. These dynamics create a situation where a few committees, based on their expertise and jurisdiction, are likely to be central to the subsystem and committees that attempt to exert influence do so based on their expertise. For example, in the tobacco policy domain the Agriculture committees in the House and Senate were the core subsystem committees throughout the 1940s and 1950s. At that time, tobacco was largely an agriculture issue, however following the 1964 Surgeon General's report that linked tobacco use to poor health outcomes, other committees, particularly the House and Senate commerce committees, with an expertise in health issues began to hold hearings (Worsham, 2006). As a result, the salient dimensions of the tobacco subsystem started to shift from the growing of tobacco to health concerns associated with tobacco.

The tensions inherent in committee expertise and expertise-based jurisdictional competition likely create subsystems that are structured by a few core committees that act as institutional anchors, coupled with committees that hold hearings about specific dimensions related to their expertise. Having developed expertise in one dimension of an issue may allow committees to gain a foothold within that issue. Taken together, committee expertise and committee jurisdiction work to keep the number of committees involved with the issue of UNF at a minimum. However, when other committees become active in the subsystem they will likely only be involved in a few dimensions. Therefore, I posit the following hypotheses:

H1: The majority of hearings about used nuclear fuel few will take place in only a few committees

H2: Committees outside these few will hold hearings about dimensions within their realm of expertise

Figure 4.1: Number of Used Nuclear Fuel Hearings by Congress (94th–112th)



4.3 Data and Methods

The test the hypotheses presented above, I draw on the 140 Congressional hearings about UNF that occurred from 1975 to 2012. Figure 4.1 illustrates the number of hearings held per Congress.

Overall, the 96th Congress (1979-1980) held the most hearings at 24.[3] As discussed in Chapter 3, this was around the time that the nuclear energy subsystem was undergoing a profound shift and the used nuclear subsystem was being formed. The fewest number of hearings per Congress was 2, which occurred in the 105th, 107th, and 110th Congresses. The hearings were coded by Congress, year, chamber, committee, sub-committee, type (legislative or nonlegislative), and majority party.

Dependent Variables: The dependent variables for the analysis in this chapter are the seven dimensions of the UNF issue. As a reminder, these dimensions include programmatic, safety/regulation, Yucca Mountain, site selection, science/technical, storage, and transportation. The dependent variables were drawn from the ver-

[3]As noted in Chapter 2, these hearings do not include appropriation hearings.

bal opening statements of each witness at each hearing and proportions for each dimension were estimated for each statement. These proportion estimates range from 0 to 1 and are treated as continuous. As shown in Chapter 2, these estimated proportions can be small, near 0, indicating that particular dimension was hardly discussed in that statement, or rather large (a maximum of 0.82) which indicates that the majority of that statement (an estimated 82%) was about that particular dimension.

Independent Variables: The hypotheses in this chapter posit that committees vary both in their involvement in the UNF subsystem and the attention they play to the various dimensions of UNF policy. Therefore, the main independent variables of interest are the various committees in Congress that held hearings dealing with UNF from 1975 to 2012. The analysis examines the number of committees holding hearings, the number of witnesses appearing in those hearings, and the number of Congresses in which each committee held a hearing about UNF. In addition, OLS models are used to estimate the attention (i.e., salience) that each committee gives to the various UNF dimensions, controlling for other factors that are discussed below.

As noted, the main focus in this chapter is the central role that congressional committees can play in policy subsystems and issue definitions. This role is argued to be based largely on the expertise and jurisdictional scope of the committees, however other institutional factors might play a role in determining the attention that committees pay to particular issues or issue dimensions. One of the largest factors is the political party that holds the majority in Congress. The majority party in either chamber of Congress has immense power to set the agenda and determine procedures (Cox and McCubbins, 2005). In addition, political parties can act as important cues in determining salient legislation (Krutz, 2005). Given the influence of political parties, it is possible that some dimensions become more or less salient depending on the majority party. Therefore, when estimating the attention committees pay to the dimensions of the UNF debate, I use a dummy variable for Republican majority to statistically control for party effects. The variable is coded 1 if Republicans held the majority in the chamber and 0 if Democrats held the majority.

Apart from party control, the type of hearing, legislative or nonlegislative (i.e., oversight or investigative), might have an impact on the salience of the dimensions. Legislative hearings imply an institutional demand for a different type of information, because the information needed to consider legislation is likely different than the information needed for oversight. For example, the safety/regulation dimension is not likely to be as salient in a hearing considering legislation versus a hearing exploring the progress of the Nuclear Regulatory Commission in developing safety regulations for a repository site. To control for hearing type I created a legislative hearing dummy variable, which is coded 1 if the hearing considered legislation and 0 otherwise.[4]

Finally, as shown in Chapter 3, the salience of the various UNF dimensions vary over time across the four UNF policy eras. To control for this effect, I used fixed effects for each of the four eras. This variable was coded 1 for the pre-NWPA era, 2 for the NWPAA era, 3 for the Yucca Mountain era, and 4 for the Post-Yucca era. The pre-NWPA era was the excluded referent. The analysis were performed separately for the House and the Senate, and the results for the House are presented in the next section, followed by the results for the Senate.

[4]The hearing summaries provide a clear indication if the intended purpose of the hearing is to consider a specific bill or set of bills.

4.4 Results

4.4.1 House

The first hypothesis posited that, due to subsystem dynamics and expertise, the number of committees active in the UNF subsystem (i.e., holding hearings) would be small. Put another way, of the committees that are involved in the UNF subsystem, the bulk of actively will be contained to only a few. To test this hypothesis, I examine the number of UNF hearings held by each of the committees involved, the number of witnesses in those hearings, and the number of Congresses in which each committee held UNF hearings. Taken together, these measures illustrate the level of activity in the UNF subsystem for each committee. Overall, seven House committees held hearings about UNF.[5] These committees, the number of hearings, witnesses, and Congresses are shown in Table 4.1.

Table 4.1: UNF Subsystem Activity by House Committee

Committee	Hearings	Witnesses	Congresses
Budget	3	12	2
Energy and Commerce	26	254	15
Foreign Affairs	1	4	1
Governmental Reform	8	53	3
Natural Resources	23	314	10
Science, Space, and Technology	10	77	6
Transportation and Infrastructure	2	14	2

Number of hearings χ^2(59.62) significant at $p < 0.001$

As shown in Table 4.1, the majority of hearings in the House were held by the Energy and Commerce committee and the Natural Resources committee. The χ^2 (59.62)—based on differences in the number of hearings—is statistically significant and this confirms my expectation that the majority of the hearings are held by a

[5]Committee names are based on the names used in the 112th Congress, the last Congress in the dataset. Changes in committees names were keep consistent using the Congressional committees codebook from the Policy Agendas website http://www.policyagendas.org/page/datasets-codebooks

few expert committees.[6] In addition, the Natural Resources committee had the most witnesses at 314, and the Energy and Commerce committee was the most active across time, holding hearings in 15 different Congresses. Following Energy and Commerce and Natural Resources was the Science, Space, and Technology committee with 10 hearings and 77 witnesses across 6 Congresses. Next was Governmental Reform committee with 8 hearings and 53 witnesses in 3 sessions of Congress. Finally, the Budget committees held 3 hearings, Transportation and Infrastructure held 2, and the Foreign Affairs committee held 1 hearing dealing with UNF. Broadly speaking, the Energy and Commerce and Natural Resources committees were the foci of committee expertise in the House for the issue of UNF. Next, I examine whether significant differences in the salience of dimensions existed across committees in the House.

Hypothesis *H2* stated that committees, outside of the core subsystem committees, that become active in a subsystem do so by leveraging their expertise in a dimension(s) relevant to the subsystem. Evidence in support of the working hypothesis would show that relative to the anchor committee(s), less attention would be paid to most dimensions, and more attention paid to only one or a few dimensions. For example, a clear expectation is that the Transportation committee will pay more attention to the transportation dimension and less attention to the others. To test this hypothesis, I use OLS analysis with robust standards errors. The committees are dummy variables and the anchor committee is the excluded referent. For the House analysis, the Natural Resources committee is the excluded referent based on the fact that they saw the most witnesses.[7] The results of the OLS analysis are present in Table 4.2.

Looking across the second row of Table 4.2 we see that the Budget committee

[6] In this case a null finding would show a more even distribution of hearings across committees.

[7] While, the Energy and Commerce committee held the most hearings in the most Congresses, I chose the Natural Resources committee as the referent because dimension salience is based on witness testimony and they had seen the most witnesses.

Table 4.2: OLS Estimates of Dimension Salience by House Committee

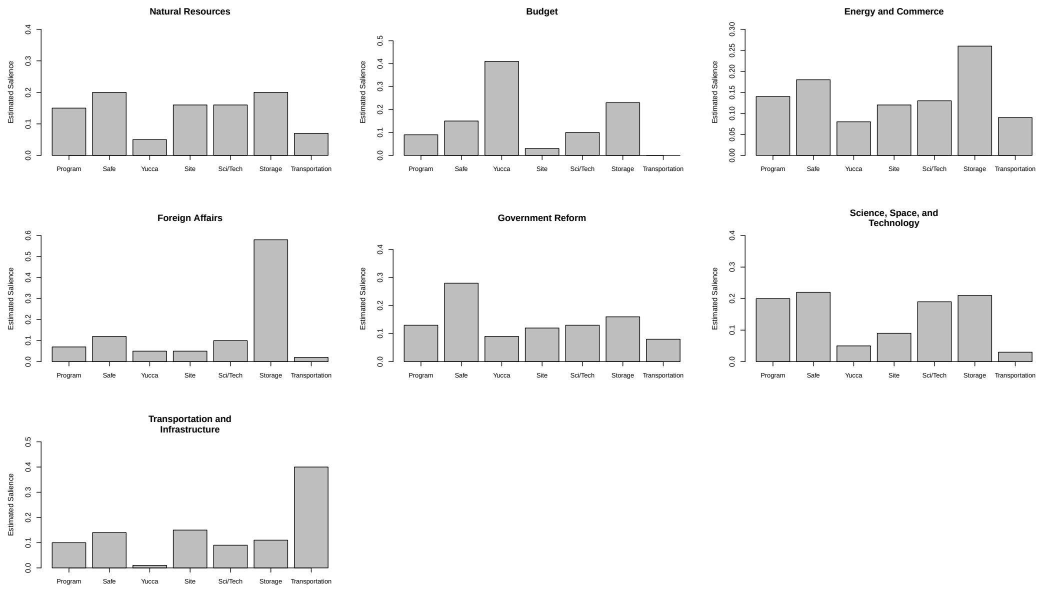
	Program	Safe	Yucca	Site	Sci/Tech	Storage	Trans
(Intercept)	0.15***	0.20***	0.05***	0.16***	0.16***	0.20***	0.07***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)
Budget	−0.06**	−0.05***	0.36***	−0.13***	−0.06***	0.03	−0.08***
	(0.02)	(0.01)	(0.05)	(0.02)	(0.01)	(0.04)	(0.02)
Energy/Commerce	−0.01	−0.02**	0.03***	−0.04***	−0.03***	0.06***	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Foreign Affairs	−0.08***	−0.08***	−0.00	−0.11***	−0.06***	0.38***	−0.05**
	(0.02)	(0.02)	(0.02)	(0.03)	(0.01)	(0.04)	(0.02)
Government Reform	−0.02	0.08**	0.04***	−0.04*	−0.03†	−0.04*	0.01
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Science	0.06**	0.02	−0.01	−0.07***	0.03†	0.01	−0.04***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
Trans/Infrastructure	−0.05†	−0.06***	−0.04**	−0.01	−0.07***	−0.10***	0.33***
	(0.03)	(0.01)	(0.01)	(0.04)	(0.02)	(0.02)	(0.05)
Republican Majority	0.01	−0.00	0.05**	0.01	0.02*	−0.05**	−0.05*
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Legislative	0.03*	−0.05***	0.01	0.02*	−0.03**	−0.01	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	728	728	728	728	728	728	728
adj. R^2	0.18	0.33	0.63	0.13	0.11	0.26	0.21
Resid. sd	0.14	0.09	0.08	0.12	0.10	0.12	0.10

Robust standard errors in parentheses. Fixed effect for eras not shown
† significant at $p < .10$; $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$

was significantly less likely than the Natural Resources committee to hear testimony about all the dimensions but the Yucca Mountain and storage dimensions. The Budget committee was significantly more likely to pay attention to the Yucca Mountain dimension, and no more or less likely to pay attention to the storage dimension. The Energy and Commerce committee, the other core UNF subsystem committee, was more likely to find the Yucca Mountain dimension and the storage dimension salient. The Foreign Affairs committee paid more attention to the storage dimension, than the Natural Resources committee. The Governmental Reform committee focused their attention on the safety/regulation dimension, and the Science committee focused more on the programmatic and the science and technical dimension.[8] Finally, the Transportation committee, as expected, paid the most attention to the transportation dimension.

[8]The science and technical dimension was significant in a one-tailed test.

Figure 4.2: Estimated Dimension Salience for each House Committee



For the control variables, the Yucca Mountain and the science and technical dimensions were more salient, on average, when the Republicans held the majority in the House, whereas the storage and transportation dimensions were less salient. The programmatic, site selection, and transportation dimension were all more salient, on average, in hearings that considered legislation relative to nonlegislative hearings. The safety/regulation and the science and technical dimensions were less salient during legislative hearings.

Using the OLS models presented in Table 4.2, I estimate the salience of each dimension for each of the committees active in the UNF subsystem. These estimates hold the Republican majority and legislative hearing variables consistent at their median. In addition, I hold the policy era variable constant at it mode, which is the first policy era (pre-NWPA). The results are presented in Figure 4.2.

These estimates help to illustrate the differences in salience that the various attach to each dimension. As shown, the Natural Resources committee's attention is relatively evenly split across the program, safety/regulation, site selection, science/technical, and storage dimensions. For the Budget committee however, the Yucca Mountain dimension is most salient with an estimated salience of 0.41. This means that, on average, an estimated 41% of the testimony heard about UNF by the Budget committee focused on the Yucca Mountain dimension. The storage dimensions was estimated to be the most salient from the Energy and Commerce committee at 0.26. Storage was also the most salient dimension for the Foreign Affairs, with an estimate of 0.58. The committee on Government Reform heard the most testimony on the safety/regulation dimension. Attention of the Science, Space, and Technology committee was relatively even on the program, safety/regulation, science/technical, and storage dimensions. Finally, for the Transportation committee an estimated 40% of the testimony focused on the transportation dimension.

Overall, these results tend to confirm both hypotheses. In the House, the Energy and Commerce and Natural Resources committees held the most hearings and tended to spread their attention evenly across dimensions. These are also the committees that would be expected to have expertise related to UNF management given that the issue crosses energy, environmental, and science/technical boundaries. In addition, committees that participated less frequently tended to focus their attention on one or two dimensions related to their expertise. Most notably, the Transportation and Infrastructure committee was the most active on the transportation dimension. The Foreign Affairs committee was most active on the storage dimension, because that dimension involves questions about the reprocessing of used nuclear material, which raises questions about nuclear proliferation. Finally, the Budget committee mostly heard testimony about Yucca Mountain.

This is likely because the failure of Yucca Mountain to become operational has major budget implications because of the nuclear waste trust fund and the liabilities associated with the failure of the government to take possession of the used nuclear material at the various power plants as stipulated by the NWPA. The next section examines the relevant Senate committees.

4.4.2 Senate

To test the first hypothesis with regard to the Senate, I examine the six Senate committees active in the UNF subsystem. The committees and the number of hearings, number of witnesses, and the number of Congresses are shown in Table 4.3.

Table 4.3: UNF Subsystem Activity by Senate Committee

Committee	Hearings	Witnesses	Congresses
Agriculture, Nutrition, and Forestry	1	9	1
Appropriations	3	10	2
Commerce, Science, and Transportation	5	64	3
Energy and Natural Resources	26	211	12
Environment and Public Works	11	175	8
Governmental Affairs	3	51	3

Number of hearings $\chi^2(53.98)$ significant at $p < 0.001$

Within the Senate, jurisdiction over UNF was largely dominated by one committee, Energy and Natural Resources.[9] This committee held the most hearings, by far, with 26. In addition, they saw the most witnesses with 211, and were active across the most Congresses at 12. As with the House results, the χ^2 (53.98) for the number of hearings in the Senate is significant, providing evidence for *H1.* The Environment and Public Works committee had the second highest number of hearings with 11, less than half of the Energy and Natural Resources committee, yet they

[9]Senator J. Bennett Johnson who, as discussed in Chapter 3, was instrumental in the development of UNF policy served on the Energy and Natural Resources committee for many years, and was the committee chair from 1987 to 1995 (Vandenbosch and Vandenbosch, 2007).

saw 175 witnesses and held hearings across 8 Congresses. The Commerce, Science, and Transportation committee held 5 hearings, Appropriations and Governmental Affairs each held 3 hearings, and the Agriculture, Nutrition, and Forestry committee held 1 hearing. As with the hearings in the House, I examine the differences of attention paid to each dimension by Senate committee using OLS models with robust standard errors. The Senate committees are dummy variables and the excluded referent is the Energy and Natural Resources committee.

Table 4.4: OLS Estimates of Dimension Salience by Senate Committee

	Program	Safe	Yucca	Site	Sci/Tech	Storage	Trans
(Intercept)	0.32***	0.13***	0.08***	0.12***	0.20***	0.15***	−0.00
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Agriculture	−0.13*	−0.04	−0.01	0.06	−0.06*	−0.00	0.18***
	(0.05)	(0.05)	(0.01)	(0.05)	(0.03)	(0.04)	(0.05)
Appropriations	−0.02	0.10†	−0.03	−0.03	0.03	−0.08*	0.03
	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
Comm/Sci/Trans	−0.22***	0.05*	−0.03***	−0.04*	−0.01	−0.02	0.26***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Environment/Public Works	−0.03†	0.01	−0.01	0.00	−0.01	−0.00	0.03*
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Governmental Affairs	−0.05	0.02	−0.02	−0.02	−0.05*	0.03	0.09***
	(0.04)	(0.04)	(0.01)	(0.02)	(0.03)	(0.02)	(0.03)
Republican Majority	−0.03	0.00	−0.00	0.05***	−0.02†	−0.01	0.00
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Legislative	−0.03*	−0.03*	−0.01†	0.04***	−0.06***	0.03**	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	501	501	501	501	501	501	501
adj. R^2	0.19	0.15	0.53	0.13	0.08	0.13	0.25
Resid. sd	0.14	0.09	0.07	0.11	0.11	0.10	0.12

Robust standard errors in parentheses. Fixed effect for eras not shown
† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

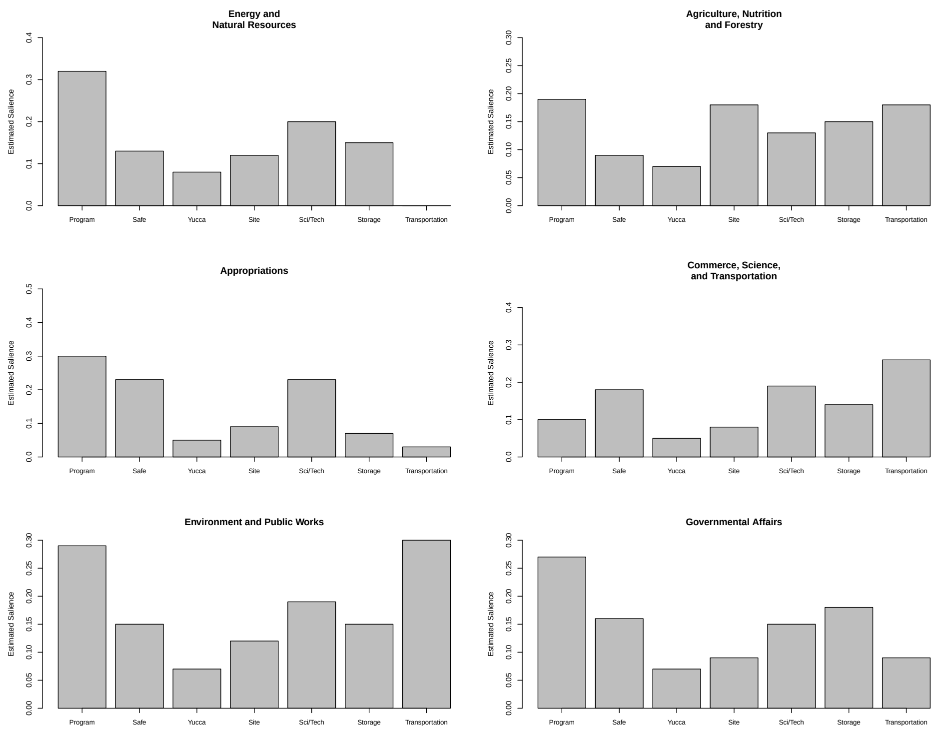
Table 4.4 present the results of the OLS analysis. As with the House, there are significant differences in the salience of the dimensions across the Senate committees, although these differences don't seem as pronounced. The Agriculture committee was less likely to find the programmatic and the science and technical dimensions salient, compared to the Energy and Natural Resources committee, but was more likely to find the transportation dimension salient. The Appropriations committee found the safety/regulation more salient, using a one-tailed test, and the storage dimension less salient, all else equal. The Commerce, Science, and Transportation committee was more likely to pay attention to the safety/regulation and transportation dimensions, and less likely to pay attention to the programmatic, Yucca Mountain, and site selection dimensions. The Environment and Public Works, the second most active committee, was similar to the Energy and Natural Resources, only differing in paying less attention to the programmatic dimension, in a one-tailed test, and more attention to the transportation dimension. Finally, Governmental Affairs was less likely to pay attention to science and technical issues and more likely to pay attention to the transportation dimension.

In regards to the control variables, when Republicans hold the majority in the Senate, on average the site selection dimension is more salient and the science and technical dimension was less salient in a one-tailed test. The programmatic, safety/regulation, Yucca Mountain, and the science and technical dimensions were all less salient in Senate hearings that considered legislation versus other hearings. The site selection, storage, and transportation dimensions were all more salient in legislative hearings, all else equal.

As with the House models, the Senate models were used to make point predictions for each dimension within each of the committees. These results are illustrated in Figure 4.3.

As can be seen in Figure 4.3, the results for the Senate committees show attention more evenly divided among the dimensions. Holding all else equal, the Energy and Natural Resources committee was most likely to hear testimony on the programmatic dimension, which an estimated mean of 0.32. In addition, the Energy and Natural Resources committee was estimated to hear no testimony on the transportation dimension. The transportation dimension was salient however, for the Environment and Public Works committee (the other core committee in the UNF subsystem) with an estimated 30% of the testimony being about transportation. The transportation dimension was also salient for the Commerce, Science, and Transportation committee with an estimated 0.26.

Figure 4.3: Estimated Dimension Salience for each Senate Committee



The first hypothesis posited that the number of committees involved int he UNF subsystem with be limited to a few core committees that anchor the subsystem. Much like the House results, the Senate results seem to confirm this expectation. The central Senate committee was the Energy and Natural Resources committee which held the most hearings at 26, saw the most witnesses with 211, and held hearings in 12 Congresses. The second hypothesis stated that committee involvement in the UNF subsystem, outside of the anchor committees, would be limited and based on committee expertise and jurisdiction. Evidence in support of this hypothesis was weaker in the Senate compared to the findings for the House. While, the Commerce, Science, and Transportation committee was most active on the transportation dimension and less active on other dimensions overall, as compared to the House, the Senate seemed to have committees more active across several dimensions. This may be because the Senate has traditionally been less reliant on committees than the House (Stewart, 2001), possibly because the Senate has only 100 members compared to the House with 435. The smaller number of members may mean that committees need to have broader expertise and jurisdictional boundaries. For example, the Agriculture, Nutrition, and Forestry committee held only one hearing, from 1975 to 2012, about UNF. It took place in the 96th Congress (1980), and was focused on the impact of a nuclear waste site on rural communities (US Senate, 1980). While seemingly narrow in scope and bound by committee expertise—rural communities are certainly closely related to agriculture issues—this hearing touched on many of the dimensions of UNF. It was just as likely as the anchor committee to focus on safety/regulation, site selection and storage dimensions; and more likely to pay attention to the transportation dimension. An additional reason may be that the Senate rules give individual senators a lot of latitude to influence the larger chamber and these dynamics allow opportunities for Senators to expand the jurisdictional span of their committee(s). For example, Harry Reid, during the 108th Congress was the ranking member of the Appropriations subcommittee on Energy and Water Development. This subcommittee had some expertise in the issue of UNF largely because they appropriated funds for the Yucca Mountain project. In the 108th Congress two hearings were held by this subcommittee, one of these hearings (discussed in Chapter 3) was focused on workers at Yucca Mountain being exposed to silica (US Senate, 2004), which would seem to be outside the purview of the Appropriations committee. This is an example of a powerful committee member leveraging involvement in one part of an issue—funding in this case—in an attempt to focus attention on other dimensions of the UNF issue.

4.5 Summary

This chapter examined the role of institutions in processing information and defining policy issues. Institutions structure policy subsystems by their expertise and jurisdictional authority. This expertise and authority results from the parallel processing of issues that a complex policymaking environment requires. In other words, the parallel processing of information across various sub-units within an institution encourages the development and concentration of expertise and reduces overall information costs for policymakers. In addition, committees attempt to leverage this expertise to expand their influence into other policy subsystems. These factors combine to allow institutions great latitude to influence issue definitions by signaling the salient dimensions of an issue to the full Congress. This chapter looked at the activity of Congressional committees in the UNF subsystem and found that a few core committees were most likely to hold hearings. A second finding, was that committees tended to vary in the attention paid to each dimension largely based on the committees realm of expertise. In short, the core subsystem committees were spread across several of the dimensions and outlier committees were more narrowly focused. Overall, the conclusion is that institutions take information and shape issue definitions through expertise and jurisdictional competition.

Chapter 5

Policy Actors, Information, and Issue Definitions

Previous chapters have demonstrated that the issue of UNF is dynamic and complex, and that Congressional committees within policy subsystems compete for influence in a subsystem based on their expertise. This chapter shifts the focus from institutions to policy actors active within the UNF subsystem. Specifically, this chapter examines how policy actors shape, or attempt to shape, the information that is made available to policymakers. A complex policymaking environment leads to disproportionate information processing—where some information is weighted more than other information—however there are likely to be systematic elements that influence which issue dimensions are salient at a given time. One possible category of influence explored in this chapter is strategic policy actors. These actors can alter the nature and content of information that they present to policymakers through strategic framing. As discussed in Chapter 1, information is characterized as signals in the policymaking environment, and these signals can consist of the issue dimensions that the source of the signal finds most relevant. By signaling which dimensions are salient, policy actors can shape how the issue is defined. In short, as the analysis in this chapter will demonstrate, policy actors attempt to define issues in systematic ways by highlighting some dimensions over others.

5.1 Strategic Policy Actors and Issue Dimensions

Policy actors are defined as individuals or groups with an interest, expertise, and sustained involvement in a policy subsystem. These can include individual policy entrepreneurs, federal agencies, interest groups, and/or coalitions. Policy actors seek to influence policy choices[1] and can be motivated to do so by material interests and/or purposive beliefs (Wilson, 1973; Moe, 1981; Jenkins-Smith and Clair, 1993; Sabatier and Weible, 2007) or they can be motivated by expertise and the norm of "neutral competence" (Weimer, 2005). Finally, policy actors are strategic in the way(s) that they attempt to influence collective policy choices.

Policy actors employ multiple strategies in attempting to influence public policy. One way that actors seek to shape policy choices is by attempting to define policy issues in a manner that advantages their preferred positions. For example, policy actors may attempt to frame or redefine a policy issue to alter the scope of conflict surrounding that issue. Since at least Schattschneider (1960), scholars have argued that policy actors attempt to either expand or contain conflict in a policy area. Actors that perceive themselves to be "winning" attempt to contain conflict within the established policy subsystem in an effort to maintain the status quo, whereas actors that perceive themselves as "losing" attempt to expand conflict to disrupt the status quo. Framing an issue in the broadest possible terms can attract other policy actors to become concerned about the issue. Therefore, policy actors that view themselves as losing a particular policy battle may attempt to redefine a policy issue to appeal to a broader (and more sympathetic) audience (Pralle, 2006).

Policy issues that are multidimensional and complex, like UNF management, offer opportunities for the strategic manipulation of issue dimensions by motivated

[1]Note that for analytical clarity policy actors are considered distinct from policy or decision makers, however there is certainty much overlap as some policy actors are also policymakers (e.g., federal agencies, elected officials).

policy actors. In essence, issue complexity allows policy actors to highlight certain dimensions over others in an attempt to frame or define a policy issue. That is the key insight behind Riker's heresthetics (see Riker, 1984, 1986, 1990; Shepsle, 2003; Moser, Patty and Penn, 2009). Heresthetics involve policy actors constructing the issue space in a way that promotes their preferred outcome. Often, this is accomplished by adding new dimensions to an issue that will expand the conflict to draw in new actors and/or split the dominant coalition (Riker, 1986). For example, in the early 1970's the Department of Defense proposed bringing shipments of nerve gas weapons from Japan through the port of Seattle. These weapons would then be transported by rail through Washington State to Oregon to be decommissioned. Senator Magnuson of Washington was firmly against this proposal, and was successful in rallying a critical number of Senators to block the proposal by arguing that the Senate had not been given a voice in the treaty negotiations with Japan. This argument moved enough conservative Senators, who were chiefly concerned about the traditional "advise and consent" role of the Senate, to Magnuson's side (this story is discussed in Riker, 1986, 1990; Baumgartner et al., 2009). In a similar vein, other scholars have noted that policy actors "problem surf" in attempt to attach their preferred solution to a salient policy problem (Kingdon, 1984; Boscarino, 2009). Attaching a solution to a problem involves altering the issue space in an attempt to redefine an issue.

5.2 Policy Actors in the Used Nuclear Fuel Domain

As noted above, policy actors are individuals or groups that have a sustained involvement in a policy issue or area. Often these actors are motivated by expertise, material interest, and/or purposive beliefs to become engaged in a subsystem. These motivations are not mutually exclusive, and most policy actors develop expertise in the issues in which they engage (Baumgartner et al., 2009).

Indeed, multiple actors competitively pursuing their own policy preferences can assist Congress in creating policies where the benefits to society as a whole outweigh the costs (Esterling, 2004). The expertise and preferences of policy actors shape the information they provide to policymakers regarding the dimensions of an issue that are most salient. However, preferences among policy actors in a subsystem are often divergent, therefore policy actors likely vary systematically in the attention they pay to particular dimensions of an issue.

Policy actors within a given subsystem often include a wide range of individuals and groups. Knowing the dimensions of the UNF issue and some of the motivations of the various policy actors, hypotheses can be derived about the dimensions that particular policy actor will found most salient. Below is a discussion of the major policy actors involved in the UNF subsystem, as determined by appearing as witnesses in Congressional hearings regarding UNF. Following each discussion, I posit hypotheses about which dimensions those actors will choose to highlight.

5.2.1 Federal Agencies

Federal agencies provide expertise and knowledge about policy issues. As a result, Congress makes use of federal agencies in an attempt to lower information costs (see Krause, 2010). Traditionally, scholars have noted that federal agencies reduce search costs for Congress by providing valuable knowledge and expertise (Gailmard and Patty, 2007). More recent work has indicated that a "dual dynamic" exists between Congress and federal agencies. This dual dynamic incorporates a top-down aspect where Congress delegates policymaking authority to the bureaucracy and a bottom-up aspect where federal agencies process and package relevant information in the environment for Congress (Workman, 2009; Workman, Jones and Jochim, 2010). These dynamics imply a bureaucracy that is responsive to Congressional oversight.[2]

Federal agencies have played an extensive role in the UNF issue. As seen in Chapter 3, the DOE is the agency in charge of developing and charaterizing a site for the disposal of UNF, and the NRC and EPA and the agencies charged with regulating the facility.[3] Given that federal agencies often provide expertise to Congress, and federal agencies, such as the DOE, NRC, and the EPA, are heavily involved in the implementation of policies and the development of regulations surrounding used nuclear materials, I posit the following hypothesis:

> *H1:* ***Federal Agencies*** *are more likely to discuss the programmatic, safety/regulation, and scientific/technical dimensions, relative to other groups*

5.2.2 Interest Groups

Like federal agencies, interest groups can also provide expertise to Congress. Competition among interest groups with a developed expertise can help Congress in forming policies that are more efficient than they might be otherwise (Esterling, 2004). In addition, interest groups, through lobbying, can provide a "subsidy" to policymakers by providing their allies with relevant policy information (Hall and Deardorff, 2006). However, interest groups often have a specific policy goal in mind and attempt to influence policy choices to meet those goals. To achieve these goals interest groups are strategic and employ several strategies aimed at influencing col-

[2]However, bureaucrats can also be motivated by interests and beliefs to pursue certain policy goals (Downs, 1967; Carpenter, 2001; Meier and O'Toole, 2006). It is likely that the different federal agencies will vary in some of their interests and beliefs, however all federal agencies can be assumed to have acquired some level of expertise. The question I am interested in involves federal agencies and what dimensions they would highlight *relative to the other groups.* Further research should explore differences in dimension salience across the various federal agencies.

[3]It should be noted that federal agencies are also policymakers. In addition, agency hearings and rulemaking procedures can act as policymaking venues for other policy actors. However, for my purposes I only consider the role of federal agencies as policy actors and Congress as policymakers.

lective policy choice. These include the way they share information (Austen-Smith and Wright, 1994), the selection of policymaking venue (Baumgartner and Jones, 1993; Sabatier and Jenkins-Smith, 1999; Boehmke, Gailmard and Patty, 2013), and the way that they frame and attempt to define policy issues (Baumgartner et al., 2009).

The interest groups involved in UNF fall largely into one of two camps; industry groups or environmental groups. Industry groups represent the nuclear energy industry and are assumed to be largely motivated by material interests. Therefore, these groups are likely to be concerned about the future viability of nuclear energy. The unresolved issue of how to handle UNF has long been thought to undermine the continued and expanded use of nuclear energy (see Walker, 2009). This concern became more relevant following the decision to forgo reprocessing of used material in 1976. As a result, I posit the following hypothesis:

> *H2: **Industry Groups** are more likely to discuss the storage dimension, relative to other groups*

Environmental groups are largely motivated by beliefs and values related to the protection of the environment. While many environmentalists were initially favorable toward nuclear energy, beginning in the late 1960's environmental groups began to shift away from nuclear energy (Duffy, 1997). At first, this was due to thermal pollution run-off and its impact on fish and other wildlife, but by the mid 1970's these groups became concerned about the perceived harm nuclear materials can cause to the environment, and human health and safety. In general, environmental groups are likely to perceive increased risks associate with nuclear energy. Given the nature of the perceived risks, environmental groups are also likely to be concerned about the process of selecting a site for the storage of nuclear material. As noted, the unresolved nature of UNF disposal can work to undermine the further use of nuclear energy, therefore environmental groups are likely to highlight the site selection dimension in an attempt to prevent the successful siting of a UNF facility. Therefore, I posit that:

> *H3: **Environmental Groups** are more likely to discuss the safety/regulation and site selection dimensions, relative to other groups*

5.2.3 State and Local

Given the importance of Federalism in the US context, state and local individuals and groups are important actors in many federal government decisions. Federalism has played a large role in the UNF subsystem and has given rise to contentious debates between the federal government and the potential host states (Kearney and Garey, 1982; Carter, 1987). Throughout the development of nuclear waste policy potential host states were consistently opposed to being selected to host a repository. The concerns of these states often centered around the "top-down" approach to the process of site selection adopted by the federal government, which lead many states to distrust the process and the DOE in particular (Clary and Kraft, 1988). In addition, some state opposition could be a result of Not-In-My-BackYard (NIMBY) sentiments from residents of states that are being considered to host a site that is potentially risky (Kraft, 1991).[4] An additional risk that concerns state/local actors is the transportation of potentially hazardous materials through their state and local areas (MacGregor et al., 1994; Gawande and Jenkins-Smith, 2001; Gawande, Jenkins-Smith and Yuan, 2013).

In addition to state and local actors, native american actors have also been in active in the UNF subsystem. Several native american tribes have considered or been approached to host UNF facilities, yet they have raised many of the

[4]However NIMBY beliefs are complicated (Benford, Moore and Williams, 1993; Jenkins-Smith et al., 2011), making the NIMBY arguments a little less clear. The story is even more complicated when considering tensions between local communities and states. In many cases, such as Lyons, Kansas, Carlsbad, New Mexico, and Nye county Nevada, many of the local officials were in favor of the facility, and most of the opposition came from other parts of the state (see Walker, 2009).

same concerns as state and local actors (see Vandenbosch and Vandenbosch, 2007). Therefore, I include tribal actors as a part of the state and local category. Given the concerns of state/local/tribal actors, I posit that:

> *H4:* ***State/Local/Tribal actors*** *are more likely to discuss the site selection and transportation dimensions, relative to other groups*

5.2.4 Elected Officials

Elected officials play two roles often simultaneously, they are policy actors attempting to influence policy choices and policymakers charged with making many policy decisions. The focus here is on elected officials as policy actors attempting to shape policy choices. Major motivations of elected officials have been argued to include reelection, power within the chamber, and good public policy (Fenno, 1973). These motivations are why elected officials might seek to shape policy choices and define issues. In the UNF subsystem, elected officials largely act as representatives to their geographical area and attempt to prevent their state or local area from being selected as a host site for a repository. As a result, it is likely that their concerns match those of state/local actors.

> *H5:* ***Elected Officials*** *are more likely to discuss the site selection and transportation dimensions, relative to other groups*

5.3 Data and Methods

Once again, the data for the analysis performed in this chapter is drawn from the 140 Congressional hearings regarding used nuclear fuel from 1975 to 2012. These hearings were coded for the witness and the witness's affiliation. The data on witness affiliation is used to place witness into one of seven categories, which are described below, and these witness categories are the main independent variables for this chapter.

Dependent Variables: As in Chapter 4, the dependent variables are the seven dimensions of the UNF policy debate that were derived from hearing testimony and described in detail in Chapter 2. The values for the dimensions range from 0 to 1, with values closer to 1 indicating a higher proportion of that testimony was about that dimension, thereby indicating a higher degree of salience for that dimension with that policy actor. The next section describes the independent variables used in this chapter.

Independent Variables: The major variables of interest for this chapter are the policy actors involved in the UNF subsystem. For my purposes, policy actors are identified as those that appear as witnesses in a committee hearing. Apart from policy actors, I also control for several other factors that might influence the salience of the various dimensions.

Policy Actors

To examine group based differences, witnesses were categorized by group affiliation and then aggregated into one of seven major categories; federal agencies, state/local interests, elected officials, industry interest groups, environmental interest groups, outside experts and a miscellaneous category. *Federal agencies* include executive agency personnel (e.g., DOE, NRC, EPA) and individuals from congressional agencies (e.g., GAO, CBO). *State/Local/Tribal* interests include individuals employed by state agencies, state based interest groups, local government agencies, and Indian tribes. *Elected officials* are federal (e.g., Congress), state (e.g., governor, state legislature), and local (e.g. mayor, city council).[5] *Industry interest*

[5]Note that in this analysis elected officials are those that appear as witnesses, not those in the committee.

groups include individuals from business and industry groups (e.g., Atomic Industry Forum, Exxon Nuclear Company, General Electric Company, Nuclear Energy Institute). *Environmental interest groups* are representatives from environmental groups (e.g., Sierra Club, Natural Resources Defense Council), and other purposive interest groups that often focus on environmental issues (e.g., Union of Concerned Scientists, Public Citizen). *Outside experts* include scientific and technical experts from outside government agencies (e.g., academic institutions, national laboratories, professional associations). Table 5.1 shows the number of witnesses by policy actor type.

Table 5.1: Number of Witnesses per Policy Actor Type

Policy Actor	Number of Witnesses	Percent
Federal Agencies	368	29%
State/Local/Tribal	316	25%
Elected Officials	175	14%
Industry Groups	114	9%
Environmental Groups	100	8%
Outside Experts	136	11%
Misc	62	5%

As can be seen, federal agencies had the highest number of witnesses with 368 (29%), followed by state/local/tribal with 316 (25%). Elected officials had the third highest number with 175 (14%), followed by outside experts with 136 (11%), industry groups with 114 (9%), and environmental groups with 100 (8%). Finally, the misc category, made up of witnesses that weren't affiliated with any particular group and only appeared in one Congress (e.g., private citizens, the actor Robert Redford), had the fewest number of witnesses with 62 (5%).

The focus of this chapter is how policy actors attempt to strategically shape issue definitions. However, the ability of policy actors to shape issues may be limited by the institutional features in which they operate (Sheingate, 2006; Baumgartner et al., 2009). Therefore, the models used to test the hypotheses in this chapter contain several institutional characteristics as control variables. As seen in Chapter 4, there is substantial variation in the salience of dimensions across the various committees. Therefore, I use fixed effects for committees with the Senate Agriculture, Nutrition, and Forestry committee as the excluded referent committee. In addition, I include the controls from Chapter 4; hearing type, Republican majority, and UNF policy era. As a reminder, legislative is coded 1 if the hearings is a legislative hearing, and 0 if otherwise, and Republican majority is coded 1 if Republicans are in the majority in the chamber in which the hearing occurred, and 0 otherwise. Finally, I use fixed effects to control for the four policy eras of UNF policy evolution. The to test the hypotheses OLS regression with robust standard errors was used.[6] In addition, the analysis was performed separately for each policy actor type. The results are presented in the next section.

5.4 Results

5.4.1 Federal Agencies

Actors within federal agencies are often key players in policy subsystems. One of their key functions is to provide expertise and knowledge about the issues relevant to the subsystem. Following from this assumption, the first hypothesis, *H1*, posited that *relative to other groups* federal agencies are more likely to focus on the programmatic, safety/regulation, and scientific/technical dimensions. As noted above, this hypothesis is tested using OLS models with robust standard errors. To compare federal agencies to the other policy actors, they are the excluded referent group in the following analysis. Evidence in support of the working hypothesis would be negative and statistically significant estimated coefficients for

[6]Given the hierarchical nature of the data (Committees in chamber; chamber in Congress) I also used a mixed effects model, with random effects for Congress and committee. The results were very similar, so OLS was used for ease of interpretation.

each group in the models predicting the programmatic, safety/regulation, and scientific/technical dimensions. The results are presented in Table 5.2.

Table 5.2: OLS Estimates of *Federal Agencies* and Dimension Salience

	Program	**Safe**	Yucca	Site	**Sci/Tech**	Storage	Trans
(Intercept)	0.28***	0.10***	0.07***	0.10**	0.13***	0.15***	0.18***
	(0.05)	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.03)
Industry Groups	−0.10***	−0.05***	0.02*	0.05***	−0.07***	0.15***	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Environmental Groups	−0.09***	−0.02*	−0.01	0.12***	−0.03**	0.03*	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
State/Local/Tribal	−0.05***	−0.04***	−0.00	0.12***	−0.05***	−0.01	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Elected Officials	−0.14***	−0.02**	−0.00	0.20***	−0.05***	0.01	0.02†
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Outside Experts	−0.14***	0.02	0.01	0.07***	0.05**	0.02	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Misc	−0.17***	−0.01	−0.02*	0.17***	−0.03*	0.04*	0.02†
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Republican Majority	−0.01	0.00	0.01*	0.03**	−0.00	−0.02*	−0.01†
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Legislative	0.02**	−0.04***	−0.00	0.01	−0.03***	0.01	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	1271	1271	1271	1271	1271	1271	1271
adj. R^2	0.29	0.33	0.60	0.42	0.17	0.30	0.23
Resid. sd	0.13	0.09	0.07	0.09	0.10	0.10	0.11

Robust standard errors in parentheses. Fixed effects for committee and era not shown
† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

As can be seen in the first column of Table 5.2, all other groups, as expected, were significantly less likely then federal agencies to discuss the programmatic dimension, all else equal. Also as expected, all groups except outside experts were significantly less likely then federal agencies to discuss the safety/regulation dimension. Finally, all groups but outside experts were less likely to discuss the science/technical dimension. In fact, outside experts were significantly *more* likely than federal agencies to highlight the science/technical dimension. This is likely because outside experts are largely scientific and technical experts drawn from various universities and research centers and policymakers are drawing on their expertise in conjunction with the expertise provided by federal agencies. In general, these results confirm my expectations as federal agencies were significantly more likely to discuss the programmatic, safety/regulation, and the science/technical dimensions than all other actors but outside experts.

In terms of the dimensions that were not hypothesized, federal agencies were less likely than industry groups to highlight the Yucca Mountain dimension. In addition, they were less likely to discuss site selection than the other groups. This is likely because the site selection dimension deals with the *politics* of the site selection process. As a result, the involvement of federal agencies in site selection is likely within the programmatic and science/technical dimensions rather than the site selection dimension. Finally, they were less likely then industry groups to discuss the storage dimension.

For the control variables, Yucca Mountain and site selection, all else equal, tended to be more salient with Republicans in the majority, whereas the science/technical and transportation (in a one-tailed test) were less likely to be salient. Finally, for the legislative hearings the programmatic and transportation dimension were more salient, and the safe/regulation and science/technical dimensions were less salient than during nonlegislative hearings, all else equal.[7]

5.4.2 Interest Groups

Broadly speaking, two types of interest groups are involved in the UNF subsystem; industry groups and environmental groups. Industry groups largely represent utility companies and others involved in the production of nuclear energy. The resolution of the UNF issue is critical for the continued use of nuclear energy. Therefore, hypothesis *H2* posited that, relative to other groups, industry groups would likely highlight the storage dimension. The results are shown in Table 5.3.

Looking first at storage, as expected industry groups were significantly more likely than any other actor to highlight that dimension. This result is highly statistically significant across all other policy actors. In addition, the industry groups were more likely than the other major policy actors to discuss the Yucca

[7]The results for the control variable are the same across all policy actors, so they will not be discussed again.

Table 5.3: OLS Estimates of *Industry Groups* Dimension Salience

	Program	Safe	Yucca	Site	Sci/Tech	**Storage**	Trans
(Intercept)	0.18***	0.04*	0.09***	0.15***	0.07**	0.29***	0.18***
	(0.05)	(0.02)	(0.01)	(0.04)	(0.02)	(0.03)	(0.03)
Federal Agencies	0.10***	0.05***	−0.02*	−0.05***	0.07***	−0.15***	−0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Environmental Groups	0.01	0.03**	−0.03**	0.07***	0.03**	−0.11***	0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
State/Local/Tribal	0.05**	0.01†	−0.02**	0.07***	0.02*	−0.15***	0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Elected Officials	−0.04***	0.03***	−0.02*	0.15***	0.02†	−0.14***	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Outside Experts	−0.04**	0.07***	−0.01	0.02	0.11***	−0.13***	−0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Misc	−0.07***	0.04***	−0.04***	0.12***	0.04**	−0.11***	0.02
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Republican Majority	−0.01	0.00	0.01*	0.03**	−0.00	−0.02*	−0.01†
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Legislative	0.02**	−0.04***	−0.00	0.01	−0.03***	0.01	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	1271	1271	1271	1271	1271	1271	1271
adj. R^2	0.29	0.33	0.60	0.42	0.17	0.30	0.23
Resid. sd	0.13	0.09	0.07	0.09	0.10	0.10	0.11

Robust standard errors in parentheses. Fixed effects for committee and era not shown
† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Mountain dimension. It likely that industry groups found Yucca Mountain salient given that it was the only site being considered for a UNF repository. Finally, industry groups were less likely to discuss the safety/regulation dimension and the science and technical dimension.

The second type of interest group active in the UNF subsystem are environmental groups. These groups are largely concerned about the impacts of nuclear energy and UNF on the environment, and human health and safety. Given that *H3* posited that environmental groups would find the safety/regulation and site selection dimension most salient. The results, with environmental groups are the excluded referent group, are presented in Table 5.4.

As shown, environmental groups were more likely to discuss the safety/regulation dimension only relative to industry groups, and state/local actors (in a one-tailed test). Federal agencies and outside experts were more likely than environmental groups to discuss the safety/regulation dimension. Perhaps because discussion of the safety/regulation dimension was extremely technical in nature. In addition,

Table 5.4: OLS Estimates of *Environmental Groups* Dimension Salience

	Program	**Safe**	Yucca	**Site**	Sci/Tech	Storage	Trans
(Intercept)	0.18***	0.07***	0.06***	0.22***	0.10***	0.18***	0.19***
	(0.05)	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.03)
Federal Agencies	0.09***	0.02*	0.01	−0.12***	0.03**	−0.03*	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Industry Groups	−0.01	−0.03**	0.03**	−0.07***	−0.03**	0.11***	−0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
State/Local/Tribal	0.04*	−0.02†	0.00	0.00	−0.01	−0.04***	0.02
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Elected Officials	−0.05***	0.00	0.00	0.08***	−0.02	−0.03*	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Outside Experts	−0.05***	0.04**	0.02	−0.05***	0.08***	−0.01	−0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Misc	−0.07***	0.01	−0.01	0.05*	0.00	0.01	0.01
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Republican Majority	−0.01	0.00	0.01*	0.03**	−0.00	−0.02*	−0.01†
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Legislative	0.02**	−0.04***	−0.00	0.01	−0.03***	0.01	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	1271	1271	1271	1271	1271	1271	1271
adj. R^2	0.29	0.33	0.60	0.42	0.17	0.30	0.23
Resid. sd	0.13	0.09	0.07	0.09	0.10	0.10	0.11

Robust standard errors in parentheses. Fixed effects for committees and eras not shown
† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

federal agencies were also hypothesized to find that dimension salient, compared to other groups. Environmental groups were significantly more likely to discuss the site selection dimension than were federal agencies, industry groups, and outside experts. However, they were just as likely to discuss site selection as state/local actors, but less likely than elected officials. Once again however, other groups, state/local and elected officials in this case, were hypothesized to find those dimensions salient. Overall, these results provide some tentative evidence in support of *H3*. Compared to their interest group counterparts industry groups, environmental groups were, as expected, more likely to highlight the safety/regulation and site selection dimension.

5.4.3 State/Local/Tribal

State/local/tribal actors represent particular states, counties, cities, and native lands. In most cases these actors were involved in the UNF subsystem because they were, at one point, being considered as a potential location to host a UNF facility. As a result, *H4* posited that state/local/tribal actors would find the site selection and transportation dimension most salient. The results are shown in Table 5.5.

Table 5.5: OLS Estimates of *State/Local/Tribal Actors* Dimension Salience

	Program	Safe	Yucca	**Site**	Sci/Tech	Storage	**Trans**
(Intercept)	0.22***	0.06**	0.07***	0.22***	0.09***	0.14***	0.21***
	(0.05)	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.03)
Federal Agencies	0.05***	0.04***	0.00	−0.12***	0.05***	0.01	−0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Industry Groups	−0.05**	−0.01†	0.02**	−0.07***	−0.02*	0.15***	−0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Environmental Groups	−0.04*	0.02†	−0.00	−0.00	0.01	0.04***	−0.02
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Elected Officials	−0.09***	0.02**	0.00	0.08***	−0.00	0.01	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Outside Experts	−0.09***	0.06***	0.01	−0.05***	0.09***	0.02*	−0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Misc	−0.11***	0.03**	−0.02*	0.05*	0.02	0.04**	−0.01
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Republican Majority	−0.01	0.00	0.01*	0.03**	−0.00	−0.02*	−0.01†
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Legislative	0.02**	−0.04***	−0.00	0.01	−0.03***	0.01	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	1271	1271	1271	1271	1271	1271	1271
adj. R^2	0.29	0.33	0.60	0.42	0.17	0.30	0.23
Resid. sd	0.13	0.09	0.07	0.09	0.10	0.10	0.11

Robust standard errors in parentheses. Fixed effects for committees and eras not shown.
† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

As can be seen, state/local/tribal actors were, as expected, significantly more likely than federal agencies and industry groups to discuss the site selection dimension. However, they were less likely than elected officials to discuss that dimension. In terms of the transportation dimension, state/local/tribal actors were significantly more likely than federal agencies and industry groups to discuss that dimension. In addition, state/local/tribal actors were more likely than all actors, except federal agencies, to discuss the programmatic dimension. This is likely because state/local/tribal actors include representative from state agencies that are charged with the development and implementation of UNF programs within their state. Once again, tentative support was found for my expectations. State/local/tribal actors were more likely to discuss the site selection and transportation dimensions than most other policy actors.

5.4.4 Elected Officials

Elected officials that appear as witnesses in UNF hearings are largely acting as representatives of the geographic area. Therefore, as posited by *H5*, they are likely to highlight the site selection and transportation dimension. The results are shown in Table 5.6.

Table 5.6: OLS Estimates of *Elected Officials* Dimension Salience

	Program	Safe	Yucca	**Site**	Sci/Tech	Storage	**Trans**
(Intercept)	0.13**	0.07***	0.07***	0.30***	0.08***	0.15***	0.19***
	(0.05)	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)	(0.03)
Federal Agencies	0.14***	0.02**	0.00	−0.20***	0.05***	−0.01	−0.02†
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Industry Groups	0.04***	−0.03***	0.02*	−0.15***	−0.02†	0.14***	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Environmental Groups	0.05***	−0.00	−0.00	−0.08***	0.02	0.03*	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
State/Local/Tribal	0.09***	−0.02**	−0.00	−0.08***	0.00	−0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Outside Experts	−0.00	0.04***	0.01	−0.13***	0.10***	0.01	−0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Misc	−0.03†	0.01	−0.02*	−0.03	0.02	0.03†	0.01
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Republican Majority	−0.01	0.00	0.01*	0.03**	−0.00	−0.02*	−0.01†
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Legislative	0.02**	−0.04***	−0.00	0.01	−0.03***	0.01	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	1271	1271	1271	1271	1271	1271	1271
adj. R^2	0.29	0.33	0.60	0.42	0.17	0.30	0.23
Resid. sd	0.13	0.09	0.07	0.09	0.10	0.10	0.11

Robust standard errors in parentheses. Fixed effects for committees and eras not shown
† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

As expected, elected official were significantly more likely than all other groups to discuss the site selection dimension. However, elected officials were only more likely than federal agencies to discuss the transportation dimension (in a one-tailed test). In addition, all groups were more likely than elected officials to discuss the programmatic dimension. These results support my expectations regarding the site selection dimension, but not the transportation dimension.

5.4.5 Policy Actors and Issue Definitions

In general the results tend to confirm my hypotheses about which dimensions various policy actors would highlight. As expected, no groups discussed the programmatic, safety/regulation, or science/technical dimensions more than federal agencies. In addition, industry groups found the storage dimension more salient than all other actors. Environmental groups were more likely than industry groups to discuss the safety/regulation and site selection. Finally, as expected both state/local/tribal actors and elected officials were more likely than other actors to highlight the site selection dimension, however only state/local/tribal actors were more likely to discuss transportation. These results provided only a partial confirmation of my hypothesis regarding elected officials.

Next, I use the OLS models to predict the salience of each dimension by policy actor. For the predictions I held the dummy variables for party control and hearing type at their medians. The fixed effects for policy eras was held constant at its mode (the period with the most witnesses), the pre-NWPA era. Finally, the fixed effects for committees was also held at its mode, the House Natural Resources committee.[8] The estimated means for each policy actor across each dimension are shown in Table 5.7.

Table 5.7: Predicted Dimension Salience by Policy Actor Type

Dimensions	Federal Agencies	Elected Officials	Industry Groups	Environmental Groups	State/Local/ Tribal
Programmatic	**0.25**	0.11	0.15	0.16	0.20
Safety/Regulation	**0.20**	0.18	0.15	0.18	0.16
Yucca Mountain	0.05	0.05	0.07	0.05	0.05
Site Selection	0.09	**0.28**	0.14	**0.21**	**0.21**
Science/Technical	**0.19**	0.14	0.13	0.16	0.14
Storage	0.16	0.17	**0.31**	0.19	0.16
Transportation	0.05	0.06	0.05	0.06	0.08

Estimates based on OLS models with Rep. majority and leg. hearing at median and eras and committee at mode.

For federal agencies, the programmatic dimension was the most salient. This was as expected, given the role of federal agencies in developing and implementing policies and programs to deal with UNF. Also as expected, federal agencies were more likely to discuss the safety/regulation and the science and technical dimensions, relative to the other actors. This is likely given the nature of expertise that

[8]This committee had the most witnesses with 314.

is developed within federal agencies. The storage dimension was the most salient for the industry interest groups, with an estimated mean of 0.31. In other words, 31% of the testimony given by industry groups is estimated to be about the storage dimension. This was as expected, because the nuclear industry is concerned about finding a permanent policy solution for the problem of used materials currently gathered on nuclear power plant sites across the country. Finally, the site selection dimension was most salient for elected officials, environmental groups, and state/local/tribal actors. For elected officials and state/local/tribal actors the site selection dimension is salient because of the perceived risks associated with nuclear facilities, and for environmental groups procedural questions of site selection may act as a wedge, or a policy surrogate (Nie, 2003), to further their ultimate goal of slowing or abandoning the use of nuclear energy. Overall, each of these actors is likely concerned about the perceived fairness of the site selection process, which has always been a highly contentious aspect of UNF policy.

Overall, these results point to how policy actors attempt to shape how issues are understood. As shown, policy actors attempt to highlight the aspects of an issue that are most salient to them. This finding provides empirical support for the idea of heresthetics, where strategic policy actors attempt to construct the issue in a particular way by highlighting some dimensions over others. Much of the past work on heresthetics utilized a case study approach (e.g., Riker, 1986), however the analysis here presented empirical findings showing the systematic ways in which policy actors communicate which dimensions should be salient. Further work however, should focus on how *new* dimensions are brought into the debate. The approach adopted here allows for the examination of the relative attention paid to each dimension, yet it does not easily allow for the addition of new dimensions. As discussed in Chapter 2, the dimensions were selected, in part, based on not being time or context dependent. Therefore, future work should examine more closely the subtle ways that new dimensions, or new frames, are brought into policy debates.

The results presented here can also speak to other questions relevant to political scientists and/or policy scholars. For example, questions of political control could be addressed by examining how the dimension salience for federal agencies shifts (or doesn't) based on Presidential or Congressional partisanship. In addition, the use of expertise in information gathering by Congress can examined. For example, what type of experts (e.g., federal bureaucrats, university faculty, interest group scientists) are called on and when? What dimension(s) do these various experts highlight? Is there variation in the type expert that appears as the policy issue evolves? In addition, questions of federalism could be examined. Do different types or representatives, federal, state, or local, vary in the dimensions that they highlight? Finally, with this data the concerns of native american tribes related to the siting of a UNF facility can be examined in greater detail than has been done previously. Overall, the findings presented here are more of a beginning than a final word.

5.5 Summary

As this chapter has demonstrated, policy actors attempt to highlight some dimensions of an issue over other dimensions in an effort to alter the issue space, thereby seeking to define the policy issue. This chapter posited and tested a set of hypotheses about how policy actors attempt to define policy issues by highlighting certain dimensions. The tests confirm that policy actors differ systematically in their presentation of information, and suggest that these actors attempt to strategically employ heresthetics to shape the issue space in a way that advances their preferred definition of an issue. As was shown, federal agencies tended to highlight the programmatic, safety/regulation, and scientific and technical dimensions of the UNF issue. Industry groups attempted to shift the focus of the issue to the storage of used nuclear materials. Finally, elected officials, environmental groups, and state/local/tribal actors all seemed to highlight the site selection dimension. Overall, these findings supported the notion that policy actors are strategic and systematic in the way they provide information.

Chapter 6

Conclusion

This dissertation developed a model of issue definitions, and then examined how information can be translated into issue definitions through policy evolution, policymaking institutions, and policy actors. In this conclusion, I will restate the four points that were put forth in Chapter 1, discuss the findings in relation to those points, and discuss further work that should be pursued. The four major points of dissertation can be stated as:

- Issue definitions are a function of the weighting of the various dimensions of the issue
- These salience weights can act as signals in an information processing framework
- Dimensions vary in salience over time, and this variation is associated with policy change
- Institutions and actors within policy subsystems vary in the attention they pay to the various dimensions

6.1 Issue Definitions

Issue definitions are a function of the weighting of the various dimensions of the issue

Issue definitions—the way policy issues are understood—have long been a major consideration of policy scholars. However, in the literature, terms like "issue definition", "problem definition", and "issue framing" have often been used interchangeably. Furthermore, when applied these terms largely focus on questions of agenda setting. How can policy actors get their policy issue and/or their preferred understanding of their issue onto the policymaking agenda? Moving beyond questions of agenda setting, I developed a model of issue definitions based on the underlying attributes (i.e., dimensions) of the issue. As noted, this model is based on the underlying dimensions of the issue, and this includes dimensions related to *problems* and *solutions*, whereas often these are separate in the literature. The model can be expressed as:

$$ID_a = \sum_{i=1}^{n} s_i$$

where s_i is the salience of dimension i for issue a.

As expressed, issue definitions are function of the sum of each dimension weighted by its salience. The weights assigned to each dimension can vary over time—making issue definitions dynamic—and across policy actors.

To estimate the dimensions of the UNF policy debate, I performed LDA analysis on the opening statements of the 1,271 witnesses that appeared in 140 Congressional hearing about UNF from 1975 to 2012. As described in detail in Chapter 2, this approach was adopted after consideration of several other possible approaches. One advantage of the LDA approach is that it assumes multiple topics (i.e., dimensions) within a single document (i.e., testimony). This allowed for the estimation of the relative weights that were assigned to each of the seven dimensions for each witness. A draw back of this approach however, is that dimensions must be defined rather broadly to avoid clusters that are too context dependent (i.e., narrow or time-specific). In others words, to be able to compare dimension salience over time and across groups, the dimensions must be consistent and appear across multiple Congresses. While this approach is ideal to estimate the issue definition model, it does miss some of the nuance associated with particular frames. For example, national security elements were likely discussed when a) reprocessing was being considered in the mid-1970s and b) when Yucca Mountain was approved shortly after the 9-11 terrorist attacks. A topic modeling approach misses some of these nuances, that can likely only be determined by careful (and costly) human coding.

A second element that is left unaddressed is the tone, positive or negative, about the dimension. While knowing which dimension was highlighted is important, it is also important know how that dimension was discussed. In future research, the issue definition model should be updated to include measures of tone or evaluation about each dimension. This could be expressed as:

$$ID_a = \sum_{i=1}^{n} s_i e_i$$

where s_i is the salience of dimension i for issue a, and e_i is the evaluation of that dimension.

The evaluation of a dimension could be estimated using sentiment analysis, which is a dictionary based content analysis approach. Combining the results of the LDA analysis with sentiment analysis could present a fuller picture of how the issue is defined.

Finally, future work should examine the issue definition model across different types of text documents. For example, Congressional floor speeches could be analyzed in a similar fashion to determine the dimensions that are being debated. Similarly, comments submitted to federal agencies during the rulemaking processing could also be analyzed. As the amount of text data that is available increases, more research on the dynamic elements of issue definitions can be realized.

6.2 Information Processing

These salience weights can act as signals in an information processing framework

As discussed in Chapter 1, scholars of the policymaking process bound inquiry by the level of analysis (macro, meso, micro) and the level of abstraction (framework, theory, model). In this dissertation, I incorporate assumptions from a macro-level theory of information processing with a model of issue definitions. The theory of information processing argues that information in the policymaking environment are signals and that information processing consists of assembling and prioritizing those signals (Jones and Baumgartner, 2005; Workman, Jones and Jochim, 2009). Working from this premise, I argued that these information signals can be operationalized as signals about which of the various dimensions of a policy issue are the most salient. In other words, information sources (Congressional committees and policy actors) signal important aspects of a policy issue by highlighting certain dimensions over others. In the aggregate this directing of attention is what defines a policy issue. Considering information as signals about salient dimensions provides a theoretical bridge from information processing theory to the issue definitions model.

Given that the information processing theory is a macro-level theory, where the unit of analysis are aspects of the entire policymaking system, information signals are left unspecified. As noted above, I specified information signals as dimensions of a policy issue within a subsystem, however further work should examine other specifications. For example, information signals could be considered by type of information, which can vary from expert-based analysis to normative arguments (Esterling, 2004, 2011; Weible, 2008). Expert-based policy information is defined as "content generated by professional, scientific, and technical methods of inquiry" (Weible, 2008, 615) and is largely focused on the casual mechanisms that connect policy instruments to policy outcomes. Normative arguments link policy to moral values or core beliefs about what is "good" or "bad"; "right" or "wrong." Previous research has shown that expert-based information is more likely to be utilized in policy areas with moderate levels of disagreement (Esterling, 2011) and/or in policy subsystems that are maintained by a dominant coalition or that consist of collaborative coalitions (Weible, 2008). Further work should seek to incorporate the dimension(s) that are highlighted with the type of information presented (e.g., expert-based vs. normative) to determine which type of information is used to construct issue definitions.

Apart from the theory of information processing, the issue definition model could be incorporated into other theories or frameworks of the policy process. For example, the IDM could be used as a way to operationalize policy core beliefs in the Advocacy Coalition Framework (ACF). The ACF argues that policy actors exhibit a three-tiered structure of beliefs; with core beliefs, such as political ideology and/or cultural type, being the most abstract and applicable across multiple policy domains; followed by policy core beliefs, which are more narrow in scope and contained within a single policy domain; and secondary beliefs, which are the most narrow and refer to things like particular policy instruments (Sabatier and Jenkins-Smith, 1993; Sabatier and Weible, 2007). A second argument of the ACF, is that policy actors in subsystem are best understood as acting within coalitions that are bound together by policy core beliefs and coordinate their actions. Applied to the ACF, the IDM could establish shared policy core beliefs by determining which dimensions are highlighted by the same policy actors. The results from Chapter 5 point to two, or possibly three advocacy coalitions. Environmental groups, state/local actors, and elected officials tended to highlight the site selection dimension, whereas industry groups tended to highlight the storage dimension. This seems to suggest two coalitions, one centered on the site selection dimension and the other on questions about storage of UNF. Federal agencies, which highlighted the programmatic, safety/regulation, and science/technical dimension, may be a separate coalition, although federal agencies often occupy a middle ground between opposing coalitions (Jenkins-Smith and Clair, 1993; Sabatier and Zafonte, 1999).

6.3 Policy Evolution and Complexity

Dimensions vary in salience over time, and this variation is associated with policy change

Understanding policy change is often the goal of policy process theories. In Chapter 3, I examined policy evolution—policy change over time—and how it related to changes in the salience of the dimensions of the UNF debate. UNF policy developed over four distinct policy eras that were demarcated by policy changes. After discussing those eras, I tested a set of hypotheses about which dimensions would be most salient within each policy era. Using changepoint analysis, I determined the time and number of changepoints for each of the dimensions, and the time periods when each dimensions was most salient (had the highest mean) met my expectations. In addition, these means were statistically significant.

While the analysis presented in Chapter 3 showed associations between the salience of the various dimensions and policy change, further work should strive to link dimension salience with particular policy designs. The next step in research should explore how issue definitions are translated into policy designs. For example, Chapter 3 illustrated that the safety/regulation dimension was most salient prior to the NWPA. However, it is not clear how the discussion of the safety/regulation dimension translated into how the NWPA dealt with that dimension. Future work should included considerations of policy design, perhaps by including legislation into the LDA analysis, and how policy designs connect to issue definitions.

Next, I examined policy evolution and issue complexity. Issue complexity is defined as the number of dimensions of an issue under consideration, and I determined complexity using the Herfindahl index. Complexity was calculated for each Congress, and the mean complexity of each of the four policy eras were compared. While the UNF issue declined in complexity across the four policy eras, these declines were not statistically significant. These results indicate that policy issues do not necessarily become less complex as they evolve.

The issue of UNF remained highly complex for the majority of the period under study. Future work should examine some of the causal drivers of this complexity. Clearly, the complexity of the UNF issue is, in part, a function of its multidimensionality. However, future work should connect the appearance of witnesses and the involvement of committees to variations in issue complexity. It is likely that an increase in the number of witnesses and committees involved in the UNF subsystem increases complexity, but beyond this, certain actors or committees might be more likely than others to attempt to attach other dimensions, thereby increasing complexity. For example, complexity is likely to increase when opponents of a UNF facility are testifying, as they are likely to attempt to redefine an issue by attaching other dimensions.

6.4 Institutions

Institutions and actors within policy subsystems vary in the attention they pay to the various dimensions

After examining the change in salience of dimensions over time, I turned to the role of institutions in shaping issue definitions. Institutions help to structure policy subsystems through their expertise and jurisdictional scope. However, committees in Congress also attempt to gain influence into other subsystems buy leveraging their developed expertise. As Chapter 4 demonstrated, in both the House and the Senate, the UNF subsystem was anchored by one (or two) core committees, with other committees active on dimensions within their realm of expertise. This was most evidenced by the Transportation committees, that were more likely to focus on the transportation dimension.

Committees function as anchoring institutions in subsystems through expertise and jurisdiction, as noted, but also in their ability to control debate by selecting witnesses. Future research should examine whether differences existed between committees in the types of witnesses that they called. For example, were the core committees more likely to call on federal agencies and/or outside experts in an effort to make the most informed policy choices? Were the committees that were attempting to gain traction more likely to call interest groups or others also attempting to redefine the issue? A policymaking environment that consists of multiple institutions with competing jurisdictions, such as the UNF subsystem, offer institutional "opportunity structures" for strategic policy actors to attempt to redefine issues (Sheingate, 2006; Sabatier and Weible, 2007). Future work should examine the differences across committees in the types of witnesses they call on to testify.

In addition, it should be noted that the core committees (i.e., Energy and Commerce, Natural Resources) are those committees that are likely to large have jurisdictions, and therefore be involved in multiple subsystems (Baumgartner, Jones and MacLeod, 2000). As a result, future research should perhaps examine the various subcommittees active in a subsystem. Subcommittees are likely to have expertise and jurisdiction that is more narrowly focused within the subsystem. Therefore, it is likely that much of the work of issue defining occurs within subcommittees.

6.5 Policy Actors

Moving from institutions, Chapter 5 considered how policy actors attempt to define policy issues. The policy actors were aggregated into federal agencies, elected officials, interest groups (industry groups and environmental groups), state/local actors, outside experts, and a miscellaneous category. Several sets of hypotheses were tested regarding which dimensions would be highlighted by the various actors. The results, consistent with the hypotheses, showed that federal agencies found the programmatic, safety/regulation, and science/technical dimensions most salient; elected officials, environmental groups, and state/local actors found the site selection dimensions most salient; finally, industry groups found the storage dimension most salient.

The analysis in Chapter 5 compared aggregated groups, future research should examine intra-group differences. For example, the various federal agencies are likely to have differences in the dimensions they find most salient. The NRC and the EPA, the two agencies charged with regulating a UNF facility, are likely to find the safety/regulation dimension more salient than the DOE. Apart from intra-group differences, policy actors could be aggregated in different ways. For example, combining the issue definition model with the ACF, as discussed above, would aggregate the policy actors into coalitions, based on the dimensions they highlight.

While the evidence presented in Chapter 5 indicates that policy actors vary in the way they define issues, there are some reasons to think that the ability of policy actors to reframe or completely redefine an issue is limited. The first reason is that policy institutions have control over the sources of information from which they draw. For instance, Congressional committees decide what witnesses to call, which allows powerful committee members the ability to shape the debate (Jatkowski, 2012). The nature of who gets to testify should be considered (see Leyden, 1995), however substantive differences in dimension salience across policy actors remained even after controlling for the committee. This provides some evidence of the independent effect of policy actors in shaping the ways that issues are understood.

Apart from institutional constraints, policy actors are limited in their ability to shape issues by other policy actors. The nature of competition among policy actors can limit the ability of actors to ensure that their definition of the issue becomes most prominent. As seen in Chapter 5, policy actors varied in the dimensions they found most salient, yet it is not clear that any of these dimensions were the basis of any policy choice(s). In addition, policy actors are experts in their given issue areas, therefore are likely to be familiar with their own arguments, but also those of their opponents (Baumgartner et al., 2009). As noted in Chapter 4, institutions and institutional specialization help to create structure in the complex policymaking environment. This structure-induced stability is matched by an expertise-induced stability that exists within policy subsystems. This stability makes the task of shifting the issue space difficult for any one policy actor.

Bibliography

Austen-Smith, David and John R. Wright. 1994. "Counteractive Lobbying." *American Journal of Political Science* 38(1):25–44.

Basurto, Xavier, Gordon Kingsley, Kelly McQueen, Mshadoni Smith and Christopher M. Weible. 2010. "A Systematic Approach to Institutional Analysis: Applying Crawford and Ostrom's Grammar." *Political Research Quarterly* 63(3):523–537.

Baumgartner, Frank R. and Bryan D. Jones. 1993. *Agendas and Instability in American Politics*. Chicago, IL: University Of Chicago Press.

Baumgartner, Frank R. and Bryan D. Jones, eds. 2002. *Policy Dynamics*. Chicago, IL: University of Chicago Press.

Baumgartner, Frank R., Bryan D. Jones and Michael C. MacLeod. 2000. "The Evolution of Legislative Jurisdictions." *The Journal of Politics* 62(2):321–349.

Baumgartner, Frank R. and Christine Mahoney. 2008. "The Two Faces of Framing: Individual-Level Framing and Collective Issue Definition in the European Union." *European Union Politics* 9(3):435 –449.

Baumgartner, Frank R., Jeffrey M. Berry, Marie Hojnacki, David C. Kimball and Beth L. Leech. 2009. *Lobbying and Policy Change: Who Wins, Who Loses, and Why*. Chicago, IL: University Of Chicago Press.

Benford, Robert D., Helen A. Moore and J. Allen Williams. 1993. "In Whose Backyard?: Concern About Siting a Nuclear Waste Facility." *Sociological Inquiry* 63(1):30–48.

Blei, David M. 2012. "Probabilistic Topic Models." *Communications of the ACM* 55(4):77–84.

Blei, David M., Andrew Y. Ng and Michael I. Jordan. 2003. "Latent Dirichlet Allocation." *The Journal of Machine Learning Research* 3:993–1022.

Boehmke, Frederick J., Sean Gailmard and John W. Patty. 2013. "Business As Usual: Interest Group Access and Representation Across Policy-Making Venues." *Journal of Public Policy* 33(01):3–33.

Boscarino, Jessica E. 2009. "Surfing for Problems: Advocacy Group Strategy in U.S. Forestry Policy." *Policy Studies Journal* 37(3):415–434.

Boswell, Christina. 2012. "How Information Scarcity Influences the Policy Agenda: Evidence from U.K. Immigration Policy." *Governance* Forthcoming.

Brandt, Patrick T. and Todd Sandler. 2010. "What Do Transnational Terrorists Target? Has It Changed? Are We Safer?" *Journal of Conflict Resolution* 54(2):214–236.

BRC. 2012. Blue Ribbon Commission on American's Nuclear Future: Report to the Secretary of Energy. Technical report.

Breunig, Christian and Samuel Workman. 2010. Navigating the Dimensions of Policy Agendas. In *Annual Meeting of the American Political Science Association*.

Brewer, Garry D. and Peter deLeon. 1983. *The Foundations of Policy Analysis*. Homewood, IL: Dorsey Press.

Burstein, Paul. 2003. "The Impact of Public Opinion on Public Policy: A Review and an Agenda." *Political Research Quarterly* 56(1):29–40.

Capano, Giliberto. 2009. "Understanding Policy Change as an Epistemological and Theoretical Problem." *Journal of Comparative Policy Analysis: Research and Practice* 11(1):7.

Carpenter, Daniel P. 2001. *The Forging of Bureaucratic Autonomy: Reputations, Networks, and Policy Innovation in Executive Agencies, 1862-1928*. Princeton, NJ: Princeton University Press.

Carter, Luther J. 1987. *Nuclear Imperatives and Public Trust: Dealing with Radioactive Waste*. Washington D.C.: Resources for the Future, Inc.

Chib, Siddhartha. 1998. "Estimation and Comparison of Multiple Change-Point Models." *Journal of Econometrics* 86(2):221–241.

Clary, Bruce B. 1991. "The Enactment of the Nuclear Waste Policy Act of 1982: A Multiple Perspectives Explanation." *Review of Policy Research* 10(4):90–102.

Clary, Bruce B. and Michael E. Kraft. 1988. "Impact Assessment and Policy Failure: The Nuclear Waste Policy Act of 1982." *Review of Policy Research* 8(1):105–115.

Collingwood, Loren and John Wilkerson. 2012. "Tradeoffs in Accuracy and Efficiency in Supervised Learning Methods." *Journal of Information Technology & Politics* 9(3):298–318.

Cox, Gary W. and Mathew D. McCubbins. 2005. *Setting the Agenda: Responsible Party Government in the U.S. House of Representatives*. Cambridge: Cambridge University Press.

CQ Almanac. 1982. "Comprehensive Nuclear Waste Plan Enacted." *Congressional Quarterly Almanac* .

CQ Almanac. 1987. "Nevada Chosen to Receive Nuclear Waste." *Congressional Quarterly Almanac* .

CQ Almanac. 2000. "Clinton Rejects Legislation to Establish Temporary Nuclear Waste Dump Site." *Congressional Quarterly Almanac* .

CQ Almanac. 2002. "Bush, Hill Back Nuclear Waste Site." *Congressional Quarterly Almanac* .

CQ Researcher. 2011. "Managing Nuclear Waste: Should Spent Fuel be Stored at Yucca Mountain." *CQ Researcher* 21(4):73–96.

Crawford, Sue E. S. and Elinor Ostrom. 1995. "A Grammar of Institutions." *The American Political Science Review* 89(3):582–600.

deLeon, Peter. 1999. The Stages Approach to the Policy Process: What Has it Done? Where is it Going? In *Theories of the Policy Process*, ed. Paul Sabatier. Boulder, CO: Westview pp. 19–32.

Downs, Anthony. 1967. *Inside Bureaucracy*. Little, Brown and Company.

Duffy, Robert J. 1997. *Nuclear Politics in America: A History and Theory of Government Regulation*. Lawrence, KS: University of Kansas Press.

Enders, Walter and Todd Sandler. 1993. "The Effectiveness of Antiterrorism Policies: A Vector-Autoregression- Intervention Analysis." *The American Political Science Review* 87(4):829–844.

Epstein, David and Sharyn O'Halloran. 1999. *Delegating Powers: A Transaction Cost Politics Approach to Policy Making under Separate Powers*. Cambridge: Cambridge University Press.

Esterling, Kevin M. 2004. *The Political Economy of Expertise: Information and Efficiency in American National Politics*. Ann Arbor, MI: University of Michigan Press.

Esterling, Kevin M. 2011. "Deliberative Disagreement in U.S. Health Policy Committee Hearings." *Legislative Studies Quarterly* 36(2):169–198.

Feinerer, Ingo, Kurt Hornik and David Meyer. 2008. "Text Mining Infrastructure in R." *Journal of Statistical Software* 25(5).
URL: *http://www.jstatsoft.org/v25/i05*

Fenno, Richard. 1973. *Congressmen in Committees*. Boston, MA: Little, Brown and Co.

Gailmard, Sean and John W. Patty. 2007. "Slackers and Zealots: Civil Service, Policy Discretion, and Bureaucratic Expertise." *American Journal of Political Science* 51(4):873–889.

Gawande, Kishore and Hank Jenkins-Smith. 2001. "Nuclear Waste Transport and Residential Property Values: Estimating the Effects of Perceived Risks." *Journal of Environmental Economics and Management* 42(2):207–233.

Gawande, Kishore, Hank Jenkins-Smith and May Yuan. 2013. "The Long-Run Impact of Nuclear Waste Shipments on the Property Market: Evidence from A Quasi-Experiment." *Journal of Environmental Economics and Management* 65(1):56–73.

Gill, Jeff. 2002. *Bayesian Methods: A Social and Behavioral Sciences Approach.* Boca Raton, FL: Chapman & Hall/CRC.

Gilligan, Thomas W. and Keith Krehbiel. 1990. "Organization of Informative Committees by a Rational Legislature." *American Journal of Political Science* 34(2):531–564.

Griffiths, Thomas L. and Mark Steyvers. 2004. "Finding Scientific Topics." *Proceedings of the National Academy of Sciences* 101(Suppl 1):5228–5235.

Grimmer, Justin. 2010. "A Bayesian Hierarchical Topic Model for Political Texts: Measuring Expressed Agendas in Senate Press Releases." *Political Analysis* 18(1):1 –35.

Grimmer, Justin and Brandon M. Stewart. 2012. "Text as Data: The Promise and Pitfalls of Automatic Content Analysis Methods for Political Texts.".
URL: *http://www.stanford.edu/ jgrimmer/tad2.pdf*

Grimmer, Justin and Gary King. 2011. "General Purpose Computer-Assisted Clustering and Conceptualization." *Proceedings of the National Academy of Sciences* 108(7):2643–2650.

Hall, Richard L. and Alan V. Deardorff. 2006. "Lobbying as Legislative Subsidy." *American Political Science Review* 100(01):69–84.

Hardin, John W. 1998. "Advocacy versus Certainty: The Dynamics of Committee Jurisdiction Concentration." *The Journal of Politics* 60(2):374–397.

Hopkins, Daniel J. and Gary King. 2010. "A Method of Automated Nonparametric Content Analysis for Social Science." *American Journal of Political Science* 54(1):229–247.

Hu, Minqing and Bing Liu. 2004. Mining and Summarizing Customer Reviews. In *Proceedings of the tenth ACM SIGKDD international conference on Knowledge discovery and data mining.* p. 168177.
URL: *http://doi.acm.org/10.1145/1014052.1014073*

Huber, John D. and Charles R. Shipan. 2000. "The Costs of Control: Legislators, Agencies, and Transaction Costs." *Legislative Studies Quarterly* 25(1):25–52.

Jatkowski, Walter J. III. 2012. Subsystem Contexts and Policy Information: Conditional Effects on Information in Congressional Hearings Dissertation University of Oklahoma.

Jenkins-Smith, Hank C. 1990. *Democratic Politics and Policy Analysis*. Pacific Grove, CA: Brooks/Cole Publishing Company.

Jenkins-Smith, Hank C., Carol L. Silva, Matthew C. Nowlin and Grant deLozier. 2011. "Reversing Nuclear Opposition: Evolving Public Acceptance of a Permanent Nuclear Waste Disposal Facility." *Risk Analysis* 31(4):629–644.

Jenkins-Smith, Hank C. and Gilbert K. St. Clair. 1993. The Politics of Offshore Energy: Empirically Testing the Advocacy Coalition Framework. In *Policy Change and Learning: An Advocacy Coalition Approach*, ed. P. A. Sabatier and H. Jenkins-Smith. Boulder, CO: Westview.

Jenkins-Smith, Hank C., Gilbert K. St Clair and Brian Woods. 1991. "Explaining Change in Policy Subsystems: Analysis of Coalition Stability and Defection over Time." *American Journal of Political Science* 35(4):851–880.

Jochim, Ashley E. and Peter J. May. 2010. "Beyond Subsystems: Policy Regimes and Governance." *Policy Studies Journal* 38(2):303–327.

Jones, Bryan D. 1994*a*. "A Change of Mind or a Change of Focus? A Theory of Choice Reversals in Politics." *Journal of Public Administration Research and Theory* 4(2):141–177.

Jones, Bryan D. 1994*b*. *Reconceiving Decision-Making in Democratic Politics: Attention, Choice, and Public Policy*. Chicago, IL: University of Chicago Press.

Jones, Bryan D. 1996. Attributes, Alternatives, and the Flow of Ideas: Information Processing In Politics. In *Annual Meeting of the American Political Science Association*.

Jones, Bryan D. 2001. *Politics and the Architecture of Choice: Bounded Rationality and Governance*. Chicago, IL: University Of Chicago Press.

Jones, Bryan D. and Frank R. Baumgartner. 2005. *The Politics of Attention: How Government Prioritizes Problems*. Chicago, IL: University Of Chicago Press.

Jones, Bryan D., Frank R. Baumgartner and Erin de la Mare. 2005. "The Supply of Information and the Size of Government in the United States.".

Jones, Bryan D., Jeffery Talbert and Matthew Potoski. 2003. Uncertainty and Political Debate: How the Dimensionality of Political Issues Gets Reduced in the Legislative Process. In *Uncertainty in American Politics*, ed. Barry C. Burden. Cambridge: Cambridge University Press pp. 118–138.

Jones, Bryan D. and Michelle Wolfe. 2010. Public Policy and the Mass Media: An Information Processing Approach. In *Public Policy and Mass Media: The Interplay of Mass Communication and Political Decision Making*, ed. Sigrid Koch-Baumgarten and Katrin Voltmer. New York, NY: Routledge.

Jones, Charles O. 1984. *An Introduction to the Study of Public Policy.* 3rd ed. Fort Worth, TX: Harcourt Brace College Publishers.

Jones, Michael D. and Hank C. Jenkins-Smith. 2009. "Trans-Subsystem Dynamics: Policy Topography, Mass Opinion, and Policy Change." *Policy Studies Journal* 37(1):37–58.

Jones, Michael D. and Mark K. McBeth. 2010. "A Narrative Policy Framework: Clear Enough to Be Wrong?" *Policy Studies Journal* 38(2):329–353.

Kahan, Dan M., Donald Braman, Paul Slovic, John Gastil and Geoffrey L. Cohen. 2007. "The Second National Risk and Culture Study: Making Sense of - and Making Progress In - The American Culture War of Fact.".

Kahan, Dan M., Hank C. Jenkins-Smith, Tor Tarantola, Carol L Silva and Donald Braman. 2012. "Geoengineering and the Science Communication Environment: A Cross-Cultural Experiment.".

Kass, Robert E. and Adrian E. Raftery. 1995. "Bayes Factors." *Journal of the American Statistical Association* 90(430):773–795.

Kearney, Richard C. and Robert B. Garey. 1982. "American Federalism and the Management of Radioactive Wastes." *Public Administration Review* 42(1):14–24.

King, David C. 1997. *Turf Wars: How Congressional Committees Claim Jurisdiction.* Chicago, IL: University of Chicago Press.

Kingdon, John W. 1984. *Agendas, Alternatives and Public Policies.* New York, NY: Longman.

Kraft, Michael E. 1991. "Public And State Responses To High-Level Nuclear Waste Disposal: Learning From Policy Failure." *Review of Policy Research* 10(4):152–166.

Krause, George A. 2010. Legislative Delegation of Authority to Bureaucratic Agencies. In *The Oxford Handbook of American Bureaucracy*, ed. Robert F. Durant. Oxford: Oxford University Press pp. 521–544.

Krehbiel, Keith. 1991. *Information and Legislative Organization.* Ann Arbor: The University of Michigan Press.

Krippendorff, Klaus. 2003. *Content Analysis: An Introduction to Its Methodology.* 2nd ed. Thousand Oaks, CA: Sage Publications, Inc.

Krutz, Glen S. 2005. "Issues and Institutions: "Winnowing" in the U.S. Congress." *American Journal of Political Science* 49(2):313–326.

Laver, Michael, Kenneth Benoit and John Garry. 2003. "Extracting Policy Positions from Political Texts Using Words as Data." *The American Political Science Review* 97(2):311–331.

Leyden, Kevin M. 1995. "Interest Group Resources and Testimony at Congressional Hearings." *Legislative Studies Quarterly* 20(3):431–439.

Liu, Bing. 2012. *Sentiment Analysis and Opinion Mining*. San Rafael, CA: Morgan & Claypool Publishers.

Liu, Bing, Minqing Hu and Junsheng Cheng. 2005. Opinion Observer: Analyzing and Comparing Opinions on the Web. In *Proceedings of the 14th international conference on World Wide Web*. p. 342351.
URL: *http://doi.acm.org/10.1145/1060745.1060797*

Lowe, Will. 2008. "Understanding Wordscores." *Political Analysis* 16(4):356 –371.

Lowe, Will, Kenneth Benoit, Slava Mikhaylov and Michael Laver. 2011. "Scaling Policy Preferences from Coded Political Texts." *Legislative Studies Quarterly* 36(1):123–155.

Lowi, Theodore J. 1972. "Four Systems of Policy, Politics, and Choice." *Public Administration Review* 32(4):298–310.

Lupia, Arthur and Mathew D. McCubbins. 1994. "Learning from Oversight: Fire Alarms and Police Patrols Reconstructed." *Journal of Law, Economics, & Organization* 10(1):96–125.

MacGregor, Donald, Paul Slovic, Robert G. Mason, John Detweiler, Stephen E. Binney and Brian Dodd. 1994. "Perceived Risks of Radioactive Waste Transport Through Oregon: Results of a Statewide Survey." *Risk Analysis* 14(1):5–14.

Maltzman, Forrest. 1998. *Competing Principals: Committees, Parties, and the Organization of Congress*. Ann Arbor: The University of Michigan Press.

May, Peter J, Ashley E Jochim and Joshua Sapotichne. 2011. "Constructing Homeland Security: An Anemic Policy Regime." *Policy Studies Journal* 39(2):285–307.

McCool, Daniel. 1998. "The Subsystem Family of Concepts: A Critique and a Proposal." *Political Research Quarterly* 51(2):551–570.

Meier, Kenneth J. and Laurence J. O'Toole. 2006. "Political Control versus Bureaucratic Values: Reframing the Debate." *Public Administration Review* 66(2):177–192.

Moe, Terry M. 1981. “Toward a Broader View of Interest Groups.” *The Journal of Politics* 43(2):531–543.

Moser, Scott, John W. Patty and Elizabeth Maggie Penn. 2009. “The Structure of Heresthetical Power.” *Journal of Theoretical Politics* 21(2):139 –159.

Nasukawa, Tetsuya and Jeonghee Yi. 2003. Sentiment Analysis: Capturing Favorability using Natural Language Processing. In *Proceedings of the 2nd international conference on Knowledge capture*. p. 7077.

Nie, Martin. 2003. “Drivers of Natural Resource-Based Political Conflict.” *Policy Sciences* 36(3):307–341.

Niskanen, William A. 1971. *Bureaucracy and Representative Government*. Chicago, IL: Aldine Atherton.

Nowlin, Matthew C. 2011. “Theories of the Policy Process: State of the Research and Emerging Trends.” *Policy Studies Journal* 39(s1):41–60.

Ostrom, Elinor. 2007. Institutional Rational Choice: An Assessment of the Institutional Analysis and Development Framework. In *Theories of the Policy Process*, ed. Paul A. Sabatier. 2nd ed. Boulder, CO: Westview Press pp. 21–64.

OConnor, Brendan, Ramnath Balasubramanyan, Bryan Routledge and Noah Smith. 2010. From Tweets to Polls: Linking Text Sentiment to Public Opinion Time Series. In *Proceedings of the International AAAI Conference on Weblogs and Social Media*.

Park, Jong Hee. 2010. “Structural Change in U.S. Presidents’ Use of Force.” *American Journal of Political Science* 54(3):766782.

Poole, Keith T. and Howard Rosenthal. 1997. *Congress: A Political-Economic History of Roll Call Voting*. Oxford: Oxford University Press.

Porter, M. F. 1980. “An Algorithm for Suffix Stripping.” *Program: Electronic Library and Information Systems* 14(3):130–137.

Pralle, Sarah B. 2006. *Branching Out, Digging In: Environmental Advocacy and Agenda Setting*. Washington, D.C.: Georgetown University Press.

Quinn, Kevin M., Burt L. Monroe, Michael Colaresi, Michael H. Crespin and Dragomir R. Radev. 2010. “How to Analyze Political Attention with Minimal Assumptions and Costs.” *American Journal of Political Science* 54(1):209–228.

Redford, Emmette S. 1969. *Democracy in the Administrative State*. Oxford: Oxford University Press.

Riker, William H. 1984. “The Heresthetics of Constitution-Making: The Presidency in 1787, with Comments on Determinism and Rational Choice.” *The American Political Science Review* 78(1):1–16.

Riker, William H. 1986. *The Art of Political Manipulation*. New Haven, CT: Yale University Press.

Riker, William H. 1988. *Liberalism Against Populism: A Confrontation Between the Theory of Democracy and the Theory of Social Choice*. Long Grove, IL: Waveland Press.

Riker, William H. 1990. Heresthetic and Rhetoric in the Spatial Model. In *Advances in the Spatial Theory of Voting*, ed. James M. Enelow and Melvin J. Hinich. New York, NY: Cambridge University Press pp. 46–65.

Rochefort, David A and Roger W Cobb. 1993. "Problem Definition, Agenda Access, and Policy Choice." *Policy Studies Journal* 21(1):56–71.

Sabatier, Paul A. 1991. "Toward Better Theories of the Policy Process." *PS: Political Science and Politics* 24(2):147–156.

Sabatier, Paul A. 2007. *Theories of the Policy Process*. 2nd ed. Boulder, CO: Westview Press.

Sabatier, Paul A. and Christopher M. Weible. 2007. The Advocacy Coalition Framework: Innovations and Clarifications. In *Theories of the Policy Process*, ed. Paul A. Sabatier. Vol. 2nd Boulder, CO: Westview Press pp. 189–222.

Sabatier, Paul A. and Hank C. Jenkins-Smith. 1993. *Policy Change and Learning: An Advocacy Coalition Approach*. Boulder, CO: Westview Press.

Sabatier, Paul A. and Hank C. Jenkins-Smith. 1999. The Advocacy Coalition Framework: An Assessment. In *Theories of the Policy Process*, ed. Paul A. Sabatier. Boulder, CO: Westview pp. 117–166.

Sabatier, Paul and Matthew Zafonte. 1999. Are Bureaucrats and Scientists Members of Advocacy Coalitions? Evidence From An Intergovernmental Water Policy Subsystem. Economic Policy and Research Concerning Water Use and Watershed Management Workshop: .

Santifort, Charlinda, Todd Sandler and Patrick T. Brandt. 2013. "Terrorist Attack and Target Diversity : Changepoints and their Drivers." *Journal of Peace Research* 50(1):75–90.

Schattschneider, E. E. 1960. *The Semisovereign People: A Realist's View of Democracy in America*. Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

Schlager, Edella. 2007. A Comparison of Frameworks, Theories, and Models of Policy Processes. In *Theories of the Policy Process*, ed. Paul A. Sabatier. 2nd ed. Boulder, CO: Westview Press pp. 293–320.

Schneider, Anne and Helen Ingram. 1993. "Social Construction of Target Populations: Implications for Politics and Policy." *The American Political Science Review* 87(2):334–347.

Shanahan, Elizabeth A., Michael D. Jones and Mark K. McBeth. 2011. "Policy Narratives and Policy Processes." *Policy Studies Journal* 39(3):535–561.

Sheingate, Adam D. 2006. "Structure and Opportunity: Committee Jurisdiction and Issue Attention in Congress." *American Journal of Political Science* 50(4):844–859.

Shepsle, Kenneth A. 1979. "Institutional Arrangements and Equilibrium in Multidimensional Voting Models." *American Journal of Political Science* 23(1):27–59.

Shepsle, Kenneth A. 1989. "Studying Institutions: Some Lessons from the Rational Choice Approach." *Journal of Theoretical Politics* 1(2):131–147.

Shepsle, Kenneth A. 2003. "Losers in Politics (And How They Sometimes Become Winners): William Riker's Heresthetic." *Perspectives on Politics* 1(2):307–315.

Shepsle, Kenneth A. and Barry R. Weingast. 1981. "Structure-Induced Equilibrium and Legislative Choice." *Public Choice* 37(3):503–519.

Shepsle, Kenneth A. and Barry R. Weingast. 1987. "The Institutional Foundations of Committee Power." *The American Political Science Review* 81(1):85–104.

Siddiki, Saba, Christopher M. Weible, Xavier Basurto and John Calanni. 2011. "Dissecting Policy Designs: An Application of the Institutional Grammar Tool." *Policy Studies Journal* 39(1):79–103.

Siddiki, Saba, Xavier Basurto and Christopher M Weible. 2012. "Using the Institutional Grammar Tool to Understand Regulatory Compliance: The Case of Colorado Aquaculture." *Regulation & Governance* 6(2):167–188.

Simon, Herbert A. 1997. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations*. 4th ed. New York, NY: Free Press.

Smith, Kevin B. and Christopher W. Larimer. 2009. *The Public Policy Theory Primer*. Boulder, CO: Westview Press.

Spirling, Arthur. 2007. "Bayesian Approaches for Limited Dependent Variable Change Point Problems." *Political Analysis* 15(4):387–405.

Stewart, Charles. 2001. *Analyzing Congress*. New York, NY: W. W. Norton & Company.

Steyvers, Mark and Tom Griffiths. 2007. Probabilistic Topic Models. In *Handbook of Latent Semantic Analysis*, ed. Thomas K. Landauer, Danielle S. McNamara, Simon Dennis and Walter Kintsch. Taylor & Francis.

Stone, Deborah A. 1989. "Causal Stories and the Formation of Policy Agendas." *Political Science Quarterly* 104(2):281–300.

Talbert, Jeffery C., Bryan D. Jones and Frank R. Baumgartner. 1995. "Nonlegislative Hearings and Policy Change in Congress." *American Journal of Political Science* 39(2):383–405.

Talbert, Jeffery C. and Matthew Potoski. 2002. "Setting the Legislative Agenda: The Dimensional Structure of Bill Cosponsoring and Floor Voting." *The Journal of Politics* 64(3):864–891.

Tullock, Gordon. 1981. "Why so much Stability." *Public Choice* 37(2):189–204.

US Senate. 1980. "The Socioeconomic Effects of a Nuclear Waste Storage Site on Rural Areas and Small Communites.".

US Senate. 2004. "An Investigation into the Silica Exposure of Yucca Mountain Project Workers.".

Vandenbosch, Robert and Susanne E. Vandenbosch. 2007. *Nuclear Waste Stalemate: Political and Scientific Controversies*. Salt Lake City, UT: University of Utah Press.

Walker, J. Samuel. 2009. *The Road to Yucca Mountain: The Development of Radioactive Waste Policy in the United States*. Berkeley, CA: University of California Press.

Weible, Christopher M. 2008. "Expert-Based Information and Policy Subsystems: A Review and Synthesis." *Policy Studies Journal* 36(4):615–635.

Weimer, David L. 2005. "Institutionalizing Neutrally Competent Policy Analysis: Resources for Promoting Objectivity and Balance in Consolidating Democracies." *Policy Studies Journal* 33(2):131–146.

Weiss, Carol H. 1977. "Research for Policy's Sake: The Enlightenment Function of Social Research." *Policy Analysis* 3(4):531–545.

Western, Bruce and Meredith Kleykamp. 2004. "A Bayesian Change Point Model for Historical Time Series Analysis." *Political Analysis* 12(4):354–374.

Wilson, James Q. 1973. *Political Organizations*. New York, NY: Basic Books.

Wood, B. Dan and Alesha Doan. 2003. "The Politics of Problem Definition: Applying and Testing Threshold Models." *American Journal of Political Science* 47(4):640–653.

Workman, Samuel. 2009. Economizing Attention: Agenda Setting and the Influence of Bureaucracy in American Politics PhD thesis University of Washington. University of Washington; Ph.D.

Workman, Samuel, Bryan D. Jones and Ashley E. Jochim. 2009. "Information Processing and Policy Dynamics." *Policy Studies Journal* 37(1):75–92.

Workman, Samuel, Bryan D. Jones and Ashley E. Jochim. 2010. Policymaking, Bureaucratic Discretion, and Overhead Democracy. In *The Oxford Handbook of American Bureaucracy*, ed. Robert F. Durant. Oxford: Oxford University Press pp. 612–637.

Worsham, Jeff. 1998. "Wavering Equilibriums: Subsystem Dynamics and Agenda Control." *American Politics Research* 26(4):485 –512.

Worsham, Jeffrey. 2006. "Up in Smoke: Mapping Subsystem Dynamics in Tobacco Policy." *Policy Studies Journal* 34(3):437–452.

Young, Lori and Stuart Soroka. 2012. "Affective News: The Automated Coding of Sentiment in Political Texts." *Political Communication* 29(2):205–231.