Photocopy and Use Authorization

In presenting this dissertation in partial fulfillment of the requirements for an advanced degree at Idaho State University, I agree that the Library shall make it freely available for inspection. I further state that permission for extensive copying of my thesis for scholarly purposes may be granted by the Dean of the Graduate School, Dean of my academic division, or by the University Librarian. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature ____________________________________

Date ____

Emergence of Supportive State Nuclear Energy Policy in the 21st Century: Event History Analysis of Substantive and Symbolic Policy Adoption

by

Cheryl C. O'Brien

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Arts in the Department of Political Science

Idaho State University

Spring 2020

Committee Approval

To the Graduate Faculty:

The members of the committee appointed to examine the dissertation of CHERYL C. O'BRIEN find it satisfactory and recommend that it be accepted.

James W. Stoutenborough, PhD

Major Advisor

Donna L. Lybecker, PhD

Committee Member

Kellee J. Kirkpatrick, PhD

Committee Member

Steven E. Aumeier, PhD

Committee Member

Sarah Robey, PhD

Graduate Faculty Representative

Acknowledgements

It’s my privilege to acknowledge the many individuals who willingly invested time and interest in my academic career and the production of this dissertation. First, thank you to all the Political Science faculty, and my graduate committee: Dr. Lybecker, our Department Chair and champion of students; Dr. Kirkpatrick, American politics specialist and gifted teacher; Dr. Aumeier, a former colleague at the Idaho National Lab and nuclear and energy technical and policy expert; Dr. Robey, an energy and atomic history scholar and thoughtful lecturer; and posthumously, Dr. Jacobsen who served as my Engineering Dean through undergraduate years, Chief Scientist during my engineering career, and Associate Director of the Center for Advanced Energy Studies during my graduate studies.

I am indebted to my Major Advisor, Jim Stoutenborough, who shares my interest in science and technology policy, and taught my methods classes and additional techniques necessary for this dissertation. Dr. Stoutenborough coupled his sense of humor with high expectations allowing me to complete the Doctor of Arts Program with just enough encouragement to keep me going, while nudging me to do more, better.

Finally, I am thankful to my friends who cheered me on, and my family (especially Barry) who really made this possible.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Abbreviations

AEC	Atomic Energy Commission
CFR	Code of Federal Regulations
DOE	Department of Energy
ISO	Independent System Operator
kWh	kilowatt-hour
NRC	Nuclear Regulatory Commission
RTO	Regional Transmission Organization
UN	United Nations

Emergence of Supportive State Nuclear Energy Policy in the 21st Century:

Event History Analysis of Substantive and Symbolic Policy Adoption

Dissertation Abstract – Idaho State University (2020)

Since the Three Mile Island nuclear accident in 1979, nuclear energy has had little growth in the U.S. Cost and schedule overruns coupled with declining public support brought an end to new plants for decades. Then, in the 2000s, 31 states adopted supportive nuclear energy policy in an era of rising public support, and continued to do so even with dropping support after the Fukushima Daiichi nuclear accident. Even states with moratoriums on new nuclear plants adopted supportive policy; some even repealed moratoriums. Theory supported by a wealth of policy research suggests that policy adoption generally reacts to changes in public opinion. Is nuclear energy an exception? Are economics overwhelming attitudes? Are attitudes toward nuclear energy changing? This study applies event history analysis between 2002 and 2019 and logistical regression comparing 2003 data to 2018, to help explain what is happening. The results indicate that states are responding to public opinion, once policy content is examined. States adopt substantive policy when support is rising, but when support falls, adopt policy that is more symbolic – reassuring interest groups without offending the general public. Economic reasons matter, but attitudes, which may be shifting with concerns for climate change, make policy possible.

Key Words: energy policy, nuclear energy, nuclear power, public opinion, trust in government, state policy, policy diffusion, substantive policy, symbolic policy

CHAPTER I

Introduction

Despite stalled growth and association with major accidents that refuse to fade in collective memory, commercial nuclear energy in the U.S. is not a failed industry. It produces almost 20% of the U.S. electrical energy, more than half of all greenhouse gas-free energy, enjoys a stellar safety record, and is by far the most productive energy source with a capacity factor (ratio of energy output over time to maximum possible) of 92% (EIA 2019a; EIA 2019d). It also has a downside of unresolved radioactive waste storage problems, newsworthy accidents, an association with atomic weaponry, and high capital costs that hamper economic competitiveness.

Favorability of nuclear energy in the U.S. has vacillated between its attractions and drawbacks in response to attitudes over time. Over a 60-plus year history of commercial power production, the image of nuclear energy has alternated between the promise of the future with energy "too cheap to meter," and as a dangerous menace forced on the people by an overzealous government. A surge of plant orders occurred in the 1960s as the federal Atomic Energy Commission promoted nuclear power to utilities as a money maker, and also an environmental solution to land-intensive dams and sky-darkening fossil fuels. Enthusiasm waned in the 1970s and 1980s as utilities incurred construction cost overruns, scientists questioned safety, and the public grew suspicious of government cover-up of inadvertent radioactive exposure from weapons testing fallout. Public protest movements arose in the 1960s and 1970s, and an accident at Three Mile Island in Pennsylvania in 1979 marked a turning point for the industry when an "impossible" partial core meltdown resulted in confused utility and government emergency response (Zaretsky 2018). Nuclear energy was vilified as not only dangerous, but as an ultimate polluter with radioactive waste decaying for centuries (Hall and Kerr 1991).

Nuclear power has stalled since the 1980s. Seventeen state governments enacted moratoriums with various conditions, preventing development of new nuclear power plants (NCSL 2017). Although over 50 plants came online in the 1970s and 40 in the 1980s, only five new plants were started in the 1990s. Then, around 2000, Middle East political instability and global climate change concerns led to reconsideration of nuclear power as an abundant energy source and a feasible replacement for greenhouse gas emitting fossil fuel plants (Samuel 2017). Public support rose, and a nuclear renaissance was projected, creating renewed purpose in a safe, mature nuclear industry. But, a tsunami in Japan in February of 2011 resulting in meltdowns and hydrogen explosions at the Fukushima Daiichi plant reversed public opinion. Public support for nuclear energy had been on the rise since 2000, but began a downward trend in 2011 (see Figure 1.1), indicating more Americans opposed than supported nuclear power by 2016 (Bisconti 2016; Reinhart 2019). With rising competition from lower cost and faster to build natural gas plants, and job growth potential from popular solar and wind installations, the future of nuclear power is once again in question.

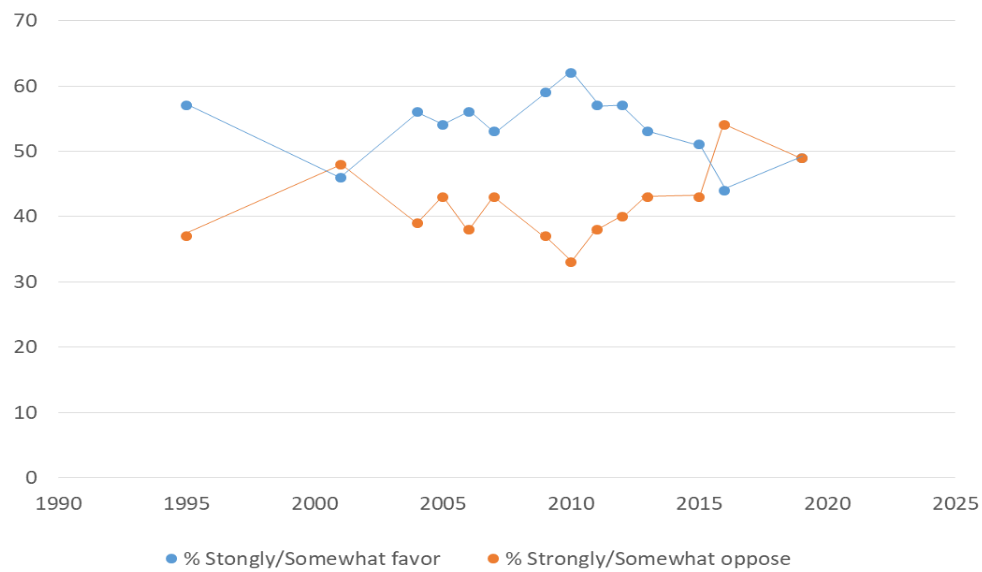

Figure 1.1 Gallup poll results: Overall, do you strongly favor, somewhat favor, somewhat oppose or strongly oppose the use of nuclear energy as one of the ways to provide electricity for the U.S.?

Source: Gallup annual Environment Poll (Reinhart 2019)

Policy tends to respond to public opinion, especially if the issue is salient (Burstein 2003; Page and Shapiro 1983). During the period of public protest and disapproval in the 1970s and 1980s, state legislatures passed measures to effectively prohibit addition of nuclear power plants (NCSL 2017). When public support once again increased, Congress passed an Energy Policy Act in 2005 offering loan guarantees for advanced nuclear reactors and cost overrun support for up to six new nuclear power plants in response to energy security concerns. States adopted supportive nuclear energy policy; three states even overturned previous moratoriums on new nuclear plants (NEI 2019). Public support then dropped back to 1990's levels after the well-publicized Fukushima Daiichi accident in 2011. However, a wave of state legislation decrying nuclear energy did not occur. In fact, as shown in Figure 1.2, after the accident, states continued to pass supportive legislation encouraging consideration of nuclear in their energy portfolios, and establishing financial incentives to keep existing nuclear plants operating. It appears that factors other than public opinion must be influencing adoption of supportive nuclear energy policy.

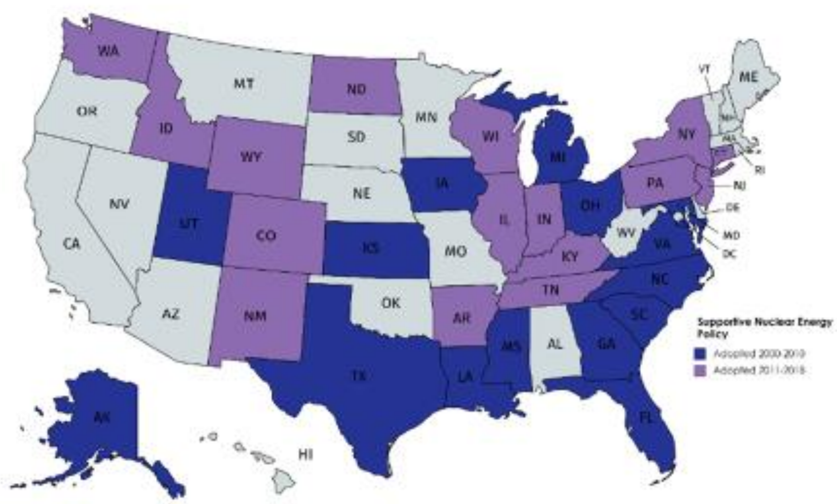

Figure 1.2 States adopting supportive nuclear energy policy after 2000
Source: Nuclear Energy Institute, 2019

What is behind this state level trend? Why does policy appear to respond to public opinion before the Fukushima Daiichi accident but not after? Are the usual indicators of state legislative trends - economics, social determinants and policy diffusion - able to explain this development? This project evaluates what factors influence states adopting policy favorable to nuclear energy such as encouraging new plants, protecting existing plants, and repealing moratoriums, despite trends in public opinion.

Why this Research Matters, and Research Questions

Understanding why states are adopting supportive nuclear energy policy despite public opinion matters on two levels. First, on a theoretical level, policy adoption tends to align with public opinion, especially as opinion is shifting. Nuclear energy policy adoption may prove to be an exception, leading to new insight into the relationship between public opinion and policy adoption.

Page and Shapiro (1983) produced much cited research in the 1980s measuring policy adoption and public opinion. The researchers compared public opinion data to federal policy adoption over 40 years. Page and Shapiro conclude that "public opinion is often a proximate cause of policy, affecting policy more than policy influences opinion" especially for "large, stable opinion changes on salient issues" (Page and Shapiro 1983, 175). Twenty years later Burstein (2003) reviews research that followed, finding Page and Shapiro's assertions remain valid for more contemporary policy adoption, and for about 75% of policy studied. On the state level, scholars find that policy reflects public opinion on a specific issue if it is measurable or otherwise readily apparent (Laz and Phillips 2012). Hogan (2008) finds that state legislators supporting legislation largely incongruent to constituent opinion are more likely to face a challenger in the next election. If states are adopting supportive policy as public support declines, nuclear energy policy could be an exception.

The second level is practical. Nuclear energy does provide advantages that may become important, especially if new reactor technologies can relieve concerns for safety, cost, and waste management. Perhaps emerging concerns that nuclear energy could alleviate are motivating legislators to pass policy not popular with the public. Possible, but not likely. Circumstances would need to be serious and compelling for a legislator who wants to get re-elected to pass policy contrary to public opinion.

Perhaps the states should let nuclear energy die a natural death and leave nuclear power production and expertise to other nations. Even when public support is increasing nuclear energy is not overly popular. Since the Fukushima Daiichi accident in 2011, public support has been trending downward, although a Gallup poll indicates a slight rebound to 49% approval in 2019 (see Figure 1.1) (Reinhart 2019). Forty-nine percent approval is still a long way from public acceptance considering that support for nuclear power plants polls similarly to support of fracking and coal mining (Pew 2016).

Nuclear plants are reaching end of life decision points. The U.S. fleet of reactors is aging beyond their original design life, and without new orders for decades, few replacements are in the pipeline. Manufacturing facilities with the equipment and expertise to construct large, high quality components needed for nuclear reactors have been lost to Korea and other emerging powers pursuing nuclear energy, including China and Russia (DOE 2020). Replacing nuclear with other energy sources is tempting as natural gas plants are much faster to construct, and wind and solar installations provide abundant jobs and are popular with the public (DOE 2017; Funk and Hefferon 2019). Public opinion on nuclear energy is ambivalent at best, considerable investment is required to rebuild domestic construction capacity, and regulation drives risk for investors. Perhaps state legislation does not matter, because so much must be overcome to revive the industry.

There are arguments for maintaining nuclear power as part of the US energy mix. One is to prevent loss of technical leadership to competitor nations that are leveraging nuclear energy's benefits for economic gain. Another is an "all of the above" approach to energy production in the U.S., where diversification of energy sources lends economic stability, as fuel and production markets rise and fall, and energy independence is valued (DOE 2020). A particularly compelling reason is concern for global climate change. The United Nations Intergovernmental Panel on Climate Change reports evidence that current concentrations and ongoing emissions of greenhouse gases could lead to irreversible damage to global ecosystems (IPCC 2013; IPCC 2018). The effort needed to preserve food production and life globally is described in the Paris Agreement organized by the United Nations Framework Convention on Climate Change (UNFCCC 2016). Agreed upon near Paris in 2015 and signed in 2016, the goal of the Paris Agreement is to keep the increase in global average temperature to well below 2 degrees Celsius over pre-industrial temperatures, limiting overall increase to 1.5 degrees Celsius. This translates to a near-term goal of leveling greenhouse gas production, and a long-term goal of net-zero emissions.

There are multiple approaches to achieving near-term and long-term climate change goals. For example, this can be a mix of increasing non-emitting renewables, carbon capture and sequestration, and energy efficiency. On the surface, it might appear that improvement in these areas could at least hold greenhouse gas emissions steady. However, as Rogelj and colleagues (2016) point out, just reducing emissions may be insufficient. If the temperature of the earth must be held within 2 degrees Celsius of pre-industrial levels, the implication is that there is a finite amount of greenhouse gas that can be emitted in the atmosphere. If so, the only logical goal is net-zero emissions. For the U.S., this means capturing and sequestering all greenhouse gas emissions from fossil fuels (including vehicles), or reaching 100% zero emission energy sources. Without effective capture and sequestration technology, increasing nuclear power as a zero emission energy source could be a meaningful alternative. Nuclear energy is perhaps the only U.S. option for producing utility scale electrical energy on demand (unlike wind and solar), with zero emission status (unlike coal and natural gas), that can be expanded in any location (unlike hydropower). Consequently, political leaders might pursue nuclear energy policy as it may matter a great deal.

States play an important role in energy planning and production in the U.S. They have siting and oversight authority and can pass legislation preventing or encouraging development of nuclear energy. As increasing partisanship stalls progress in national policy (Andris et al. 2015; Fleisher and Bond 2004), states are reinventing themselves as policy leaders (Carley 2011, Konisky and Woods 2018). Consequently, understanding what drives state legislators to pursue positive or negative legislation matters, because the stakes of climate change are high. Often, public opinion provides insight into legislative action. However, states adopting supportive policy as public support declines indicates other factors are in play. Internal determinants such as economic or social characteristics unique to states, or external determinants, such as policy diffusion, may provide explanation. States may determine whether or not nuclear energy has a future in the U.S., so state level policy adoption is studied.

This study seeks to understand why states are adopting policy on nuclear energy that does not appear to align with public opinion. Influences found in literature on economics, attitudes and public opinion, state structures, and policy diffusion are paired with states with different initial policies on nuclear energy adopting different types of policy. Four research questions are offered:

1. How do economic considerations influence state nuclear energy policy adoption?
2. How do attitudes and public opinion influence state nuclear energy policy adoption?
3. How do state government structures influence state nuclear energy policy adoption?
4. How does policy diffusion influence nuclear energy policy adoption?

To address each question, theory is tapped, quantitative event time history and other regression analyses are designed and conducted, results are reported and conclusions drawn. A chapter arises from each of these steps.

Organization of Dissertation

In this study, a chapter is devoted to sequential steps of the project. First, a brief history of nuclear energy in the U.S. is provided in Chapter 2, which includes an explanation of events that made nuclear energy salient and led to public opinion influencing the nuclear energy industry. Next, Chapter 3 reviews theory related to state policy adoption and nuclear energy. Theory informs the research questions above and aids the development of influences to evaluate. Chapter 4 describes quantitative statistical modeling to help answer the research questions. The analytical approach describes the logic behind the selection of dependent variables and the statistical methods, and also the coding of independent variables for establishing relationships with dependent variables. Chapter 4 reports the results of the quantitative analyses. Finally, Chapter 5, the Conclusion, analyzes the quantitative results given expectations formed from relevant theory. This chapter summarizes the overall findings for each research question, identifies options for future research, and offers final observations on theoretical and practical implications of this study.

With this organization in mind, concepts from each chapter are introduced, beginning with a historical perspective on nuclear power in the U.S.

Historical Perspective

The emergence and evolution of nuclear power in the U.S. followed a distinctly different path from other energy fuel sources. Unique circumstances brought attention to state legislators who responded with policy. By the end of the 20th century, 17 states had adopted moratoriums on new nuclear plants. Comparing that number to three states only recently adopting moratoriums on even less popular new coal fired plants suggests how differently nuclear energy is treated by state legislatures. Chapter 2 explains how an a-typical path to becoming a mature, utility scale power source contributes to influences such a public opinion, economics, environmental attitudes and interest group development unique to nuclear power that matter at a state level.

Unlike other energy sources, the nuclear industry did not emerge through private enterprise, but as a government program (Balogh 1991; Weart 2012). Chapter 2 describes how nuclear power originated from the massive, secret Manhattan Project military research program, culminating with the atomic bombing of Hiroshima and Nagasaki in 1945, with destructive force far beyond conventional weapons. Seventy years later, nuclear energy is still associated with atomic bombs (Butler et al. 2011; Crosby 2006), establishing a visual reference for the public unique to nuclear energy.

Chapter 2 explains why nuclear power is perceived as risky, impacting its acceptance by the public (Weart 2012, Wellock 1998). The inability to sense radiation makes the public dependent upon the industry and government for protection. Trust in government eroded mid-century with the cover up by the Atomic Energy Commission (AEC) of the extent of radioactive fallout from atomic testing, and the Three Mile Island accident (O'Neill 1994; Zaretsky 2018). Interest groups on both sides of the nuclear energy issue arose with standoffs between utilities, government programs and public opposition. There is little history in the fossil or renewable fuel energy industries to compare to the loss of trust the U.S. public has experienced with nuclear power.

As a federally sponsored program, states were initially left out of the loop. Siting decisions were made by the AEC with utility partners and little collaboration with state governments or local communities (Wellock 1998). This led to citizen backlash and increasing salience as public protests attracted media attention. The inability of the AEC as both promoter and regulator to address public concerns over siting, operational safety, and waste disposal resulted in public resentment of a seemingly undemocratic process, and states soon stepped in establishing their own regulatory offices and new policies in response to constituent concerns.

Chapter 2 explains how nuclear power's quick rise as the energy of the future "too cheap to meter," eroded over several decades as poor public relations resulted in public distrust, accidents increased fear, and increasing regulation and cost and schedule overruns made investors anxious. Nuclear power industry development reflects public opinion with a surge of growth when the public saw promise, but a rapid decline in new plants once the public soured. But as public support increased in the 2000s, investors once again submitted construction and operating licenses requests to the Nuclear Regulatory Commission (NRC) for new plants. This history contributes to current public opinion, economic viability, attitudes, and interest group activity specific to nuclear energy to which states respond. Chapter 2 expands upon how the history of nuclear power, including public opinion, has shaped these factors.

To understand state actions, theory on policy adoption is explored. This is the focus of Chapter 3.

Theories on State Energy Policy Adoption

Literature identifies multiple explanations of how policy is adopted. Economics and behavioral science are often emphasized when studying public policy (Amir et al. 2005). Chapter 3 explores policy theory identifying factors with the highest likelihood of influencing nuclear energy policy.

States adopt policy intended to maximize their economic standing (Hwang and Gray 1991), and nuclear energy is likely to have economic impact on state revenues. The $250B electric utility industry is the largest industry in the U.S. (Heiman and Solomon 2004). The utility industry also represents jobs: 1.9 million as of 2016 (DOE 2017). Not only is energy a taxable commodity, but enables industry. States pursue energy production to fuel other industry sector growth (Bekareva et al. 2017).

Chapter 3 explains why maintaining current levels of electrical production is important to states. States are losing production capacity with the retirement of coal fired and nuclear power plants (DOE, 2017; EIA, 201c). Older, less efficient coal plants have been shut down, resulting in a drop in coal fired plants by 47% since 2008 (Jell and Bowman 2018). Nuclear plants, mostly built in the 1970s and 1980s, are reaching their licensed life span, and face investment in retrofits and licensing application costs to continue operating. Minimally, this capacity needs replacement if states seek economic stability and growth (Bekareva et al. 2017).

If a primary purpose of state government is to provide developmental policies, economics may play an important role in legislative action. Literature reveals what economic elements are most likely to drive specific legislature influencing economic standing.

In addition to policy adoption for economic growth and stability, states adopt policy addressing social needs or demands. Chapter 3 explains how theory suggests states adopt policy for behavioral reasons, such as attitudes and public opinion.

As scholars assert, public policy is often adopted in response to known public concerns, especially if an issue is salient and shifting (Burstein 2003; Goss and Kamieniecki 1983; Page and Shapiro 1983). Consequently, state legislators should be motivated to respond to issues salient with the public. State legislators are likely to assess the importance of issues in the eyes of the public, and address those issues with policy.

On the surface, nuclear energy may not seem to be a particularly salient issue if compared to issues such as immigration or health care. However, nuclear energy policy may address salient 21st century issues, one of which is climate change. Chapter 3 explains how climate change is an important issue to the U.S. public, especially if they believe they will personally feel impacts, or fear for the nation (Konisky and Woods 2018; Rabe 2004). State legislators are likely to be seeking policy solutions in response to public concerns for climate change, and may view nuclear energy as climate change policy. Nuclear energy is considered a zero carbon emitting electrical energy source, so supportive legislation could be adopted in response to public climate change concerns. But, nuclear energy is also perceived as dangerous. The public may have concerns about how a nuclear energy accident, storage of waste, or proliferation of weapons grade materials might impact them personally, or the nation collectively. This risk must be weighed against perceived consequences of climate change.

Nuclear energy attitudes may reflect either negative perception of nuclear energy as a dangerous polluter, or positive perception as a climate change solution. Without a national waste repository or technical solutions, nuclear waste likely remains an environmental concern, but the zero-emissions aspect of nuclear power could provide a reason to accept nuclear energy. Chapter 3 explores attitudes in depth, including indicators that will theoretically contribute to attitudes specific to environmental or climate change concerns.

In addition to economic, and social (public opinion and attitudes) influences, Chapter 3 addresses how the structure of state governments may explain legislative outcomes. The structure determines how the state government operates. For example, states have a role in managing utilities and electrical power production and transmission and may establish a Public Utilities Commission, or fund a state energy office with varying responsibilities. A well-funded state may be more able to establish and fund administrative oversight, or have the spending discretion to offer financial incentives to promote a policy of interest, such as nuclear energy.

Theory suggests internal determinants of economics and interest groups, attitudes and public opinion, and state structure may influence nuclear energy policy adoption. No study of state policy adoption is complete without addressing external influences, by applying policy diffusion theory.

Scholarship has developed theories on how policy diffusion occurs (Berry and Berry 2007). States pursuing policy addressing a specific issue may originate policy language, or they may look to other states to see what policy has been adopted, and how effective it has been. They may then choose to imitate the policy, emulate it, or write competing policy (Karch 2007; Mesequer 2006; Oxley and Stoutenborough 2012). This behavior is driven by external determinants reflecting a state's relationships beyond its boundaries (Berry and Berry 2007). For example, in the 1970s, California was the first state to adopt a moratorium on new nuclear power plants. Between public protests and escalating construction costs, nuclear energy fell out of favor (Butler et al., 2011, Ramana, 2011), and within two decades, 16 additional states adopted moratoriums. Moratoriums share common language establishing hurdles before nuclear plants can be considered. These include existence of a national repository for high level waste, citizen votes to allow new plants, and evidence that new facilities are economically feasible for rate payers. Similarities in moratorium language is evidence that policy diffusion may have occurred.

Chapter 3 explores the theoretical literature on public opinion, economics, interest groups, environmental and climate change attitudes, state structures and policy diffusion in depth. These multiple influences add complexity to understanding policy adoption. To understand why a state might adopt supportive nuclear energy policy, a quantitative approach is applied as described in Chapter 4.

Quantitative Analytical Approach

Between 2000, and 2019, 31 states adopted what the Nuclear Energy Institute (2019) describes as supportive nuclear energy legislation and regulations. Of these, three states have reversed their moratoriums on new nuclear plants. Four have maintained their moratoriums, but adopted policy supportive of their existing nuclear power industry. This activity represents a surge in support for nuclear power that on the surface is difficult to explain given public opinion. To add clarity, a quantitative approach is taken. Statistical techniques are applied to subdivisions of policy types and moratorium status as dependent variables to seek relationships quantitatively.

Of the 31 states adopting supportive nuclear energy policy, the policy content can be described as “strong” or “soft.” Identifying policies as either “strong” or “soft” for this study provides a gradation representing level of commitment. States are adopting policy despite declining public support, and gradation adds fidelity to help explain why. The distinction between strong and soft is designed to suggest what could be substantive policy, or symbolic policy respectively.

To distinguish between these levels, strong policy is defined as policy described in a Nuclear Energy Institute report (NEI 2019) as either approving siting or operation of a specific nuclear plant, or offering a financial incentive specific to nuclear energy. For example, if policy describes mechanisms to recover capital costs of a new nuclear plant by charging customers increased rates over time, that state would be adopting strong supportive policy. Soft policy is defined as policy that encourages nuclear power in some form, but does not offer financial incentives specific to producing nuclear power commercially. Examples are including nuclear energy as an option for future planning, or tax relief for nuclear reactor research but not for a commercial project. A summary of this supportive legislation by states since 2003 is provided in Appendix A.

Figure 1.3 shows how the 50 US states fall into policy scenarios as of 2019.

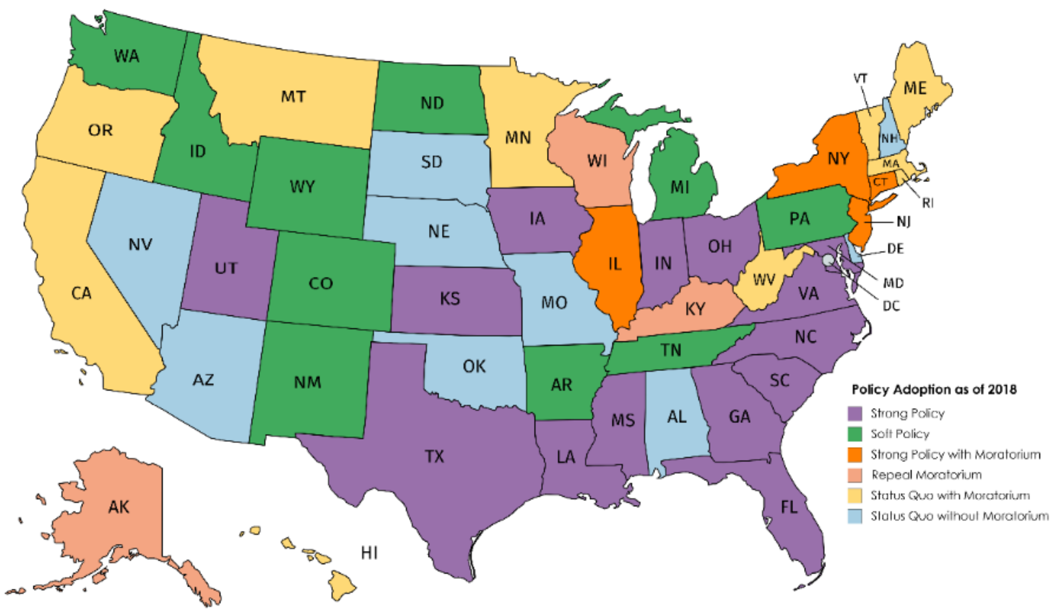

Figure 1.3 Supportive nuclear energy policy scenarios, yearend 2018

Source: Nuclear Energy Institute, 2019

At first glance, this assortment of type of policy adoption whether by a state with or without moratoriums provides little insight into why which states might adopt what policy, or no policy. There is little congruence or contrast with either the central or coastal states, mountain or plains states, or eastern or western states. An exception is southeastern coastal states adopting strong supportive policy in 2019. An explanation could be alignment of these states with existing nuclear power plants, provided in Figure 1.4.

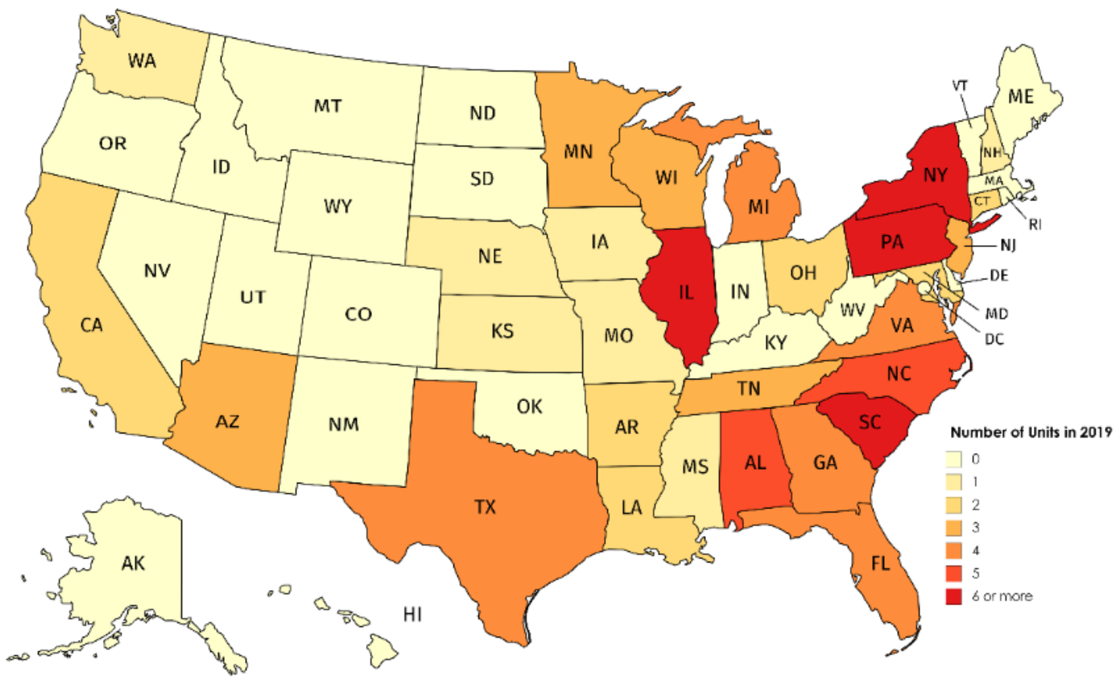

Figure 1.4 States with nuclear power plants in 2019

Source: Nuclear Regulatory Commission, August 2019

Figure 1.4 shows that southeastern coastal states have considerable nuclear energy capacity which might influence similar policy adoption. However, the states bordering the Great Lakes do too, yet their policy adoption is not consistent. Without obvious reasons why which states would adopt what policy, a quantitative approach is designed.

Because the dependent variables are defined by type of policy adopted given moratorium status over a period of time, this study benefits from the application of event history analysis. Since the 1990s, discrete event history analysis has become the accepted approach to modeling events of policy adoption (Buckley and Westerland 2004). Changes in various influences over a period of time lends better prediction of the event of policy adoption. This approach is derived from duration, or survival analyses, often used in the medical, insurance, and finance fields. Survival analysis focuses on the probability of an event occurring without possibility of reoccurring, measuring time elapsed until the event occurs. The events are discrete, as in dichotomous: either policy is adopted, or it is not. A health survival example is death of a patient (discrete event that happens once), in a logical time interval (months or years), regressed with influencing variables such as gender and type of treatment.

The dependent variables for the study are defined by various policy scenario subsets, as shown in Figure 1.5. Note that at the highest level, state policy adoption is designated by either adoption, or status quo. Policy is then separated into subsets. All policy adoption is binned as either all strong policy, or all soft policy. This is further subdivided by all policy adopted by states with moratoriums, followed by a further subdivision of either states with moratoriums adopting strong policy, or states repealing moratoriums. As suggested by Figure 1.5, the seven outcomes below the line are of most interest as they provide more fidelity. These scenarios of type of policy adopted, or maintaining policy status quo, by states both with and without moratoriums form the dependent variables for the quantitative analysis.

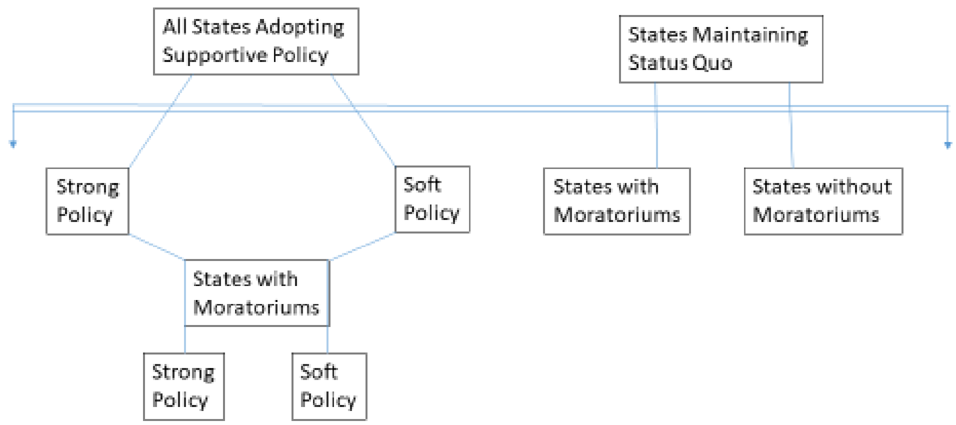

Figure 1.5. Supportive policy subsets

These dependent variables are not exclusive by state. The definition of dependent variables allow some states to be included in multiple dependent variable scenarios. For example, Illinois is included in states adopting soft policy, and again in states adopting strong policy when it followed its soft policy adoption two years later with strong policy. It is also included in the subset of states with moratoriums adopting strong legislation. Table 1.1 clarifies how states are represented per policy type and moratorium scenarios.

Table 1.1 Supportive nuclear energy policy scenarios for dependent variables

Strong Policy	Soft Policy	Strong Policy but maintains moratorium	Repeals moratorium	Status quo with moratorium	Status quo without moratorium
Connecticut Florida Georgia Illinois Indiana Iowa Kansas Louisiana Maryland Mississippi New Jersey New York North Carolina Ohio South Carolina Texas Utah Virginia	**Alaska Arkansas Colorado Idaho Illinois Kentucky Michigan New Mexico North Dakota Pennsylvania Tennessee Washington Wisconsin Wyoming**	**Connecticut Illinois New Jersey New York**	**Alaska Kentucky Wisconsin**	**California Hawaii Maine Massachusetts Minnesota Montana Oregon Rhode Island Vermont West Virginia**	**Alabama Arizona Delaware Missouri Nebraska Nevada New Hampshire Oklahoma South Dakota**

The event history analyses include policy adopted between 2002 and 2019. This time span is selected as it represents a triggering event of the passage of the Energy Policy Act in 2005 with favorable language for nuclear power, plus a few years to develop trends in influences. It also represents years-to-date flanking the Fukushima Daiichi accident, with rising national public opinion support for nuclear energy before 2011, and declining support following the accident. Theoretically, policy should reflect public opinion (Burstein 2003; Goss and Kamieniecki 1983; Page and Shapiro 1983), so less policy should be adopted after 2011 as national public opinion drops. In fact, of the 31 states adopting supportive policy after 2000, roughly half of them do so after 2011, the year of the Fukushima Daiichi accident. Including equal duration of time before and after 2011 provides data on policy adopted during periods of both increasing and decreasing public support.

As already described, Chapter 3 explores theoretical bases of various influences on supportive state nuclear energy policy adoption consistent with background on the development of nuclear energy provided in Chapter 2. Of multiple possible influences, four theoretical areas inform research questions and independent variables. Theory suggests that economics, including energy production, job creation, interest group activity and market structures may align with state policies. Attitudes and public opinion toward nuclear energy, particularly as reflected through ideological values which include risk perception and trust in government, are also likely to impact state policy. Structural elements, such as citizen initiatives and general fund revenues, theoretically may impact type of policy a state adopts. Finally, evidence of policy diffusion may provide understanding of external determinants, or influences. These influences represent independent variables for the study. Chapter 4 includes a discussion on how these variables are identified and coded for the statistical models.

Chapter 4 explains how strong or soft policy adopted, or status quo maintained, by states with and without moratoriums, form dependent variables. Data are collected for independent variables reflecting measurements as suggested by theory to be most influential: economics, attitudes and public opinion, structure of the state government, and policy diffusion. The outcomes of these models are reported in detail in Chapter 5, Results.

Results

Quantitative results are reported in Chapter 5. A total of nine models representing the seven most informative dependent variables and several baseline dependent variables for comparison result in multiple statistically significant relationships. Model fit statistics are reported, and each statistically significant relationship is identified and interpreted for analysis.

Finally, Chapter 6 provides a discussion of the quantitative results given theoretical expectations. Findings for each research question are summarized, and suggestions for further research are presented.

Findings

As discussed in Chapter 6, Conclusion, the study reveals that supportive nuclear energy policy adoption is likely influenced by economics, attitudes and public opinion, but little evidence emerges indicating influence of state government structure or policy diffusion explanations for supportive nuclear energy policy adoption.

The theoretical contribution of this study is that ultimately, Page and Shapiro's assertion that policy responds to public opinion is upheld, but only after subdividing dependent variables into type of policy adoption. This finding is explained in Chapter 6, and indicates that policy adoption studies to assess alignment with public opinion may benefit from more fidelity in policy type. Gradations in policy content may reveal alignment with public opinion that is not otherwise readily apparent.

The practical contribution of this study is a finding that attitudes may be at least as important and perhaps more important than economic determinants regarding nuclear energy policy. This could be both not terrible, but also not great for the nuclear industry. This study finds some quantitative evidence outside of opinion polling that attitudes toward nuclear energy may be aligning nuclear energy with zero emissions status. However, nuclear energy has a long association not only with radioactive waste and safety concerns, related to trust in government and industry.

New technologies may produce safer and more cost effective plants with more manageable waste streams, but unless trust in government and the nuclear industry can be repaired, realizing growth in nuclear energy production may face insurmountable hurdles.

Chapter II

Nuclear Power in the U.S.

The history of nuclear power in the U.S. is no mystery, but it is worth a review as a reminder that the emergence and evolution of nuclear power followed a distinctly different path from other energy fuel sources, leading to unique politicization. Nuclear power is the only energy source evolving from a massive weapons development program, and the only source to create enough controversy to motivate 17 states to adopt moratoriums on new nuclear plants. (Only three states have adopted moratoriums on new coal fired plants.) Nuclear plant accidents are enduring household terms: Three Mile Island, Chernobyl, Fukushima. Natural gas explosions, or even dam failures, are remembered in vague terms. The literature suggests that government promotion of nuclear power, heightened public awareness from nuclear weapons, and loss of trust in regulators has shaped today's realities for nuclear power. This path is a story of economics, attitudes and public opinion, and importantly, state government action.

Economics of Nuclear Energy

Nuclear power grew out of geopolitical concerns, not economic opportunity. Unlike industrial era private investment in fossil and hydro powered dynamos, nuclear power was developed with government funding, and promoted for government purposes (Balogh 1991; Weart 2012). Between 1939 and 1945 the U.S. Federal government spent $2 billion (23 billion in 2018 dollars) on the massive and secret Manhattan Project proving the energy capacity of nuclear fission, culminating with the atomic bombing of Hiroshima and Nagasaki in 1945. These bombs brought an end to World War II, but changed security dynamics forever (Ambrose and

Brinkley 2011; Weart 2012). The U.S. public, initially relieved that the war was over, soon realized a new reality of mutually assured destruction once the Soviet Union developed competing weapons. As a political strategy to coordinate control of nuclear technology globally, and create support within the U.S. for continued atomic development, Eisenhower launched the Atoms for Peace program in 1953 (Balogh 1991; Weart 2012). Atoms for Peace assisted international allies with nuclear technology while developing domestic applications, one of which was nuclear power generation.

The government messaging in the 1940s and 1950s on nuclear power was one of economic promise. Plentiful and low cost nuclear power would bring utopia, where Americans lived in style and luxury (Weart 2012). The Atomic Energy Commission (AEC), established in 1946, was tasked with development and regulation of all things nuclear. Staffed with and led by Manhattan Project professionals, the AEC expanded nuclear weapons development, and sought peripheral uses of the atom, including nuclear medicine and power. Congress encouraged the private sector to access nuclear technology through the AEC and build power plants with the passage of the Atomic Energy Act of 1954. Despite heavy marketing by AEC leadership, only the military appeared to take interest in nuclear energy, experimenting with submarine propulsion and nuclear aircraft. The needs of the Nuclear Navy was enough to develop private manufacturing expertise and infrastructure, and manufacturers became eager to leverage their investment into private markets (Balogh 1991; Weart 2012). With the help of federal subsidies, and risk reduction legislation of the Price-Anderson Nuclear Industries Indemnity Act in 1957, the AEC partnered with utilities and investors to create a nuclear power industry. Nuclear submarine light water reactor designs developed by the Navy were scaled up for commercial power production.

Utilities eventually had economic reasons to embrace nuclear power. As a new technology, nuclear power held too many risks for private investors. But electrical demand was doubling every decade in the first half of the century, and uranium was predicted to become the lowest cost fuel source given rising coal prices (Davis 2012; Weart 2012). In 1964, General Electric, with blessings from the AEC, made an economic case for nuclear power. Their financial experts announced that nuclear power provided cheaper power per kilowatt-hour (kWh) than fossil competitors in lifecycle evaluations (Balogh 1991; Weart 2012). Both Westinghouse and General Electric competed for a surge of contracts to build nuclear power plants. 21 plants were operating by the end of the decade, and another 56 came on line by the end of the 1970s.

Nuclear plant profits were hampered by an evolving regulatory environment (Davis 2012; Nichols and Wildavsky 1991). As the industry emerged, operational experience revealed design flaws. Proposed plant designs underwent extensive design and licensing safety reviews taking multiple years to complete. With the surge of orders and construction in the 1960s and 1970s, investors asked for regulatory relief in order to optimize economics. Investors wanted to take advantage of economies of scale with larger nuclear plants, and save transmission infrastructure costs by locating plants in metropolitan areas, near the consumers. The AEC, cognizant of the need to avoid accidents, could only impose more quality requirements such that any cost savings were consumed by additional design and construction expenses. Every major accident, Three Mile Island, Chernobyl, and Fukushima Daiichi, has resulted in new inspections and evaluations, and often retrofits for operating reactors.

Regulations drive high construction costs. As reactors were sized to take advantage of economies of scale, so too did critical components:

> The sheer scale of commercial-sized nuclear reactors means that most components must be specially designed and constructed, often with few potential suppliers worldwide. These components are then assembled on site, and structures are constructed to house the assembled components. All stages of design, construction, assembly, and testing require highly-skilled, highly-specialized engineers (Davis 2012, 53).

NRC design requirements are extensive (Nichols and Wildavsky 1991). Components critical to safety such as reactor vessels, coolant valves and pumps, instrumentation and controls, and containment structures must be sourced from qualified suppliers who carefully track source materials, storage, handling, and manufacturing processes to ensure designated quality (CFR 2019). Design is dependent upon site characteristics, such as potential for earthquakes, volcanoes, tsunamis, wildfires, tornadoes, blizzards, flooding, and hurricanes, leading to little opportunity to standardize designs and engineering studies. Davis (2012) provides data indicating that construction costs for plants built in the 1970s varied between $1,000 and $3,000 (2010 dollars) per kilowatt of capacity, then rose as high as $7,000 by the end of the 1980s. Davis' data do not include inflation and finance costs from delays which further increased costs. Reactors built in the 1970s and 1980s took an average of almost three times longer than those built in the 1950s, largely attributed to regulatory changes and reviews and citizen law suits (Balogh 1991; Davis 2012; Kraft et al. 1993). It became clear to investors by the end of the century that the capital costs and risks of nuclear energy had prevented the shining utopian image promoted in the 1950s (Davis 2012). Extensive regulation for design, quality control, construction, licensing, and operation (Nichols and Wildavsky 1987) contributed to high capital cost, and investor risk beyond other energy sources (Feinstein 1989).

In the 21st century, nuclear energy once again held economic promise. Natural gas prices were at a nearly all time high, and legislation taxing carbon emissions looked possible. In the 1990s, the NRC attempted to reduce design costs and investor risk by offering pre approval of standard reactor designs, early site permitting, and combined construction and operating license applications (Kraft et al. 1993). The Energy Policy Act in 2005 included production tax credits and loan guarantees through the U.S. Department of Energy (DOE) for new reactors. In 2006 and 2007, the NRC received 17 license applications for 24 new reactors. A renaissance looked possible, but was stalled when natural gas prices dropped, Congress failed to pass carbon emissions legislation, and the Fukushima Daiichi accident reminded the public about their fears of nuclear power (Davis 2012). After all, Chernobyl could be excused due to design flaws and Russian government incompetence, but Japan is a technically advanced nation (Butler et al. 2011). Fifteen years after the Energy Policy Act of 2005, only one project is under construction.

Public Opinion Pendulum

The public was accepting of nuclear power in the 1950s, but support diminished with loss of public trust in the AEC during the 1960s and safety and environmental concerns in the 1970s. The Three Mile Island accident in 1979, and the NRC’s inability to direct response, became a tipping point for public opinion (Zaretsky 2018). Only at the turn of the century did support for nuclear power begin to rise.

In the 1950s, the AEC was actively promoting nuclear power. Not only would nuclear power provide endless, cheap power, but it was clean. In 1952, London experienced a weather pattern settling a blanket of coal particulate smog on the city, killing 4,000 people. U.S. cities were also polluted; “Pittsburgh was suffocating in smog” (Weart 2012, 91). Not only was air quality a public concern in the 1950s but the public was growing increasingly concerned over siting of hydropower projects (Wellock 1998). Nuclear energy was a potential solution to air pollution and land intensive dams. Trust in scientists and experts was high, and utopian promises were hard to resist. Polls in the 1950s indicated the public had bought in to the government promotion of nuclear power with public support.

Public support began to shift, but initially not due to reactor safety concerns. The AEC was promoting nuclear power, but that represented less than 10% of its total budget in the mid-1950s. The primary focus of the AEC was continued weapons development. Nuclear power, waste management, and nuclear medicine were fringe interests. This would lead to a public relations crisis connecting nuclear power oversight to weapons testing mismanagement. The AEC oversaw the development and testing of increasingly powerful hydrogen bombs, and miscalculated both technical parameters, and public awareness. The Castle Bravo detonation in the South Pacific resulted in an explosion roughly 1,000 times more powerful than the Hiroshima and Nagasaki bombs, and twice as powerful as predicted by AEC scientists. Japanese fishermen out of range of the pre-test prediction impact area developed radiation sickness, creating an international incident. Later weapons tests on the US mainland also overshot predictions, with radioactive fallout reaching communities hundreds of miles away. Citizens soon learned that not only had the AEC failed to correctly understand their test parameters, but denied the extent of contamination. The AEC's "father-knows-best" reassurances became offensive to the public. Technical and communication misjudgments severely diminished public trust in the nuclear regulating authority, and public support for nuclear power (O'Neill 1994; Wellock 1998; Weart 2012).

Nuclear power is viewed by the public as risky (Ramana 2011). Thanks to the Maximum Credible Accident developed by the AEC to assure the public they had thought of every contingency, the public began to associate nuclear plant accidents with weapons and radioactive fallout. Waste streams, although volumetrically minimal compared to coal waste streams, are radioactive and are linked to cancer. Radiation cannot be sensed, so instrumentation must be used to detect and measure radioactivity. Radioactivity can be long lasting, and radiation had been linked to cancer and genetic mutations by the 1950s. Although wastes from fossil fuels are also health threats, people can see and smell air pollution and ash piles, and take some action to avoid them. The inability to sense radiation coupled with potentially serious health consequences makes radioactive contamination particularly "dreaded" (Slovic 1987; Weart 2012). The public is solely dependent upon utilities and government for protection. Nuclear accidents have serious consequences: not only potential for health impacts, but environmental contamination with social displacement and economic consequences (Butler et al. 2011). Nuclear waste is stored temporarily at reactors without means of permanent disposition, leading to uncertainty of future contamination issues. If that is not enough to worry about, uranium enrichment and some spent fuel products have potential to produce weapons grade nuclear materials, which could be stolen and misused. The public found many reasons to be wary of nuclear energy, and the ability of utilities and the government to manage risks.

It was in this environment that ideological views of nuclear energy began to form. During the early days of utopian promise, both liberals and conservatives supported nuclear energy. But as fears of radiation sickness from testing fallout grew, those fears translated to nuclear power generation whether small emissions from operations, or radioactive waste from disposal of spent fuel and contaminated materials. Liberals, with egalitarian values, saw nuclear power as an environmental threat to health and ecosystems. Conservatives did not deny the health hazards of radioactive contamination, but with traditional values such as respect for authority, were more accepting of weapons testing as a means to national security, and nuclear power as economic potential. All citizens relied on the regulatory capability of the federal government for protection from accidents and releases, but conservatives were more likely to trust those institutions. Eventually, attitudes against nuclear power became identified more strongly with liberal Democrats. In the 1960s, as trust in government diminished, both Democrats and Republicans reduced support for nuclear power.

It was not until the 1970s that public opinion polls indicated serious concerns for nuclear plant safety (Balogh 1991). Throughout the 1960s, citizens mobilized nationally against nuclear weapons testing until it was banned later that decade. This diminished much of the citizen movement, but some turned their efforts to protesting nuclear power, and were particularly successful in mobilizing communities targeted for nuclear plants. California protests, for example, initially focused on scenic conservation. (Pacific Gas & Electric preferred siting nuclear plants on coastal sites to take advantage of ejecting coolant water into the ocean.) Residents with expensive coastal homes (Angela Lansbury and Bob Hope) objected to impacts on property values (Wellock 1998). Scholars argue that because conservation and NIMBY objections were not enough to stop powerful utilities, AEC, and complacent California Public Utilities Commission, citizens countered with environmental objections such as threats to fisheries from heated water. Opposition to nuclear power gained momentum once geophysicists questioned adequate seismic fault mapping, and university scientists questioned emergency coolant component design, which was enough for the AEC to cancel several reactor projects in California (Weart 2012; Wellock 1998). Eventually, AEC was confronted with radioactive waste disposition in addition to safety concerns on a national stage. Public opinion in the 1970s aligned with safety concerns (Rosa and Freudenburg 1993). “Disgust at the thought of nuclear wastes could easily transfer into moral disgust, a belief that the nuclear officials responsible for waste were unreliable or dishonest” (Weart 2012, 174).

In an effort to regain public confidence, Congress replaced the AEC (serving conflicting roles of regulator and promoter) with a more neutral NRC in 1974, and moved weapons program management to DOE (Davis 2012). The NRC would regulate commercial nuclear power, radioactive materials, storage and disposal of spent fuel, licensing and inspection of reactors. This would be an independent commission, intended to be apolitical. However, five years later, a partial meltdown of reactor number 2 of the Three Mile Island Nuclear Generating Station set public opinion on a negative trend. The NRC was ineffective in coordinating emergency response with the utility and state officials, providing inconsistent information, and triggering a belated evacuation of some residents, later shown to likely be unnecessary

(Zaretsky 2018). A downturn in public opinion combined with unfavorable economics quelled further construction permits and license requests for nuclear reactors. Although over 20 new plants already in process came online in the 1980s, no new plants came online the following 30 years.

Few public opinion polls are found to reflect public attitudes toward nuclear energy in the 1990s. However, Gallup has consistently polled on nuclear power plant support since 2000, showing consistent increases in support, but only until 2011 (Reinhart 2019). Analysists attribute the Fukushima Daiichi nuclear accident to the downward trend in public opinion, to the point that nuclear power plants are about as popular with the public as fracking. By the time of the Three Mile Island accident in 1979, state governments were taking action to respond to citizen concerns.

Evolving State Government Role

In 1976, citizens in California had had enough. Threatened with an upcoming ballot on a citizen initiative highly restrictive of nuclear power, the California legislature passed a moratorium on new nuclear plants in California until a federal solution to nuclear waste management is found (Wellock 1998). Other states followed, and by the end of the century, a total of 17 states had moratoriums on new nuclear plant construction. These statutes were similar, requiring federal high level waste disposal or reprocessing (California, Connecticut, Illinois, Maine, Oregon, West Virginia), approval by state commissioner or legislature (New Jersey, Hawaii, Illinois, Maine, Rhode Island, Vermont) or voter approval (Maine, Massachusetts, Montana, Oregon). These conditions on new plants suggest that legislators were responding to concerns for public safety and health, and sufficient state oversight.

In the 1950s, state governments were largely left out of the regulatory loop. Nuclear energy was initially developed and promoted by the federal government through Atoms for Peace projects. Atomic experts felt that nuclear power could only be managed by a centralized authority due to technical complexity. The AEC was able to maintain centralized control because they employed most of the nuclear physics expertise. This changed, however, in the 1970s as commercial plants were planned, and utilities and manufactures developed their own expertise. This expertise also expanded into state government, especially natural resources agencies, as citizens and scientists questioned environmental impacts of injecting heated water into waterways or contamination of crops and livestock. As citizens complained to their local authorities about how little legal recourse they had in the siting of nuclear plants and other management decisions, state governments became more active. Early nuclear power adopters such as California, formed state level commissions and passed legislation to provide more state intervention between citizens and the AEC.

Congress deferred to states by allowing states to assume some nuclear regulatory authority under the 1954 Atomic Energy Act. States were allowed to license byproducts such as radioisotopes, fuel sources including uranium and thorium, and some special nuclear materials (Balogh 1992). This power allowed states to participate in waste storage decisions, and veto shipments from other states. States also used their power to grant or deny proffered federal funding to impact nuclear power industry in their states, require environmental impact statements, and use taxation authority to either encourage or repulse nuclear power plant investments (ESGI 2017; Forza 2010; WNA 2020). In addition, states manage emergency response, and play a key role in nuclear safety decisions that may impact nearby residents (NRC nd).

States regulate energy production, transmission and distribution within their states regardless of energy source. Most states either have public utilities commissions to regulate traditional utilities, or they have chosen to restructure utilities to provide more competition. States participate in regional organizations, choosing to provide power to citizens on a cost-plus basis or real time wholesale markets, such as operated by Regional Transmission Organizations. State government has a role in ensuring consistent, competitively priced power for citizens, business and industry.

Given questionable economic viability, and lackluster public demand, why would states start developing supportive policy after the turn of the century? States are likely responding to concerns for energy security, and growing concern for global climate change.

Energy security is both a national and a state issue. The U.S. emerged from multiple 1970's energy crises triggered by political events in oil rich nations outside the U.S. by applying diplomacy, price stabilization, fuel reserves, and energy efficiency. In the 1990s, the Gulf War involving Saudi Arabia, Kuwait, and Iraq created new concerns for U.S. energy security. Domestically, at the turn of the century, deregulation learning curves and market manipulation by energy commodities companies, drought, and delays in bringing new capacity on line caused energy shortages and large-scale blackouts at the turn of the century. The federal government, state governments, and utilities sought production security, which nuclear power might deliver.

Nuclear plants provided 20% of US electrical power in 2000 (IAEA 2001), and were “cash cows” because capital costs had been recovered since coming online in the 1970s and 1980s. But these plants were reaching their 40 year design life and requiring 20 year life extensions, or facing shutdown. State leaders may have needed policy that would protect their existing fleet of nuclear plants, or allow new generation.

Between 2000 and 2020, four commercial nuclear reactors have shut down (NEA 2018; NRC nd) largely due to market conditions (Shea and Hartman 2017). Other plants struggled in restructured, whole-sale markets until state governments stepped in with legislation. For example, when Exelon announced the intended closures of the Clinton Power Station by 2017, and Quad Cities plant in 2018, the Illinois state government adopted SB 2814 providing Zero Emissions Credits making the plants economically viable.

Finally, concerns for climate change became front page news in the early 1990s (Kraft et al. 1993; Revkin 2018). Nuclear power could be part of a plan to reduce carbon emissions (Klinsky and Dowlatabadi 2009). Nuclear power may have only contributed 20% of the total electrical power production, but in 2000, it represented as much as 70% of all carbon free electrical production, with little wind and solar power contribution at the time.

Nuclear power’s image as the energy of the future “too cheap to meter,” failed to materialize as regulation and other events conspired to keep construction costs high, and the AEC mismanaged their role as both promoter and regulator of nuclear power, losing the trust of the public. Other emerging energy industries, wind and solar, have also been promoted by the government, enjoying substantial subsidies, but unlike nuclear power, construction costs have decreased, and public support has increased such that there is public demand. Hydropower dam failures, natural gas explosions, and coal mining accidents have caused hundreds to thousands of deaths of both civilians and workers, while no deaths from commercial nuclear power plant accidents have occurred in the U.S. But, only nuclear power is associated with massive destructive power, given its birth from the nuclear weapons program. Mismanagement of nuclear weapons testing, and radioactive waste concerns eroded public support over several decades as increasing government regulation and cost and schedule overruns made investors anxious. Lack of public partnerships resulted in establishment of state oversight and moratoriums unique to nuclear energy. This history shapes current public opinion, economic viability, environmental associations, and interest group activity that impacts state energy policy. Chapter 3 reviews literature and theory on influences that shape state policies.

Chapter III

Influences on State Policy Adoption

"WHEREAS, Idaho has the potential to become a regional and global leader in the development of advanced reactors including small modular reactor technology;" Idaho Executive Order No. 2018-07, March 2018

"WHEREAS, Illinois' nuclear power plants are an enormous economic engine for the State, employing more than 5,300 workers across 43 counties in high-paying jobs that average 36% above local wage rates, with a total direct payroll in Illinois of $550 million a year;" Illinois House Resolution 1146, May 2014.

"WHEREAS, In addition to the reliability, security, grid resilience and economic attributes, Pennsylvania's fuel-secure baseload nuclear power plants also provide more than 93% of this Commonwealth's emissions-free electricity and are the only emissions-free, predictable and reliable electric generation source;" Pennsylvania S.B 227/H. B. 576 January, 2017

"WHEREAS, The threat of radioactive water could be devastating to Michigan's tourism and agriculture industries. Roughly 124 million travelers come to Michigan each year, and many potential tourists may be discouraged from a trip to the Great Lakes, creating severe economic hardship for the state's vast tourist destinations. Michigan's agriculture industry, which adds more than $100 billion to the state economy annually, is dependent on Great Lakes water for irrigation. Polluted water used for irrigation could contaminate

agricultural crops and livestock in the state and cause serious harm to the well-being of the general public;" Michigan Senate Resolution 92, 2019

Having established that nuclear energy's unique past helped formulate an active role for state governments, understanding what influences state action is necessary to determine why states adopted supportive nuclear legislation after 2000. Theory on state government is important for understanding what might influence legislators and executives to support certain types of policy.

The examples of policy language above reflect the many factors that may influence nuclear energy policy – whether positive or negative. Policy could be influenced by generic influences, like saving jobs, or less obvious factors such as protecting tourism or becoming a research leader. All these examples represent perhaps hundreds of possible influences. However, literature indicates that some influences are more likely to be relevant to nuclear energy policy adoption than others.

Economics and behavioral science are often addressed when studying public policy and policy adoption (Amir et al. 2005). At the state level, two lines of inquiry may be used to explain state government action: what are internal determinants, and is diffusion occurring (Berry and Berry 2015). Internal determinants are described as political, economic or social characteristics unique to a state. Literature focuses on not only economics, but behavior such as response to local public opinion, interest groups, and environmental attitudes. Consequently, the influences studied for this research include local public opinion, economics, interest group involvement, and environmental and climate change attitudes. Policy diffusion theoretical approaches are based on external factors relating to relationships between states and other levels of government. States may be in competition, or states may have similar problems and look to see what policies other states are trying. Some state are by nature more likely to experiment with policy, and if effective, become policy innovation leaders. Internal determinants are reviewed and diffusion is considered to assess policy influence. In addition, the structure of the state government is evaluated for impact on legislative behavior. Theoretical bases for these influences are reviewed.

Economics

If local governments are primarily economic developmental-allocational-redistributive actors (Peterson 1981), so too are states (Hwang and Gray 1991). State governments are developmental, adopting policy intended to maximize their economic situation (Hwang and Gray 1991). Allocational policies are viewed as those neither hurting nor helping a state's economy – just routine functions. Redistributive polices are those that improve social conditions (help low-income citizens, protect the environment), sometimes at economic expense. State legislators pursue developmental policies in particular to attract support for re-election by growing economic sectors, and expanding the overall economic pie. Integral to a strong economy is availability of reliable electrical power (Bekareva et al. 2017). Legislatures are likely to adopt energy policy that increases economic viability.

Not all economic development projects are popular. Scholars frequently study local politics on issues with clear divisions within a community. As Sharp and Alex-Assensoh (2005) suggest in a study of city governments formulating statues on morality issues such as gambling, if there is a buck to be made, economics can win even over core moral value objections. If nuclear energy presents a strong economic opportunity, other influences such as environmental attitudes and public opinion may be second to the economic interests.

To understand economic opportunities for nuclear power, electrical power capacity, fuel source cost, job competition, market structures, and possible interest group pressures are discussed.

Electrical Power Capacity

Electrical demand grew in the U.S. during the 20th century culminating with the energy crisis in the 1970s when demand exceeded supply. The U.S. took action to secure energy production, and although demand continued to increase for decades, electricity sales leveled out in 2007, largely attributed to energy efficiency (Woodward 2019). In 2018, demand once again increased by 4%. This increase, however, is not due to electric vehicles, or to population growth as in previous decades, but to weather (Woodward 2019). The Energy Information Administration reports that cold winters and a hot 2018 summer drove demand to power heating and cooling in both residential and commercial sectors, while industrial demand decreased (Woodward 2019). 2019 projections indicate that electrical consumption may continue to increase due to growth in housing and commercial floor space given an improved economy (Woodward 2019). However this rate is expected to be less than 0.05% per year as technology continues to increase energy efficiency (Woodward 2019). Consequently, electricity is not a big growth industry. The electrical industry is likely to be focused on maintaining production, rather than increasing production, as electrons cannot be stockpiled.

Maintaining production will be important to state governments as electricity is considered an essential service in the U.S., enabling commerce and a high standard of living. Adequate and reliable electricity is essential for economic stability (Bekareva et al. 2017). States are losing production capacity with the retirement of coal fired and nuclear power plants (DOE 2017; EIA 2017d). Older, less efficient coal plants have been shut down, resulting in a drop in coal fired plants by 47% since 2008 (Jell and Bowman 2018). Nuclear plants, mostly built in the 1970s and 1980s, are reaching their licensed life span, and face investment in retrofits and licensing application costs to continue operating. Minimally, this capacity needs replacement.

State legislators may care about ensuring adequate and reliable electrical power, but with the exception of a few (Hawaii, Alaska, Texas) states are not self-sufficient. Three extensive, interconnected transmission grids cover the contiguous U.S. states and much of Canada. The Western, Eastern and Texas grids serve to equalize supply and smooth alternating current waves providing consistency and reliability from multiple plants in multiple locations. Quality does not vary; a customer in one state receives essentially the same product as a customer in another state within the same grid. Consequently, price of power is a determining factor, especially because low price is related to economic growth (Bekareva et al. 2017).

Price per kilowatt-hour differs by energy source, and the risks that different energy sources represent. In 2019, electricity in the US was generated with multiple fuel sources. Most was generated using natural gas (37%), followed by coal at 24%, nuclear at 19%, wind and hydropower each at 7%, and solar at 3% (EIA 2019d). Comparing generation costs is complicated by various factors. For example, in a lifecycle cost analysis, fuel cost, capital construction cost, operating and maintenance cost, waste management and decommissioning costs all contribute. These costs vary per fuel source. Wind, solar, and hydropower (excepting diversion of water resources from other industries) have no fuel cost. In 2019, natural gas and coal fuels prices per unit of energy produced were roughly \$3/mmBtu (dollars per million British Thermal Units). Nuclear fuel cost is considerably less at around \$0.75/mmBtu (EIA 2020). But if construction costs are compared, nuclear energy represents by far the highest upfront development and capital costs due to extensive safety studies required for NRC licensing and certification, and the need for large, high quality manufactured components (Davis 2012; Shea and Hartman 2017). Hydropower capital cost can also be considerable for a large dam. Capital costs for solar and wind have been a high portion of total cost given low energy output per solar panel or wind turbine in the past, but as these markets grow, costs have fallen (EIA 2020).

Differences in operating and maintenance costs are less comparable. Some fuel sources are more efficient than others, as indicated by capacity factors. Capacity factors reflect the percent of time the plant is able to produce power, given maintenance downtime and fuel availability. Nuclear has by far the highest capacity factor at 92%. Natural gas and coal follow at about 55%, hydropower at 38%, wind at 35% and solar 25% (DOE 2017). Fuel availability can be an issue with wind and solar power, and even hydropower is dependent on precipitation, while nuclear and fossil fuels are currently abundant or can be stockpiled. However, waste management and decommissioning of nuclear and fossil fuel plants contribute to costs that wind and solar avoid. Consequently, life cycle cost assessment of various fuel sources when evaluated for fuel cost, capital investment and operations, maintenance, and disposition is complex.

In addition to calculating life cycle costs, risk must be factored into financial investment decisions. For example, fuel prices for natural gas, coal, and nuclear energy can vary per supply and demand, taxes, tariffs, etc. Although fuel price is not an issue for wind and solar, consistent supply is as these sources are dependent upon uncontrollable natural conditions. Even natural gas production depends on uninterrupted delivery through pipelines that may be undersized as demand grows. Fuel for coal and nuclear plants (and to some extent hydropower with pumped storage) have the ability to store fuel reserves on site, an advantage for reducing fuel supply and price risk.

Nuclear energy is perceived as a high risk investment due to an extensive regulatory environment, and concerns for component availability (Davis 2012; Morgan et al. 2018). Regulation requires certified suppliers to ensure quality, and the US has lost much of this capacity. The 400 suppliers and 900 N-stamp holders (qualified fabricators) available in 1987 have dropped to 80 and 200 respectively in 20 years (Harding 2007). Other risks associated with nuclear plants are safety and liability. Although commercial nuclear power plants in the U.S. have an outstanding safety record (zero direct fatalities from accidents), accidents outside the U.S. have had devastating social impacts to citizens with extended evacuations, and loss of local economies (Butler et al. 2011, Ramana 2011). Investors have concern for liability. Nuclear plants in the US are currently covered by the Price-Anderson Nuclear Industries indemnity Act. This act was first passed in 1957 and protects commercial nuclear industry from liability claims. Initially adopted to encourage development of a young industry, as a mature industry this protection may be lifted, as it expires in 2025. Multiple risks must be considered by investors.

Fuel Source Competition

Energy source pricing and risk assessment, consequently, is complicated. However, in the 21st century, energy providers are replacing lost nuclear and coal capacity with natural gas (EIA 2020). Natural gas is utility scale, and extraction technologies such as fracking, plus a lack of carbon tax, has led to lower prices for new natural gas electrical generation capacity (Davis 2012). Natural gas plants are easier to site, and can be constructed in 20 months compared to nuclear plants which can take a decade from proposal to operation (Shea and Hartman 2017). Wind and solar installations are becoming more competitive as the market has grown, aided with federal and state financial incentives (Cleveland 2019). Many states have adopted Renewable Portfolio Standards with goals and incentives to increase market share of wind and solar energy (EIA 2019b, Cleveland 2019). Consequently, wind and solar installations are projected to be the fastest growing sectors for new power generation (EIA 2020). New nuclear plants have difficulty competing with natural gas and renewables, especially with regulatory uncertainty and high capital costs.

Given lower start up and operation costs of natural gas, wind and solar energy sources, it is hard to make an argument that a state legislator would incentivize new nuclear capacity purely for economic reasons. However, existing nuclear plants can be competitive given high capacity factors and the ability to keep fuel reserves on site. It is possible state legislators may consider policy that allows continued operation of nuclear power plants for economic reasons, because the plants produce utility scale levels of energy on demand as base level supply, which renewables like wind and solar energy do not. Nuclear is also considered a zero carbon emitter, which could increase cost effectiveness if national carbon standards are adopted in the future.

State legislators will appreciate the need to maintain energy supply, as coal fired plants and nuclear plants are closed to maintain economic stability. Economic instability results in job loss which can be disruptive to communities. Policy providing both energy production and jobs may be attractive to legislators. Different types of plants provide varying levels of types of jobs.

Jobs

State legislators frequently rely on jobs as an important economic indicator (Clark 1994; Cohen and King 2004; Stigler 1973). It is possible that state legislators may see power plants as job creation tools. Heiman and Solomon (2004) claim that the $250B electric utility industry is the largest industry in the U.S. based on revenue and investments. Nation-wide, electric power generation and fuels technologies accounted for 1.9 million jobs in 2016, 55% of which resided in fossil fuels generation and extraction (DOE 2017). Electrical generation fuel sources are shifting as reflected by declining employment in coal mining, and growing construction employment in natural gas, solar, and wind energy industries.

The electrical power industry provides jobs in fuel extraction (for fossil and nuclear), manufacturing, wholesale trade, distribution and transport, and professional and business services. Energy production provides jobs whether fuel supply, construction, or operations. The contribution of energy fuels mining and extraction is significant. This industry accounted for 62% of all mining jobs in the U.S. in 2016 (DOE 2017). But as coal plant capacity was replaced, coal production dropped 42% from 2012 to 2019 (EIA 2019c). Significant job growth in the electrical sector has occurred in construction as natural gas solar and wind generation is added. Construction for the electrical energy industry represented about 10% of all construction jobs in

2016. This surge in construction also added manufacturing jobs. Manufacturing of generation components such as panels, turbines and generators account for 800,000, or 6.6 percent, of all manufacturing jobs in the U.S. In addition, wholesale trade, distribution, transport, professional and business services provide another 11 million jobs (DOE 2017).

Nuclear energy is not generating many construction jobs. In 2019, only two units were under construction, the first in more than 30 years (Morgan et al. 2018). In 2016, 68,000 people were employed in nuclear power industries, compared to 374,000 employed in solar industries despite nuclear representing about 19% of all generation, and solar only 3%. As such, state legislators may not see new nuclear energy as a job creator. An exception might be made, however, if new technology provides lower costs and risks. Examples include advanced gas-cooled, accident tolerant reactors, and small modular reactors. Small modular reactors utilize conventional technology but each reactor is sized to be factory built and transported to a site saving capital costs, with fewer "moving parts" that can fail during operation, reducing accident risk. It is possible that legislators might leave a door open for new nuclear technology without going as far as offering financial incentives for construction. But, if legislators are seeking job growth, wind and solar installations may be more likely to receive their attention.

Market Structures

State governments have a role in managing the delivery of electricity. Early production and distribution of power was a mix of public and privately owned energy plants and distribution systems in close proximity. Technical breakthroughs leading to stepping up AC voltage through substations allowed long distance transmission. Larger utilities soon bought out local competition. Utilities are considered natural monopolies: utilities have high fixed costs (plant, transmission and distribution infrastructure) so the industry benefits from economy of scale, with a single provider covering a large customer base to spread the burden of the fixed costs. Electricity is considered an essential service, powering industry and providing economic stability and growth. State governments regulate utilities to ensure uninterrupted service within reasonable cost to consumers. Most states established entities such as a Public Utilities Commissions with the power to set electrical rates, and oversee siting of new plants and distribution system investments. This model provides cost based rates where the utility is allowed to bill in a cost-plus arrangement. Utilities typically are vertically oriented: utilities will own and operate power plants, transmission systems, substations, distribution systems, and customer billing. Profit is guaranteed, but limited by state regulation.

Electricity is a unique product. It must be generated for essentially instantaneous consumption. Energy storage technology such as batteries and flywheels to date are economically inefficient. Excess electricity is a cost. Delivering precisely the amount of power needed at any given point of time is a complicated process. In the U.S., this is aided with extensive, interconnected transmission grids. Early on, transmission and distribution systems were owned and operated by both public and private (investor owned) entities for their own interests, until federal law required transmission systems to carry energy from any generator.

With the passage of the Energy Policy Act in 1992, some states began restructuring of their utilities for the purpose of encouraging more competition to lower consumer prices, and respond to consumer demand for renewable energy (Heiman and Solomon 2004). Restructuring minimally means that utilities sell off some levels of their vertical structures, such that various levels compete directly as independent companies. For example, a nuclear plant might compete on a kWh cost basis with a fossil fuel plant. Competing transmission systems companies were also established. Many utilities sold off generation and transmission levels, but maintained their distribution and customer service operations. In some restructured states, utilities joined Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs). Membership in these organizations allows a shift from cost based rates of traditional, vertical utility models, to market based rates, where utilities bid in a wholesale market on electrical production in day ahead markets, and real time markets. RTOs and ISOs are non-commercial, independent entities regulated by both states and federal officials. Some non-restructured utilities are also members of RTOs or ISOs. Most RTOs and ISOs operate in the Northeast and Midwest and into Canada, and some within states such as California, Texas, and New York.

Balancing electrical generation with instant demand on a shared grid with multiple owners and suppliers is a complicated undertaking. Grid operators are either utilities, a party with pooled utility resources, or a RTO or ISO. Grid operators issue instructions to power plants to ramp up or ramp down to meet instantaneous demand. States with the cost-plus models allow utilities to share capacity and transmission with other utilities in cooperative agreements. States with market based models function through RTOs and ISOs. RTOs and ISOs theoretically must rely on sophisticated systems to adjust generation to match rapid fluctuations in electrical supply and demand, and therefore are better equipped to manage transmission congestion (Hartman, 2016). Reports are mixed on whether RTO and ISO structures have decreased consumer costs or service (APPA 2019; Becker-Blease 2008).

Literature suggests that membership in a wholesale market structures can be detrimental to nuclear power (APPA 2019; Shea and Hartman 2017; WNA 2020). Because bidding is based on short term markets on a daily basis, RTO and ISO management may make it difficult for nuclear energy producers to pursue life extension upgrades or new nuclear plants, as it is difficult to recover high capital costs, despite low operating costs, to realize a profit. Cost-plus structures, in contrast, include these costs in the rates set by utility commissions. Longer term power purchase agreements, common in traditional, vertically structured markets reduce investor risk, but are more difficult in restructured markets, and have even been legally challenged. The literature indicates that restructuring, occurring in the Northeast and Midwest, may explain new legislation for incentivizing existing nuclear plants to avoid shut down (APPA 2019; Parenti 2011; Shea and Hartman 2017; WNA 2020).

Some states choose not only to restructure their traditional, vertical utilities, but to allow consumer selection of providers. In these states, the end customer can evaluate cost and service contracts offered by multiple utilities, selecting their own provider. Although cost is no doubt a determining factor, customers may be willing to pay premiums for power from a specific power source or other reasons. This may impact nuclear energy providers, dependent upon customer attitude toward nuclear power as dangerous and polluting, or as a zero carbon emissions energy source. An end-use customer’s attitude toward consuming nuclear energy may be reflected in interest group activity.

Interest Groups

Interest groups are part of pluralist democracy. Policy makers must weigh the opinions of voting citizens with needs of organized interest groups, who represent business, professional, and social considerations. Interest groups can be more effective than individuals in interacting with legislators, serving as liaisons, sources of information, agenda builders, and policy option providers. The number of interest groups, and corresponding influence has escalated in the past century (Baumgartner and Leech 2001).

State legislators are likely to be influenced by interest groups. Scholars suggest that interest groups materialize when states address new policy issues, such as the growth in marijuana interest groups in states considering legalization (Newmark and Nownes 2018). Scholars have argued that interest groups may have undue influence, resulting in promotion of a specific issue that may conflict with overall public good (Olson 1965, Schattsneider 1975). Other evidence suggests that as the number of interest groups in a state increases, it is more likely that policy is adopted that reflects public opinion (Yackee 2009). Conversely, too many interest groups may lead to stalled legislation (Gray and Lowrey 1995), particularly if there is political party balance, and division on an issue (Bowling and Ferguson 2001). Whether influencing or stalling legislation, interest groups pressure may impact energy policy.

Nuclear power interest groups are likely to reflect business interests (utilities), professional interests (labor and science), and social interests (environment and climate change). Business and professional interest groups are considered economic in nature, and collectively represent perhaps 80% of interest group activity in the U.S. (Baumgartner and

Leech 2001, Schlozman and Tierney 1983). Business interest groups are those promoting industry such as utilities, mining, or manufacturing companies seeking business opportunities through more favorable legislation. Likewise, interest groups can be professionally oriented, such as societies of professionals seeking to establish and enhance their particular profession. Nuclear energy economic interests, whether pro-nuclear, or as a competitor such as coal production, are likely reflected in the size of the particular industry within a state, such as number of nuclear plants, or amount of coal produced. Professional interests specific to nuclear energy may be represented by universities offering nuclear engineering degree, or DOE national laboratories providing nuclear research. Professionals may be updating legislators on nuclear energy job opportunities or technical advances. However, there is evidence that business interests have considerably more influence on agenda setting than either professional or social organizations (Danielian and Page 1994). Consequently, business interests such as utilities seeking low cost energy options, or the coal industry losing mining production, are likely to influence energy policy more than professional interests are able.

A primary role of interest groups is providing information. Literature suggests that knowledge is an indicator of attitudes toward issues associated with risk, such as climate change, and nuclear power itself. Business and professional interest groups are likely to have an educational role with state officials, impacting influence on nuclear power support. For example, interest groups are likely to present nuclear power as a high capacity energy provider, while wind and solar sources, more publically popular options, are much less reliable. Legislators interested in maintaining a consistent energy supply need to compliment intermittent renewables with either hydropower, nuclear or fossil fuel sources. Hydropower is dependent upon geography and precipitation, and fossil fuels emit carbon dioxide and particulate pollution. Nuclear energy is highly reliable, but generates toxic waste. If interest groups are educating legislators, tough decisions must be made, and legislators will be appreciative of information and policy options.

Reviewing various economic considerations for nuclear energy such as competition and pricing, jobs, market structures, and the roles of interest groups, economic factors are likely to influence policy adoption. The first research question is addressed in the following hypothesis:

H1: Economic considerations will influence state nuclear energy policy.

Economics matter, but are not the only determinant. Recall that states will adopt policy that is developmental (economic growth) and also policy that is redistributive (social conditions). States will adopt redistributive policy at the expense of economic growth if there is sufficient social need. The review of the economic literature suggests that states may not adopt supportive nuclear policy purely for economic reasons. It is possible that states are influenced by public attitudes and opinions on social needs.

Attitudes and Public Opinion

Policy tends to reflect public opinion (Burstein 2003; Goss and Kamieniecki 1983; Page and Shapiro 1983). Page and Shapiro (1983) produced much cited research in the 1980s measuring policy adoption and public opinion. The researchers compared public opinion data to federal policy adoption over 40 years. Page and Shapiro conclude that “public opinion is often a proximate cause of policy, affecting policy more than policy influences opinion” especially for “large, stable opinion changes on salient issues” (Page and Shapiro 1983, 175). Twenty years later Burstein (2003) reviews research that followed, finding Page and Shapiro's assertions remain valid for more contemporary policy adoption for up to 75% of policy studied. Public opinion even appears to be more impactful than influences from interest groups. If states are adopting policy that does not align with public opinion, as appears to be the case with nuclear energy after 2011, either nuclear energy is not salient, or nuclear energy is an exception to the theoretical expectation.

State Legislators Respond to Public Opinion

As scholars assert, public policy is often adopted in response to known public concerns, especially if an issue is salient and shifting (Burstein 2003; Goss and Kamieniecki 1983; Page and Shapiro 1983). If an issue presents a perception of a risk either to individuals personally, or the nation collectively, it is likely to be salient (Miller et al. 2016). Miller and colleagues (2016) find that issues of personal consequence, in particular, motivate support for political candidates providing a mitigation strategy. Consequently, state legislators should be motivated to respond to issues salient to the public. Scholars find this is often the case in state legislation, if public opinion on a specific issue is measurable or otherwise readily apparent (Laz and Phillips 2012). State legislators are likely to assess the importance of issues in the eyes of the public, and address those issues with policy.

Salience is important for policy formation as policy alignment with public opinion is more likely if an issue is salient (Burstein 2003; Page and Shapiro 1983). Issue salience is reflected in media activity. Media in the U.S. is a business, and producers and publishers seek material to increase advertising and subscription sales, or in other words, material of interest to consumers (Clawson and Oxley 2013). Increasing media coverage on an issue indicates increasing public interest (Helbling and Tresch 2011; Roberts et al. 2002). Helbling and Tresch (2011) find that the amount of media coverage is a more accurate predictor of issue salience than other methods of measurement such as expert judgements and public opinion surveys. Multiple mechanisms are used by scholars and practitioners to identify issue salience.

Nuclear energy policy may address two salient 21st century issues. The economy is a perpetually salient issue (Wlezien 2005) and often linked to voting behavior (Lin et al. 2010). Nuclear energy policy may address economic concerns as electrical power is essential for sustaining quality of life and economic growth. Nuclear energy policy could also address energy security concerns if dependence on fuel from unstable nation states is perceived as a risk to the economy. Legislators might support nuclear energy for economic reasons. However, as discussed above, electrical power is not projected to be a growth industry, nor a security concern as the U.S. recently became a net energy exporter (EIA 2017). The public is unlikely to place importance on nuclear energy policy only for energy production capacity or energy security economic concerns in the early 21st century.

The second salient issue which nuclear energy policy might address is climate change. Climate change is an important issue to the U.S. public, especially if they believe they will personally feel impacts (Konisky and Woods 2018; Rabe 2004). As a salient issue, climate change is consistently included in Gallup and Pew Research Center public opinion polls. A Gallup poll in 2019 indicated the public believed the importance of climate change for the 2020 presidential election is slightly more important than abortion, and slightly less than immigration (Hrynowski 2020). If the literature is correct, then legislators are likely to be seeking policy solutions in response to public concerns in their state for climate change. For example, if the electorate perceives their state is experiencing climate change in the form of rising sea levels and severe storms, their legislature is more likely to adopt policy to address it (Rabe 2004, Konisky and Wood 2018).

State legislators may view nuclear energy as a climate change policy. Nuclear energy is considered a zero carbon emissions electrical energy source, so supportive legislation could be adopted in response to public climate change concerns. But, it is also perceived as dangerous. The public may have concerns about how a nuclear energy accident, storage of waste, or proliferation of weapons grade materials might impact them personally, or the nation collectively. This risk must be weighed against perceived consequences of climate change.

Public opinion polls provide indication of attitudes toward nuclear energy at the collective, national level. Some states have moratoriums on nuclear energy, and other states are actively promoting nuclear energy, so public opinion is likely to vary at the state level. Understanding state level public opinion is aided by acknowledging attitudes that shape opinion.

Ideology and Political Party Identity as Attitude Predictors

Public opinion polls, the standard for opinion measurement, are largely conducted with national samples. National polls may include respondent location as a question, but there are too few respondents sampled in most states to identify a representative sample at the state level. Polls specific to state attitudes are rare, and questionnaire wording consistency across polls is unlikely. Consequently, scholars seek other indicators finding that ideology or political party position on an issue serves as an adequate surrogate (Calfano 2010; Phillips 2018).

Erikson and colleagues (1993) find legislative policy is likely to align with prevailing ideology, and ideology aligns with political party on many issues. State legislators are often chosen by voters for political party or individual characteristics such as personality (Phillips 2018). Consequently political party or ideological leaning can represent public opinion. In fact, Hogan (2008) finds that state legislators supporting legislation largely incongruent to constituent opinion are more likely to face a challenger in the next election. However, states can vary on how closely their legislatures respond to constituent wishes (Lax and Phillips 2012). For example, if one political party is dominant, congruence is more likely, indicating a link between public opinion and party identification. Anecdotal evidence that legislators listen to public opinion on nuclear energy is reflected in the states that adopted moratoriums on new nuclear plants in the 1900s. Maine, Massachusetts, Montana and Oregon all require voter approval to retract the moratoriums.

To understand how ideological leanings could reflect attitudes and public opinion, the role of values is explored. Values are believed to form as a result of socialization and experience, and tend to be relatively stable in individuals, such as traditional values (patriotism, stability, individualism) and egalitarian attitudes (concern for others, open to change). Traditional and egalitarian world views reflect ideological conservative and liberal values, respectively. Environmental attitudes serve as an example for explaining how values shape attitudes reflecting ideology.

When the first Earth Day was held, environmental attitudes were cross cultural and bipartisan. Landmark environmental protection legislation was passed in the 1970s, supported by both political parties. However, ideological divisions appeared toward the end of the century as concerns arose that clean air and clean water protection came at an economic price (Dunlap 2001; Shipan and Lowry 2001). Those with conservative values may value the environment, but concerns for environment can be outweighed by economic concerns if protections impact business and industry growth (Dunlap 2001; Shipan and Lowry 2001). Those with liberal values relate environmental damage to collective harm, which is valued over economic concerns (Dunlap 2001; Kantieniecki 1995; Shipan and Lowry 2001). Republican and Democrat parties in the 1980s adopted these ideological views. Ideology and political party identification remain strong predictors of environmental attitudes in general.

Scholars have studied environmental attitudes unique to states, and as reflected in adopted policy. Attitudes are tied to ideology, and also to a state’s environmental policies. States with Democratic governors and legislatures are more likely to adopt environmental protection measures, while states with Republican leadership may be more likely to sacrifice protections if they believe it might achieve economic growth (Konisky and Woods 2018).

Is there evidence that ideology reflects nuclear energy attitudes? A Pew Research Center Poll in 2014 finds that of those favoring building more nuclear power plants, 60% identified as Republican, and 35% identified as Democrat. When ideology is included, the gap widens, with 73% of conservative Republicans supporting nuclear power expansion compared to 36% of liberal Democrats (Pew 2015). This alignment by ideology and party may be explained by attitudes specific to nuclear energy.

Attitudes toward nuclear energy are shaped by risk perception (Mumpower et al. 2013; Slovic et al. 1991; Stoutenborough et al. 2013). Scholars find that risk perception is formed through values, beliefs, and trust in institutions (Whitfield et al. 2009, Stoutenborough et al. 2013). Risk perception is a function of beliefs of psychometric factors of severity, magnitude of number effected, likelihood, and level of knowledge (fear of the unknown) of a particular threat (Sjoberg et al. 2004). For example, climate change is a global threat that is projected to lead to food shortages, disease, mass migration and even pandemics (high severity, high number impacted) (Curseu et al. 2010; Homer-Dixon 2004). Likelihood is as projected by scientists, and belief in likelihood depends on trust in scientific institutions. Those trusting scientists may believe climate change damage is likely to occur. The higher the perceived severity, number effected, and likelihood, the higher the risk perception. Adding to the perceived threat is inability to know how it will actually play out, or fear of the unknown.

Risk perception is also linked to level of knowledge. Greater knowledge leads to lower risk perception. If people have experience with an event that did not result in specific harm, that event does not seem as risky as it might to those with less experience. O'Brien (2018) finds evidence that those living near nuclear power plants that have more reported incidents may be more likely to support expanded nuclear production. Existing plants may also provide additional public acceptability, as Bisconti (2016) finds that familiarity increases support for nuclear power. Experience with a threat increases knowledge and removes the mystery of the actual impact.

However, although the public has had limited experience with nuclear accidents (Three Mile Island, Chernobyl, Fukushima Daiichi), the public views nuclear accidents with "dread."

Slovic (1987) explains that dread is enhanced when people feel unable to provide for their own protection. Radioactive contamination can be fatal and can only be measured with instrumentation. If people cannot see or sense radiation, they must rely on others for protection.

Attitudes toward nuclear power are related not only level of perceived danger, but to trust in government (Stoutenborough et al. 2013). Whitfield and colleagues (2009) find that increased trust in nuclear regulatory institutions results in lower perceived risk of nuclear power. The public cannot sense radiation, so they must rely on various institutions to provide assurance of safety. Trust in institutions such as industry, government regulators and scientists are often tied to core values. Conservatives are associated with valuing hierarchy, so conservatives usually value authority more than liberals. Attitudes reflect ideology, but can be issue specific. For a complex issue such as energy, O'Brien and Stoutenborough (2018) find that more conservative individuals are more likely than liberal individuals to seek information from the U.S. DOE, business interest groups, and utilities, suggesting more trust in these institutions. Values regarding trust in industry and government authorities are key to relating conservative ideology to increased support for nuclear energy.

How Nuclear Energy fits within Environmental and Climate Change Attitudes

Nuclear power was an environmental concern before it became recognized as zero carbon in relationship to climate change. Ironically, nuclear power was initially supported by the Sierra Club in California in the 1950s as an alternative to large hydropower projects that sacrificed natural, scenic watersheds (Hetch Hetchy Project in Yosemite National Park, for example) (Wellock 1998). But the Sierra Club reversed its support once both public and scientific communities began to question safety. In addition to high perceived risk of nuclear plant accidents, attitudes in the 20th century viewed nuclear waste as an environmental pollution problem (Balogh 1991; Wellock 1998). An example of how nuclear waste is perceived is demonstrated with this observation in the 1991-1992 *Green Book Index*:

> One two-millionth of a curie of plutonium can cause lung cancer, yet the United States produces waste which radiates 11.2 billion curies each year. Ninety-three percent of the radwaste comes from nuclear power plants. Even at low levels, radiation can cause cancer, sterility, cataracts, premature aging, and genetic mutations. Studies have linked above-normal rates of leukemia and other cancers to radiation leaks from upwind nuclear power plants (Hall and Kerr 1992, 45).

Although scientific accuracy of this description and a comparison of the health risks of fossil fuels can be argued (Camden 2005, Kharecha and Hansen 2013) it reflects negative environmental attitudes toward nuclear power. Ideological views of nuclear energy as an environmental problem may be entrenched in attitudes.

Environmental protection has ideological association. Those with liberal values relate environmental protection to collective well-being, an egalitarian value. Conservatives may also value environmental protection, but will weigh the economic cost. “Republicans and conservatives are significantly less pro-environment than their Democratic and liberal counterparts” (Dunlap, 2001; 45). Ideology and political party identification remain strong predictors of environmental attitudes in general.

Nuclear energy may be associated with hazardous waste as an environmental issue, but it is also considered a zero carbon emissions energy source that could help reduce the threat of climate change. The results of a Pew Research Center poll indicates that Americans see climate change as more of a threat than Russia or China's power and influence (Pew 2019), indicating it is a salient issue collectively. However, there is a considerable partisan gap in perception of the seriousness of the threat. Of those believing climate change is a threat, 84% of those identifying as Democrat view it as a major threat, but only 27% of Republicans. Why Democrats are more concerned about climate change, but are less supportive of nuclear energy, may be explained by values toward environmental protection. Environmental protection encompasses a multitude of issues like deforestation, air and water pollution. Climate change is an issue within this broader umbrella of environmental concerns. Liberals with environmental protection attitudes may view the environmental risks of nuclear plant waste too great to overcome the benefits of zero carbon nuclear energy emissions. In fact, Whitfield and colleagues (2009) find that in 1997, perceived risk of climate change did not impact attitudes toward nuclear power, suggesting that the threat of nuclear energy as a safety or environmental risk outweighed its attraction as a zero carbon emissions energy source.

Nuclear Energy Attitudes: Polluter or Climate Change Solution

Could attitudes be shifting away from nuclear as unsafe and polluting to a climate change solution? One indication may be statements from environmental movement leaders asking for new consideration of nuclear power. As Lee observes,

> Since the early days of the modern environmental movement, nuclear power has been considered dangerous, expensive as well as unnecessary – with most major green NGOs running long-standing and influential anti-nuclear campaigns, from Greenpeace and Friends of the Earth down to the single-issue Campaign for Nuclear Disarmament. But now many of those same people – from Executive Director or Greenpeace UK, Stephen Tindale, to Guardian writer George Monboit and activists and writers Mark Lynas and Stewart Brand among others - are arguing that nuclear far from being ghastly, is green. (Lee 2011, 1)

Nuclear energy may still be perceived by Democrats as dangerous and expensive, but perhaps not as unnecessary. Democrats may be more accepting of nuclear power if the impact of climate change is viewed as severe. There is also a trend that nuclear energy is less popular with Republicans (Pew 2015). Republicans may not have viewed nuclear energy as dangerous, expensive or unnecessary as Democrats in the past, but perhaps now view nuclear as more expensive, unnecessary given abundance of fossil fuels, or even more dangerous, given trends in reduced trust in government institutions (Vavreck 2015).

There may be evidence of shrinking partisan gap regarding support for nuclear power. Questions concerning support for new nuclear power plants in a 2014 Pew Research poll were repeated in 2019. As indicated in Table 3.1, there may be anecdotal evidence that the gap between conservative Republicans and liberal Democrats is shrinking.

Table 3.1. Percent of respondents supporting more nuclear plants

Source: Pew Research Center polls conducted in 2014 and 2019

		2014		2019	
Conservative Republicans		73	37 point spread	63	24 point spread
Moderate/Liberal Republicans		55		51	
Mod./Conservative Democrats		37		43	
Liberal Democrats		36		39	

The gap of 37 percentage points in in 2014 may have closed to 24 points in 2019, with possible movement by both parties: Republicans reducing their support for nuclear power, and Democrats increasing support although detailed analysis is needed to evaluate whether this is an actual trend. Future polls may clarify if there truly is a trend where the threat of climate change may outweigh perceptions of safety and pollution risks of nuclear energy.

Nuclear energy environmental attitudes may reflect either negative perception of nuclear energy as a dangerous polluter, or positive perception as a climate change solution. Without a national repository or technical solutions, nuclear waste likely remains an environmental concern, but the zero-emissions aspect of nuclear power could provide a reason to reconsider nuclear energy. There may be other indicators such as adoption of state policy on renewables.

State Adoption of Environmental Goals as Attitude Predictors

The gap in political party views on climate change is not reflected in one of the most popular climate change solutions, expansion of renewable electrical generation. Wind and solar energy is popular with both political parties as found in results of a 2019 Pew Research Center poll (Funk and Hefferon 2019), shown in Figure 3.1.

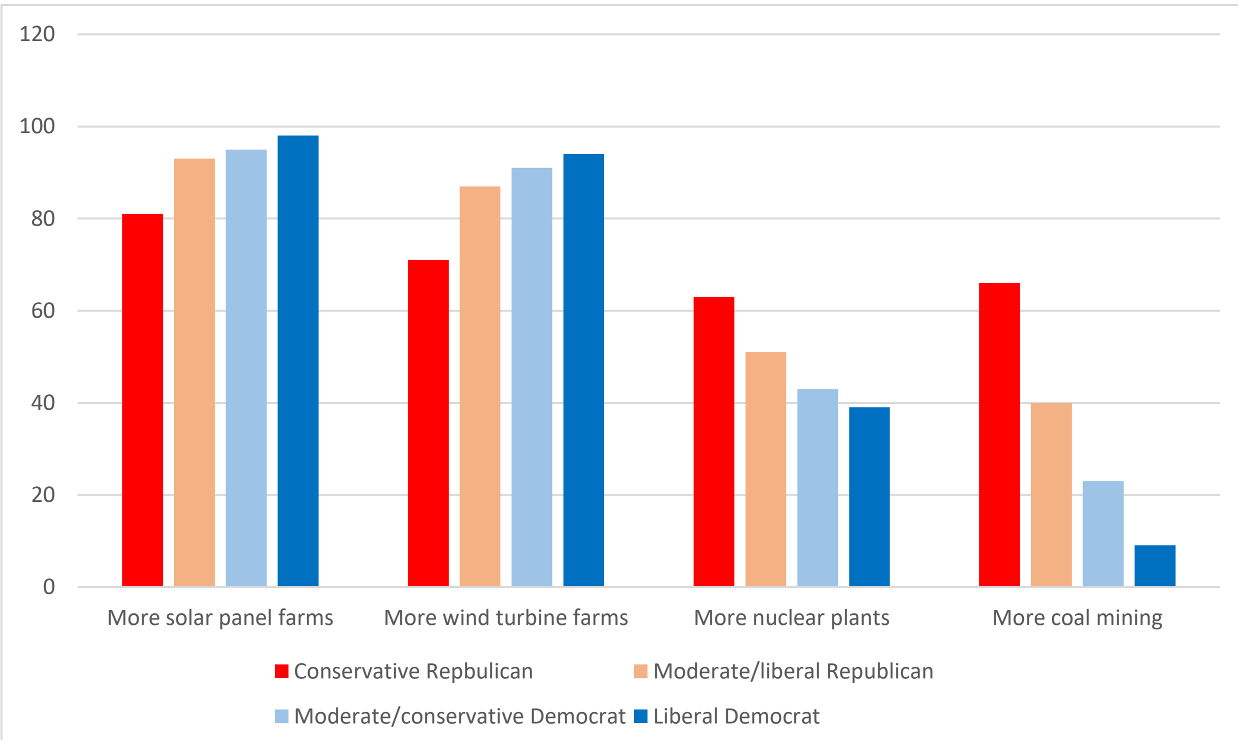

Figure 3.1 Percent of US adults who say they favor expanding each energy source

Source: Pew Research Center survey conducted October 2019 "U.S. Public Views on Climate and Energy"

Of those polled, 85% and 92% favored expanding wind and solar installations respectively. The gap between conservative republicans and liberal democrats was limited to 23 and 17 percentage points for wind and solar, impressive given a gap of over 50 percentage points when asked about fossil fuels. Shea and Hartman (2017), and Bekareva and colleagues (2017) suggest the bi-partisan support for wind and solar energy is economically as well as environmentally driven. Wind and solar installation is a growth industry, attracting Republican support for economic reasons, and Democratic support for environmental protection.

If renewable energy such as wind and solar are popular with both parties, state support of renewables may not necessarily reflect state ideological differences. As of 2019, 27 states have adopted Renewable Portfolio Standards with varying levels of both voluntary and mandatory goals (Carley and Miller 2012). The focus of these goals is to encourage renewable power generation. “Renewable” energy literally means those energy sources which are not depleted during consumption of energy, such as solar and wind (EIA 2019b). Most renewable sources are by nature low polluting and low carbon emitting compared to fossil fuels, such that both pollution and climate change concerns are addressed. If states adopt supportive nuclear energy policy in addition to Renewable Portfolio Standards, states might be responding to conservative support for nuclear energy, or it may indicate shifting emphasis on climate change concerns.

Attitudes specific to climate change may be more strongly tied to states’ reactions to the federal government adoption and then suspension of carbon emissions limits established in the UN Paris agreement. In 2016, the Obama administration pledged to join the UN Paris Agreement, with a goal to keep increases in global average temperatures to well below 2° C above pre-industrial levels, and become net zero emitting by 2050 (Somander 2016; UNFCCC 2016). Some states had tired of waiting for federal level action and had already adopted specific carbon reduction goals. The Trump administration then announced the U.S. would abandon the Paris Agreement by 2019. States joined the US Climate Alliance adopting goals reflecting of the

Paris Agreement, possibly in response to loss of a Federal commitment. Member states predominately have Democrat governors, but include states with Republican. Membership may reflect environmental attitudes, but are not specific to increasing only renewable energy power generation. If states are pursuing zero emissions goals specifically, and adopting supportive nuclear legislation, this could indicate that attitudes toward nuclear energy as a solution to climate change could be shifting.

What might indicate whether citizens within a state view nuclear energy as a pollutant and safety risk, or as a climate change solution? At the national level, public opinion of nuclear power has been dropping since the Fukushima Daiichi nuclear accident in Japan in 2011. But attitudes appear to differ between states as some adopt renewable portfolio standards or zero emissions goals, and some do not. Some states adopt supportive nuclear policy, and others do not. State level public opinion on a specific issue can be difficult to obtain.

Public opinion may be supportive if a state has existing nuclear plants and the public perceives benefits of high paying jobs and reliable energy (Shea and Hartman 2017) and has accepted operational risks (O'Brien, 2018). Likewise, public opinion may be negative from perceived threats from nuclear power as dangerous (Stoutenborough et al. 2014), or as a competitor to another energy industry. Without quality opinion polling at the state level, public opinion on nuclear energy may be reflected in ideology, and in other actions states may take (Phillips 2018).

Public opinion often drives policy, and attitudes toward nuclear energy form public opinion. The second research question will be addressed in the following hypothesis:

H2: Attitudes and public opinion will influence state nuclear energy policy.

Nuclear energy can be viewed as dangerous and polluting, or as part of a climate change solution. Consequently, attitudes, and therefore public opinion, may be mixed. By assessing state level ideological leanings to indicate attitudes toward nuclear energy in general, and other indicators such as commitment to renewable energy and climate change solutions in particular, state level attitudes may be revealed.

Theory supports economics and attitudes and public opinion as influences on state policy adoption. Next, theory on how state government structures may impact legislative or executive action is reviewed.

Structure of State Government

In addition to theory on economic, political and social internal determinants discussed above, the structure of state governments may impact policy outcomes. Two of these structural elements are the capacity for citizen initiatives, and the level of state general fund revenue.

Citizen initiatives allow for direct democracy because citizens by-pass their own representatives. Legislators appreciate the power of a public vote, such as Maine, Massachusetts, Montana and Oregon requiring voter approval to retract the moratoriums on new nuclear plants. Citizen initiatives are a mechanism for citizens to force a public vote to change an existing statue or law, or require their legislature to enact a law rather than relying on the state legislature to act on their own will. As of 2019, 23 US states allow citizen initiatives, largely western states. Most scholarship has focused on initiative process, initiative strategies, interest group involvement, the role of elite endorsements and initiative entrepreneurs in predicting whether or not initiatives pass or fail (Bowler et al. 1998). Other research considers how citizens determine how to vote on an initiative if unable to apply a political party choice heuristic (Banducci 1998; Kuklinski et al. 1982).

Literature on how the presence of citizen initiatives reflects upon state legislative behavior is more meager. However, Gerber (1998) suggests that initiatives are becoming a means of indirect influence on state government actors. Given rising costs of mobilizing and promoting initiatives and a low rate of success, the true purpose of pursuing citizen initiatives may be that interest groups can apply pressure to legislatures and governors to take action before they are “stuck” with an initiative that would be too loose or too restrictive for political tastes. Indeed, in 1976, the California legislature passed the first state moratorium in the U.S. restricting new nuclear plants unless certain conditions are met, when threatened with Proposition 15. Proposition 15, the *Nuclear Power Plants Initiative*, which would have been much more restrictive (Williams, 2001). The capacity for citizen initiatives may indicate a state legislature is more likely to be proactive in providing nuclear legislation.

General fund revenue represents not only the economic prosperity of a state, but may also indicate greater discretionary spending power. States may be better able to offer financial incentives to pursue an economic or social benefit if their general fund revenue is greater relative to other states. For example, Ringquist (1993) finds a state may be more likely to be a policy leader if it is relatively wealthy. Whether a state is more economically prosperous, or is structured to generate more revenue per capita for government allocation may impact nuclear energy policy.

The third research question is addressed in the following hypothesis:

H3: State government structure will influence state nuclear energy policy.

Including government structure characteristics along with economic, attitudes and public opinion influences, understanding of policy adoption is enhanced.

Policy Diffusion

Economics and behavioral science are often emphasized when studying public policy and policy maker decisions (Amir et al. 2005). At the state level, two lines of inquiry are often used to explain state action: internal determinants, and policy diffusion (Berry and Berry 2007). Internal determinants of economics, environmental attitudes, and state government structures are reviewed above. The remaining question is whether policy diffusion, drawn from external determinants such as competition between states, could influence state nuclear energy adoption.

Scholarship has developed theories on how diffusion occurs (Berry and Berry, 2007). States pursuing policy addressing a specific issue may originate unique policy language for their state, or they may look to other states to see what policy has been adopted, and how effective it has been. They may then choose to imitate the policy, emulate it, or write competing policy (Karch 2007; Mesequer 2006; Oxley and Stoutenborough 2012). If policy is imitated, it is adopted quickly with similar language without regard for effectiveness or sufficient research to assess transfer of effectiveness (Bache and Olsson 2001). This may represent symbolic policy, or policy that is not necessarily meant to be effective, but may address a particular concern of a specific interest (Edelman 1964). Emulated policy is more likely to be modified to suit a particular state's characteristics, and will generally have a lag time after the initiating state adopts policy, to assess effectiveness (Eyestone 1977; Oxley and Stoutenborough 2012). For example, in the 1970s, California was the first state to adopt a moratorium on new nuclear power plants. Between public protests and escalating construction costs, nuclear energy fell out of favor (Butler et al. 2011; Ramana 2011), and within two decades, 16 additional states adopted moratoriums. Moratoriums shared common language establishing specific conditions before nuclear plants could be considered. These included existence of a national repository for high level waste, citizen votes to allow new plants, and evidence that new facilities are economically feasible for rate payers. Similarities in moratorium language is evidence that policy diffusion may have occurred (Eyestone 1977; Linder et al. 2018).

Competitive policy is adopted when a state feels threatened by the state initiating policy, and may be more aggressive, and like individuals, states may be more daring when facing competition. Competition may reflect attracting big employers like Amazon with favorable tax packages, or easing environmental regulations to attract heavy industries. Alternatively, states may adopt environmental controls to attract tourism or green industries. These approaches may result in "race to the top" and "race to the bottom" policy diffusion (Berry and Berry 2007).

What features of nuclear energy policy might reflect incidence of policy diffusion? Diffusion is often assessed for regional/neighbor, leader/laggard, vertical (federal influence), or bottom-up (grass roots) mechanisms. States sharing borders are likely to compete for commerce, and may practice competitive or cooperative regional/neighbor diffusion. Leader/laggard diffusion occurs when a state is an innovator and often the first to experiment with new policy, while other states take a laggard approach, assessing effectiveness before adopting. States may also look to states with similar ideological leadership. Environmental policy, in particular, is often innovated in Democratic leaning states seeking to be environmentally progressive (Rabe 2004, Konisky and Woods 2018). Leaders set examples for climate change policy that may be adopted nationally, or in fellow states. Vertical diffusion occurs in response to federal government policy adoption, to which the states are directed to act, or they choose to act. For example federal grants may motivate states to adopt particular policies to take advantage of those opportunities. Finally, policy may result from bottom up, or grassroots pressures. Citizens may be demanding states to take action on specific policy in response to national policy (or lack of). When these pressures appear, states may become policy innovators.

Nuclear energy policy may be diffused as regional/neighbor. If states share generation and transmission within regional systems such as RTOs and ISOs for example, they may be more likely to cooperate with each other to assure adequate energy generation and supply. If these states have nuclear plants, they may assess measures other states are using to protect their nuclear fleet. Or, they may be competing with other states within their region to attract new nuclear energy capacity. These states might offer financial incentives, such as favorable pricing or cost recovery mechanisms to compete for utilities seeking a location for a new plant. Consequently, neighbor policy diffusion could be occurring if states in a region are adopting similar policy. The fourth research question is addressed in the following hypothesis:

H4: Diffusion of policy between states may influence state nuclear energy policy.

Policy diffusion represents external impacts such as cooperation or competition between states. Other impacts on state nuclear policy adoption are general demographic determinates.

Demographics

What other factors might influence adoption of supportive nuclear energy policy? General internal determinants of population, level of education, level of state income and financial resources may play a role.

Population density may matter. The Nuclear Regulatory Commission grants certificates and licenses after extensive safety design regulations are met in accordance with Code of Federal Regulations *10 CFR Part 50 – Domestic Licensing of Production and Utilization Facilities* (CFR 1978-2020). Part of these regulations require calculation of theoretical radioactivity release either during operation or accidents. To protect the public, these calculations must indicate that only small doses could potentially reach set perimeters of plants. Regardless of these rules, locating new plants in dense populations may be met with resistance, given public risk perception.

Alternately, states with remote populations may be seeking reliable energy supplies. Small modular reactors are marketed to address such circumstances (Hopkins 2018). Alaska, with remote area energy needs, repealed their moratorium on new nuclear plants in 2010, allowing “small-scale nuclear reactor developers” to seek opportunities for plants (NEI 2019, 1). States with low population densities may be more able to site new nuclear plants, either because the plants are farther from large metropolitan areas who would object, or the public seeks energy independence in a remote area.

Level of education of the population may matter. More educated citizenry may develop better informed attitudes. These attitudes may align with either in support or opposition to nuclear power, although Kuklinski and colleagues (1982) find that when faced with a decision when political party alignment is not possible, such as voting in a citizen initiative, voters more knowledgeable on nuclear energy were more supportive than less knowledgeable voters. More knowledge is also related to lower risk perceptions (Sjoberg and Drottz-Sjoberg 1991; Stoutenborough et al. 2013). A more educated citizenry may be more aware of the impact extensive government regulation has on nuclear power safety, and develop more supportive attitudes toward nuclear energy.

The above exploration of theory suggests that economics, attitudes and public opinion, state government structure, and policy diffusion mechanisms may be most influential in understanding why states are adopting supportive nuclear energy policy during a period of rising and falling public support. Detailed analysis should reveal understanding. Chapter 4, Analytical Approach, describes quantitative analyses to provide answers.

Chapter IV

Analytical Approach

Since the turn of the century, states have been adopting supportive nuclear energy policy. This is curious given the dearth of new reactor projects since the 1980s, and luke-warm public support (Pew 2016). Are states really serious about promoting nuclear energy, or are they using policy to respond to some other issue symbolically? Why supportive policy is adopted during this time may be better understood if it is known what type of policy is adopted in what circumstances. To this end, a quantitative analysis using statistical regression techniques is performed. The types of supportive policies adopted by states with different existing policies on nuclear energy are regressed with theoretical influences to determine any statistically significant relationships and provide quantitative evidence to inform conclusions.

Research Questions and Data

Once theory is reviewed for the most likely influences on state energy policy adoption, those influences help formulate research questions. Four research questions inform the analysis and analytical approach:

1. How do economic considerations influence state nuclear energy policy adoption?
2. How do attitudes and public opinion influence state nuclear energy policy adoption?
3. How do government structures influence state nuclear energy policy adoption?
4. How does policy diffusion influence nuclear energy policy adoption?

To address these questions, statistical analysis is applied to seek quantitative relationships between various influences and type of policy adopted by states. Adoption of policy supportive of nuclear energy serves as dependent variables. Various policy scenarios, including whether or not a state has a moratorium on new nuclear plants, are subdivided to form dependent variables providing additional fidelity. As discussed in Chapter 3, there is a multitude of potential independent variables, and theory leads to identification of influences likely to provide the most insight. The next step is determining how to measure influences appropriate for quantitative analysis. Data measuring independent variables of economics, attitudes and public opinion, structure of state government, diffusion, and demographic controls are collected. Methodological strategy for developing statistical models is described.

Dependent Variables

As discussed in Chapter 1, supportive policies differ across a range of content. Some states appear to be considering nuclear energy in future state plans, while some are offering financial incentives to either attract new plants or ensure existing plants remain competitive. Some states are adopting supportive policy despite past moratoriums on new nuclear power plants. Some are even lifting moratoriums. Identifying what factors might influence what specific type of policy is adopted, or not, may reveal how state governments may be using policy to address issues. To this end, types of policy depending on content, and whether or not a state has a moratorium on new plants, defines dependent variables.

The types of policies reflected in dependent variables reflect whether the policy content may be symbolic, or substantive. In theory, symbolic policy is political in nature, designed to reassure or educate a target group in the electorate, but not produce much meaningful change (Edelman 1964). Substantive policy, however, is intended to be impactful. By identifying policy as either potentially symbolic or substantive, a level of commitment to nuclear energy can be inferred. States with substantive policy may have different drivers than a state with symbolic policy. Substantive policy can be identified if tangible expenditures are included (Jaro and Baer 1976). Expenditure of resources (either by the government or consumers) to build or protect a plant represents a stronger commitment than say, including nuclear energy in a feasibility study of future energy sources for the state. A state that is more committed may have different characteristics and therefore different motivations, than one that is more symbolically committed, or states not adopting any supportive policy.

Expenditures in the form of financial incentives are not the only policy content that suggests a solid commitment to commercial nuclear power. For example, some state statues require a state entity to approve new reactors or continued operation of existing reactors. A state approving specific reactor operations should also indicate commitment. Some states offer financial incentives that relate to nuclear energy, but are not specific to commercial nuclear plants, so these policies do not necessarily reflect a substantive commitment to nuclear power. Consequently, instead of identifying policy as either substantive or symbolic, for the purposes of this study, policy is identified as either “strong” or “soft.”

The primary data source for identifying policy as either strong or soft is provided by the Nuclear Energy Institute in a report tracking state supportive nuclear energy policies adopted between 2000 and 2019 (NEI 2019). The report lists all policies created through legislation, executive orders, or state energy authority regulations, and provides a synopsis of the policy content.

For this study, strong policy is defined as policy described in the NEI report as either approving siting or operation of a specific nuclear plant, or offering a financial incentive specific to nuclear energy. If the NEI report synopsis meets these criteria, a state is coded as “one” in the year the policy is adopted, and “zero” in previous years[1]. For example, if policy describes mechanisms to recover capital costs of a new nuclear plant by charging consumers increased rates over time, that state would be adopting strong supportive policy. Georgia allows “a utility to recover from its customers the costs of financing associated with the construction of a nuclear plant,” and Illinois allows “utilities to recover through tariff charges all the costs associated with the purchase of zero emission credits from zero emission facilities” (NEI 2019). With this definition, strong policy represents more substantive policy (Jaro and Baer 1976). Financial investment suggests commitment.

Soft policy is defined as policy that encourages nuclear power in some form, but does not offer financial incentives specific to producing nuclear power commercially, or authorizes a specific plant. For example, South Carolina directs the state to establish a comprehensive energy plan that encourages the development of clean energy sources like nuclear energy, but does not offer any financial incentives. Idaho resolves to be a leader in reactor research and offers a tax break to a research institution for research on Small Modular Reactors, but not to

[1]A description of the coding of the dependent variables is included in the Code Book, attached as Appendix B.

an investor to build a Small Modular Reactor for commercial use. Tennessee encourages federal regulators to support license application for safe operation of Watts Bar Unit 2, but this is indirect support as Tennessee is not awarding the license. These three examples of policy are considered “soft” for the purposes of this analysis. Soft policy represents more symbolic policy in that there is no specific financial sacrifice. The policy synopsis for each state in accordance with these definitions is included in Appendix A.

The statistical analyses include policy adopted between 2002 and 2019. This time span is selected as it represents a triggering event of the passage of the Energy Policy Act in 2005 with favorable language for nuclear power, preceded by a few years to establish trends in independent variables. It also represents years-to-date flanking the Fukushima Daiichi accident, with rising national public support for nuclear energy before 2011, and declining support following the accident. Theoretically, policy should reflect public opinion (Burstein 2003; Goss and Kamieniecki 1983; Page and Shapiro 1983), so less policy should be adopted after 2011 as national public opinion drops. Including equal duration of time before and after 2011 provides data on policy adopted during periods of both increasing and decreasing public support.

Because strong policy represents more meaningful commitment to nuclear energy than soft, strong policy envelops soft policy. Therefore, if a state adopts strong policy, and a few years later also adopts soft policy, the state is coded for strong policy only. If a state adopts soft policy first, and follows with strong policy, policy is coded as soft until strong policy is adopted. In this data set, this occurs once. Illinois adopts soft policy in 2014 and strong policy in 2016. Once strong policy is adopted, the state is coded for strong policy until policy is retracted. No evidence was found that any of the supportive policy had been rescinded between 2002 and 2019, so accommodations for policy retraction are not needed.

Recall that the dependent variables are identified not only for strong or soft policy adoption, but states' moratorium status. Seventeen states had moratoriums on new nuclear plants in 2003. States with moratoriums that subsequently adopt supportive policy are of interest because adopting supportive policy despite moratoriums likely requires more justification, and therefore commitment, than states without moratoriums might need. Four of these states adopted strong nuclear energy policy after 2003, and three states repealed their moratoriums. The states repealing their moratoriums, however, do not adopt strong policy as defined for this study, so these adoptions are considered soft policy. These particular policy events are included in the statistical analysis as they suggest policy change which might aid understanding of the research questions.

Dependent variables are selected by type of policy adopted, and whether states had a moratorium on new nuclear plants as of 2003. A total of 31 states adopted strong or soft policy by 2019, including seven states who previously had moratoriums. The remaining 19 states maintain their status quo. A model of 31 states adopting supportive policy serves as a baseline model, as it captures all influences for any type of policy. Subsets of these 31 states are then modeled for better understanding of what influences specific types of supportive policy. Of the 31 states adopting policy, 18 have adopted strong legislation, and 14 have adopted soft legislation and executive orders since 2003. (Recall that Illinois first adopts soft policy and then strong policy for a total of 32 events by 31 states). Subsets of adoption of strong and soft policy respectively by these states with moratoriums in 2003 are the next level of dependent variables.

Within those 31 states adopting strong or soft policy, seven states had moratoriums in 2003. These seven states produce a further subset. The seven states can be further divided to represent states adopting strong supportive policy while maintaining their moratorium (4 states) and those adopting soft policy while lifting their moratoriums (3 states). Consequently, six dependent variables and models are identified:

1. All supportive policy adopted (31 states)
2. Strong supportive policy adopted (18 states)
3. Soft supportive policy adopted (14 states)
4. Strong or soft supportive policy adopted by states with moratoriums (7 states)
5. Strong supportive policy adopted by states maintaining moratoriums (4 states)
6. Soft supportive policy adopted by states lifting their moratoriums (3 states).

In addition to these sets of dependent variables addressing policy adoption, three additional dependent variables addressing a status quo condition are examined. These status quo variables represent those states taking no legislative or executive action between 2002 and 2019. Status quo states may have relationships with influences which states that adopt policy do not. Influences relating to status quo states may also change over time, providing insight into policy adoption behavior. Of specific interest are the states with moratoriums. Perhaps there are predictors in 2003 that are not present in 2018, or vice versa, that may be compared to states with moratoriums that do adopt supportive policy. Status quo of states with moratoriums, and status quo of states without moratoriums are evaluated separately. First, a dependent variable of the 17 states with moratoriums in 2003 is modeled, providing comparison for two status quo conditions[2]. These scenarios result in the final three dependent variables and models:

7. Moratoriums in 2003 (17 states)
8. Status quo maintaining moratoriums through 2018 (10 states)
9. Status quo with no moratorium through 2018 (9 states).

A description of the coding of the dependent variables is included in the Code Book, found in Appendix B.

Statistical Models

Since the 1990s, discrete event history analysis has become the accepted approach to modeling events of policy adoption (Buckley and Westerland 2004). This approach is derived from duration, or survival analyses, often used in the medical, insurance, and finance fields. Survival analysis focuses on the probability of an event occurring without possibility of reoccurring, measuring time elapsed until the event occurs. The events are discrete, as in dichotomous: either policy is adopted, or it is not. Using the example of a health study, the event is the death of a patient (discrete event that happens once), in a logical time interval (months or years) regressed with influencing variables such as gender and type of treatment. Survival probability is the probability of surviving given independent variables coupled with the

[2] A case of states without moratoriums in 2003 is a reversal of the original coding, i.e., instead of states with moratoriums in 2003 coded as "1", states without moratoriums are coded as "1." Consequently any relationships realized in one model are the same for the other model is the sign on the coefficients are flipped.

probability of surviving as time elapses. Regardless of independent variables, the longer the patient lives, the more likely the patient is to die, lowering survival probability. Thus, survival analysis includes duration dependence. This translates to state policy adoption, as the more time passes, the more likely a state is to adopt policy.

The appeal of survival analysis techniques are that the event is both dichotomous (it happens or it does not), and once the event happens, it no longer has relevance to the analysis. Just as the characteristics of the patient no longer contributes meaningful information after death, data on states once policy is adopted is not useful. The time elapsed, or the time a participant is at risk (for example, if measuring time to death, time zero is date of birth or of exposure to a contagion) until an event occurs, is of interest to event probability. Survival techniques also allow for events that fail to occur over the timeline of a specific study (the patient survives), as a censored event, meaning those states that fail to adopt specific policy still provide meaningful input to the results.

The social sciences apply a form of survival analyses referred to as event history analysis. Event history analysis, like survival analysis, is duration dependent. Event history analyses provide techniques to account for inadequacies of standard regression analysis to properly account for time (Steele 2005). First, techniques recognize that durations will always be positive, as it is assumed the more time passes, the more likely the event is to occur. Event history analysis also allows the independent variables to vary over time. For example, if unemployment levels represents the overall condition of a state’s economy, and a state’s economic condition predicts support for nuclear energy, then it becomes important to recognize that changes in unemployment rates over time should influence the likelihood of policy adoption.

The data set in this study is a combination of time series, or a single participant with measurements every year, and cross sectional, or multiple participants over that same period of time. When combined, the collected data is known as a panel time series. Analyzing time series data can be complicated as not only do the independent variables vary over time, but do so both internally and externally. In other words, a state's general fund revenue varies internally from year to year if the state legislature changes tax rates. Coal extraction, however, is impacted externally, because other states are shutting down coal fired plants. Internal fluctuations can be particularly problematic, creating bias when estimating the external fluctuations. This can be corrected with random effects estimators (Kennedy 2003), which are applied to the models in this study.

Using event history analysis also requires correction for duration dependence. Like survival analyses of patients, once a state adopts supportive nuclear power policy, subsequent years are dropped from the model because the patient died. Including data on states after they adopt policy causes estimation error, so after the event occurs, that state is dropped from the data set. This explains why data may be available for 50 states over 16 years, but observations will decrease as states adopting policy are dropped over the study duration.

Event history analysis techniques are also managed for hazard rate assumptions. The hazard is the probability that an event occurs at a specific time. A flat hazard rate assumes this probability is constant over time. However, state policy adoption scholars find significant evidence that states influence each other and policy diffusion occurs. For example, in a health survival study, the participants' deaths are independent of another participants' death, but states may be influenced by other states adopting policy. If policy diffusion is occurring among states, each state is not independent of the others as they may be imitating or emulating policy adopted by another state for purposes of competition. Policy diffusion can cause the hazard rate to become unstable. To correct for this, Box-Steffensmeier and Jones (2004) recommend including a trend variable which essentially uses time itself as a regression parameter. Given the year that the most states are adopting the dependent variable policy, time intervals of the square root of the number of years either before or after that particular year is included as an independent variable. This stabilizes the hazard rate, allowing the model to perform as expected (Box-Steffensmeier and Jones 2004).

Beck and colleagues (1998) also suggest using complementary log log regression over other dichotomous dependent variable techniques such as logit and probit for rare events such as state policy adoption. Given a population of 50 states, at most only a few are likely to adopt specific policy in any year. The "S" shape of the complementary log log probability curve between zero and one has a tighter slope near one than logit or probit curves, which is more representative of rare event fit.

With a population limited to 50 states, collecting data over 16 years for event history analyses greatly increases observations. Models with more observations generally provide better model statistics, but rare events are an exception. Rare events can become too infrequent to develop meaningful relationships, because not enough variation exists within the dependent variables. Event hazard analysis techniques (with the described modifications) are applied to the first four of the dependent variables described above, but are not possible when events become too rare, which happens with the two dependent variables with the smallest number of events. For these two cases, data specific to the 50 states in 2018 represent variables in complementary log-log regression analyses.

A dependent variable of a moratorium in 2003 is evaluated with 2003 data with logistical regression. Meanwhile, because of the rare event bias, the two status quo dependent variables are evaluated with 2018 data with complementary log-log regression. This selection of dependent variables, coupled with the selection of independent variables are designed to provide insight to the research questions.

Independent Variables

Chapter 3 explores theoretical bases of various influences on supportive state nuclear energy policy adoption consistent with background on the development of nuclear energy described in Chapter 2. Of multiple possible influences, three theoretical areas inform research questions and independent variables. Theory suggests that economics, including energy production, job creation, interest group activity and market structures may align with state policies. Attitudes and public opinion toward nuclear energy, particularly as reflected through ideological values which include risk perception and trust in government, are also likely to impact state policy. Finally, structural elements, such as citizen initiatives and general fund revenues, and policy diffusion mechanisms such as neighbor diffusion, theoretically may impact type of policy a state adopts.

Independent Variables - Economics

Economics are likely to influence state energy policy (Hwang and Gray 1991; Peterson 1981; Sharp and Alex-Assensoh 2005). State governments are developmental actors seeking economic growth. To measure the influence of economics, several indicators are identified: existing nuclear energy industry, competition from other industries, pressure to provide jobs, and energy market structures.

Energy production is directly tied to economic growth (Bekareva et al. 2017). States may wish to protect existing power plants to maintain or grow industry. If states already have nuclear power plants, and those plants are facing either life extension investments or retirement, legislators may pass policy to save existing production capacity. Existing plants may also provide additional public acceptability, as Bisconti (2016) suggests that familiarity increases support for nuclear power necessary for adding new capacity. The number of existing plants in each state are coded to capture these possible influences. Capturing the number of plants in a state (adjusting for reactors shut down between 2002 and 2019) provides a measure of production and therefore business interests, and may also reflect support from multiple state legislators if plants are in multiple districts[1].

States often protect industries that are threatened by outside forces (Kauffman 2016). States may see nuclear energy or natural gas as competition to coal mineral extraction. Chapter 3 establishes that coal fired plants are being replaced with other high capacity fuel sources such as natural gas and nuclear power. This creates concerns in states with coal mining industries. Short tons of coal extracted in each state is collected to represent coal industry business interests to assess whether this is an influence for states maintaining status quo, and not adopting supportive nuclear energy policy[1].

Jobs are an important economic indicator to which legislators respond. Unemployment is a long standing economic health indicator, and a salient economic issue for state legislators (Clark 1994; Cohen and King 2004; Stigler 1973). Legislators will seek policy that improves unemployment rates. States with higher unemployment rates may be seeking nuclear energy production to boost state economies, or nuclear research programs to establish technology industries. Unemployment rates are collected to gauge pressure to increase job opportunities[1].

Utility market structures are also likely to influence state policy on nuclear energy. The literature suggests two types of market structures may contribute to nuclear energy policy adoption. First, late in the 20th century, Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) were formed both within states (New York and Texas for example), and also across state lines particularly in the Midwest and Northeast. RTOs and ISOs are intended to provide competitive pricing as energy distributers bid on next day and real time wholesale markets. Theoretically, nuclear energy is not as competitive in wholesale markets as in traditional, cost-plus markets, and may need financial assistance from state governments (APPA 2019; Shea and Hartman 2007; WNA 2020). To assess the impact of RTOs and ISOs, whether a state participates is included as an independent variable. Rather than state by state, RTOs and ISOs are formed between individual utilities and service areas. Consequently, data are coded as "one" for states with a majority of land area within a RTO area to assess possible economic impact, and otherwise as "zero"[1].

A second market structure relates to restructuring of traditional, cost-plus markets. States passed legislation to restructure traditional vertically oriented utilities, where a company produces energy, builds and owns transmission infrastructure, and bills customers within the geographic area of the transmission reach. Multiple states restructured utilities to encourage price competition, such that each horizontal layer competes directly within that layer. Some states allow customer selection of utility provider with access to a particular energy source in this market structure. End customers are likely to consider price, but may also choose to pay a premium for a preferred energy source. States with restructured utilities offering customer choice are coded as "one," as a variable potentially influencing nuclear energy policy adoption[1].

Interest groups have been shown to influence adoption of legislation (Bowling and Ferguson 2001; Gray and Lowrey 1995; Yackee 2009). The majority of economic Interest groups are business-focused in nature, such as utilities, mining, or manufacturing companies seeking profit enhancement through more favorable legislation. The influence of business interest groups is likely captured in economic variables already described. Economic interest groups can also be professionally oriented, such as societies of professionals seeking to establish and enhance their particular profession.

Professional interests specific to nuclear energy may be represented by whether a state houses a university offering a nuclear engineering degree. These institutions may be advising legislators on their perceived importance of their industry, as they are preparing students for those job markets. The 21 states housing universities offering nuclear engineering degrees are in states with either research or commercial nuclear reactors, providing students access to real world experience and eventual careers. Universities also offer nuclear physics degrees, but engineering degrees are the preferred measure, as a quick analysis of job openings websites such as Indeed suggest that nuclear engineers are recruited for the nuclear energy and weapons industries, while nuclear physicists are sought for nuclear medicine and weapons openings. The number of universities within a state offering nuclear engineering degrees is included as an independent variable[1].

DOE National Laboratories that have a nuclear research function may also represent professional interest group influence. These laboratories attract professionals not directly tied to commercial enterprise, who like universities, promote their professions rather than seeking profits. Most DOE national laboratories provide research for both nuclear energy and nuclear weapons and clean-up, regardless of their primary mission (DOE 2019). Of the DOE laboratories, some employ less than 1000 persons, some are midsize with between 3,000 and 5,000 employees, and some large, with 19,000 to 22,000 employees, with relatively stable employment levels over time. Larger laboratories will have financial and social impacts on communities (INL 2019), and their presence may influence legislators' attitudes toward nuclear energy. The presence of these laboratories is coded as number of employees per lab to capture size and spatial distribution within a state that may be represented by multiple state legislators[1]. Including data on universities and national laboratories provides professional interest group measures to complement economic business variables such as number of nuclear plants that can represent those interests.

Interest groups can also be social groups seeking legislative relief for social problems, such as pollution or greenhouse gas emissions. Nuclear energy economic business interests, whether pro-nuclear or as a competitor such as coal production, are likely consistent with the economic measures captured with number of nuclear plants and coal production discussed above. Likewise, social interests are captured with the environmental and climate change attitudes discussed below.

Independent Variables – Attitudes and Public Opinion

In addition to economic independent variables described above, theory as discussed in Chapter 3 suggests that attitudes and public opinion will also be impactful. Attitudes regarding risk perception and trust in government, environment, and climate change are related to support for nuclear power (Mumpower et al. 2013; Slovic et al. 1991; Stoutenborough et al. 2013). As Slovic (1999, 689) observes, "perceptions of risks have been found to determine the priorities and legislative agendas of regulatory bodies." Risk perceptions can impact public opinion which often aligns with policy change, especially if attitudes are shifting and the issue is salient (Burstein 2003; Page and Shapiro 1983).

Chapters 2 and 3 explain why risk perception and trust in government and industry in particular, are indicators of attitudes toward nuclear energy, to which legislators are likely to respond (Leiss 2003; Sjoberg et al. 2004). The public may perceive high risk if they view nuclear energy waste exposure or accidents as severe (radiation sickness or cancer), and high magnitude of number effected (evacuations), especially if they have little personal knowledge (Mumpower et al. 2013; Slovic et al. 1991; Stoutenborough et al. 2013). Those with higher risk perceptions of nuclear energy are less likely to support nuclear energy policy; but risk perception is mitigated with trust in institutions. If citizens believe that government and industry are effectively managing risks, they are more likely to support nuclear energy.

Attitudes toward nuclear energy is often measured with public opinion polls. However, state level public opinion surveys are few, and most surveys addressing nuclear power use national samples without adequate observations to provide meaningful state level data. For example, a national poll reaching 1200 respondents may draw only one or two respondents from a low population state like Wyoming, which is not enough to statistically represent the entire state population. Scholars, however, have found ideology is a viable surrogate for public opinion (Calfano 2010; Phillips 2018). Citizen ideology data serve as the primary measure of attitudes and public opinion. Although both conservatives and liberals may “dread” nuclear energy, citizens with more conservative ideologies are more likely to trust authorities such as regulators or industry given more traditional, hierarchical values (Clawson and Oxley 2013), and view nuclear energy more favorably. Conservatives are also more likely to accept environmental risk if there is economic value (Dunlap 2001, Kantieniecki 1995, Shipan and Lowry 2001). Liberals are more likely to support environmental and climate change protections despite economic cost due to more egalitarian attitudes and values (Cruz 2017). Citizen ideology scores as proposed by Berry and colleagues are collected from the most updated listings (Berry et al. 2013), and included as an independent variable. Greater scores indicate more liberal ideologies[1].

In addition to citizen ideology, specific environmental attitudes are measured through adoption and rigor of Renewable Portfolio Standards, and membership in the U.S. Climate Alliance. Renewable Portfolio Standards goals focus on growing alternative energy markets like solar, wind, and hydropower, or energy sources that are considered renewable, clean, and low carbon, reflecting environmental protection attitudes. Renewable Portfolio Standard goals can be either voluntary or mandatory. Mandatory goals reflect a stronger commitment, and likely stronger attitudes toward environmental protection, so states are coded a “one” for voluntary, and “two” as mandatory, and “zero” for no Standard[1]. Renewable Portfolio Standards are distinct from US Climate Alliance memberships, where the target is to achieve net zero emissions, addressing climate change concerns. Whether or not a state has joined the U.S. Climate Alliance is included as an independent variable coded as “one” or “zero,” possibly distinguishing attitudes toward environmental protection with renewables, with attitudes toward climate change[1].

Central to this study is explaining why states continue to adopt supportive nuclear energy policy after public support for nuclear energy declines. As discussed above, state public opinion measured with polls is difficult to find, and instead, citizen ideology in a state may be used as a surrogate for state level public opinion. However, the rise and fall of national public opinion should inform the results. To capture the change in national public opinion, a timing variable is included. Years after 2011 are coded as “one,” and before and including 2011 are included as “zero.” 2011 is included as “before” even though the Fukushima Daiichi accident triggering a drop in public support occurred late in February of 2011, it is likely legislation was already in process by the time it was adopted[1].

Scholars argue that public opinion is more impactful if it is salient. If there is evidence that nuclear energy is in the news, it is likely that citizens are thinking and talking about it (Clawson and Oxley 2013; Druckman 2001). A measure for salience is included, because public opinion is more likely to be reflected in policy if an issue is salient (Burstein 2003; Page and Shapiro 1983). As discussed in Chapter 3, number of media news stories if a preferred salience measure. For this study, salience is measured with data on the number of news stories (print and electronic media) containing "nuclear plants" for each state during each year from 2003-2018[1].

Independent Variables – State Government Structures

State structural elements of capacity for citizen initiatives and general fund revenue may influence energy policy, as explored in Chapter 3. Theory suggests that states with citizen initiatives may be more responsive to public attitudes, especially on salient issues (Gerber 1998, Williams 2001). State legislatures may support policy to get in front of a potential citizen initiative to align themselves with the public to improve their chances for re-election. If a state has citizen initiatives specific to legislation it is coded as "one" as an independent variable, and otherwise as "zero[1]."

States may be better able to offer the financial incentives that define strong supportive nuclear energy policy if their general fund revenue is greater relative to other states. More funds may indicate greater discretionary spending power. Data on annual General Fund Revenue for each state over the 16 years are collected, and normalized for state population[1]. This independent variable is included as states with more revenue per person than others may be more able to offer financial incentives in policy.

Control Variables

State demographic data are collected as control variables. These include measures of population and education. Low population density may be attractive to investors from a risk perspective, or, states with remote populations may see small modular reactors as an energy solution. Population density is collected as a control variable[1]. States with higher education attainment may produce more informed citizens on issues that relate to nuclear energy, such as climate change and environmental protection. Annual percent of the state population who are college graduates is provided to represent education attainment in each state.

Descriptions of coding and data sources for the independent variables are provided in the Code Book, attached as Appendix B.

Diffusion Variables

Scholars often suggest diffusion mechanisms to explain adoption of similar legislation between states. As discussed in Chapter 3, diffusion mechanisms are varied. States competing economically may adopt policy to attract industries by offering tax breaks, or may be emulating other states with successful policies. Policy adopted by states with similar features such as existing nuclear plants or national laboratories can be compared to evaluate competitive pressures. Time intervals between policy adoptions may provide insight as to whether the policy is imitated, or emulated after time has passed and effectiveness is evaluated. Of various policy diffusion mechanisms, neighbor diffusion may occur if states sharing energy networks, or participating in RTOs and ISOs, are seeking cooperation or competition. A variable to assess neighbor diffusion is created by calculating percentage of bordering states that have already adopted the policy. Neighbor diffusion is included as a diffusion independent variable in the regression analysis[1].

Model Development

A longitudinal data set is established as described above for event history analysis. Independent variables will impact dependent variables differently, so a process is executed to identify the most impactful independent variables for each model. Independent variables resulting in the most statistically significant relationships with each dependent variable are methodically identified.

As explained above, adoption of state legislation is a rare event. If rare event models are over specified (i.e. too many independent variables), bias can cause errors when estimating probability of the dependent variable moving from zero to one, resulting in biased standard errors. To address over specification issues, a baseline model is established with the dependent variable of any adoption of supportive nuclear energy policy (31 states over 16 years). Consistent with event history analysis, this baseline model reflects time elapsed for a state to move from status quo to not status quo. The baseline model provides a set of independent variable measures influencing states both with and without moratoriums on new nuclear plants. All independent variables are tested for multicollinearity to ensure model quality.

Sixteen independent variables are established using the baseline model of any supportive nuclear policy adopted between 2002 and 2019 (31 states). Seven variables reflect economics and interest group influences (number of nuclear plants, coal extraction, unemployment rate, RTO/ISO, customer energy choice, nuclear universities, and DOE national laboratories), four reflect attitudes and public opinion (citizen ideology, Renewable Portfolio Standard, U.S. Climate Alliance membership, and nuclear news), two are used to assess influence of government structure (citizen initiatives and general fund revenue), and two demographic measures are included for controls (population density and college degrees). In addition, a diffusion variable is included to assess any evidence of neighbor policy diffusion mechanisms.

Once the baseline case of all 31 states adopting policy of any kind is established, subsequent models, reflecting dependent variables that are subsets of the baseline dependent variable, are created to explore nuance to address research questions. The subset dependent variables contain even fewer events than the baseline model, so the threat of a rare event bias is even greater. This means that the likelihood of having over-specified models is higher. The subset dependent variables restrict events of policy adoption, as first, policy adoption is separated into strong and hard policy, and then separated into states with moratoriums at the start of the study. Therefore, a process is adopted to methodically eliminate independent variables to remove the over-specification bias. Some independent variables included in the baseline model are removed as they are no longer relevant. For example, none of the states repealing moratoriums have DOE national laboratories. Other variables also become less relevant, such as coal extraction industries are relatively minimal outside of five or six states. To release less meaningful independent variables for a particular dependent variable, the independent variables included in the baseline model, minus the ones that no longer exist (national lab example), are eliminated one by one, targeting those indicating the least statistical significance indicated by the Z-test values. Statistically, models with too many extremely weak predictors can suffer from the over-specification bias. Consequently, this process is repeated until the Wald Chi2 probability of the overall model is less than 0.10. A Wald Chi2 above 0.10

indicates that the model is not any good, and that any statistically significant estimate may not actually be statistically significant. Therefore, for hypothesis testing, it is essential for the Wald Chi2 to be below 0.10. This process provides model stability with objective variable elimination.

The process for eliminating independent variables in the baseline model from the subset models is applied to dependent variables of strong policy (18 states), soft policy (14 states), and further subsets of states having moratoriums in 2003 but then adopted supportive policy (7 states). Event history analysis methodology for longitudinal data is applied, adjusted with trend variables. These dependent variables are treated as rare events, and model statistics benefit from complementary log-log regression because it provides the most accurate distribution of the probability of the dependent variable moving from zero to one.

The remaining five models do not lend to time series as either status quo cases which do not have policy adoption events, or with subsets of adopted policy with too few events to render meaningful results. For these models, logistical and complementary log-log regressions are used as appropriate. Results of the regression analyses are reported and relationships compared with theory and discussed for relevance in Chapter 5, Results.

CHAPTER V

RESULTS

To address research questions on what influences states to adopt nuclear energy policy, nine cases of statistical models representing nine dependent variables are analyzed as described in Chapter 4:

Case 1. All supportive policy adopted (31 states)

Case 2. Strong supportive policy adopted (18 states)

Case 3. Soft supportive policy adopted (14 states)

Case 4. Strong or soft supportive policy adopted by states with moratoriums (7 states)

Case 5. Strong supportive policy adopted by states maintaining moratoriums (4 states)

Case 6. Soft supportive policy adopted by states lifting their moratoriums (3 states).

Case 7. Moratoriums in 2003 (17 states)

Case 8. Status quo maintaining moratoriums through 2018 (10 states)

Case 9. Status quo with no moratorium through 2018 (9 states).

Recall Figure 1.5 from Chapter 1 showing how the dependent variables are specified between two delineators: soft or strong policy, and whether or not the state had a moratorium on new nuclear plants in 2003. Figure 5.1 shows how the nine statistical models align with Figure 1.5.

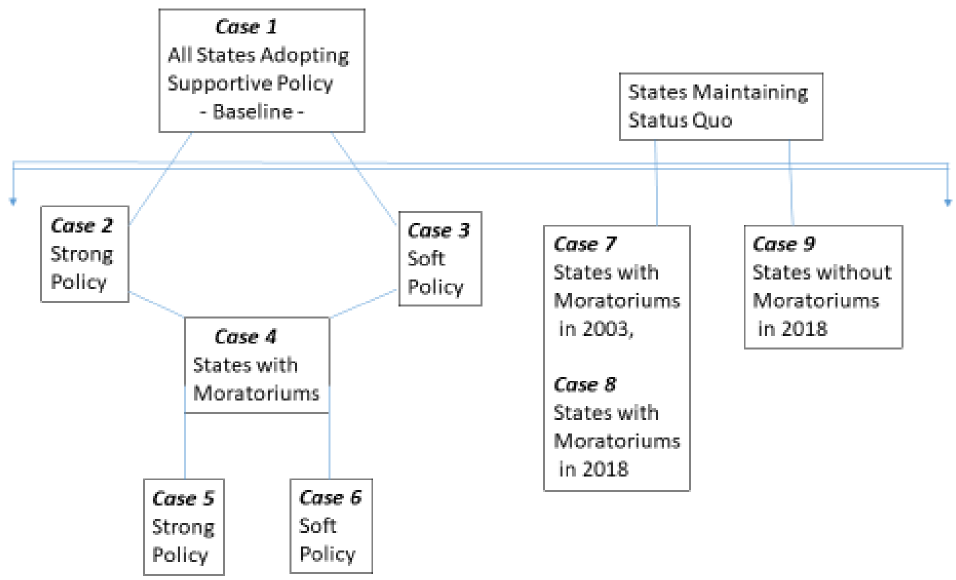

Figure 5.1 Statistical model alignment with strong policy, soft policy, moratorium, and no moratorium

As mentioned previously, the cases below the line are of most interest because they provide more fidelity. Results reporting for each of the nine cases follows.

Model Results, Baseline Event History Analysis

Before reporting quantitative results of the cases with more fidelity, the results of the baseline model, Case 1, are addressed. Recall that as the most general case (all states adopting any type of policy), this model is used to establish theoretically appropriate independent variables. Even in this model, adoption of policy is a rare event, with only 31 events in 601 occurrences. If rare event models are over specified (i.e. too many independent variables), bias can cause errors when estimating probability, as not enough variation exists within the dependent variables. Case 1 is a baseline for independent variables, while subsequent models with even fewer events eliminate independent variables in a methodical manner to reduce error as needed.

The baseline model is 31 states adopting supportive legislation between 2002 and 2019. Figure 5.2 indicates how many states adopted policy in each year.

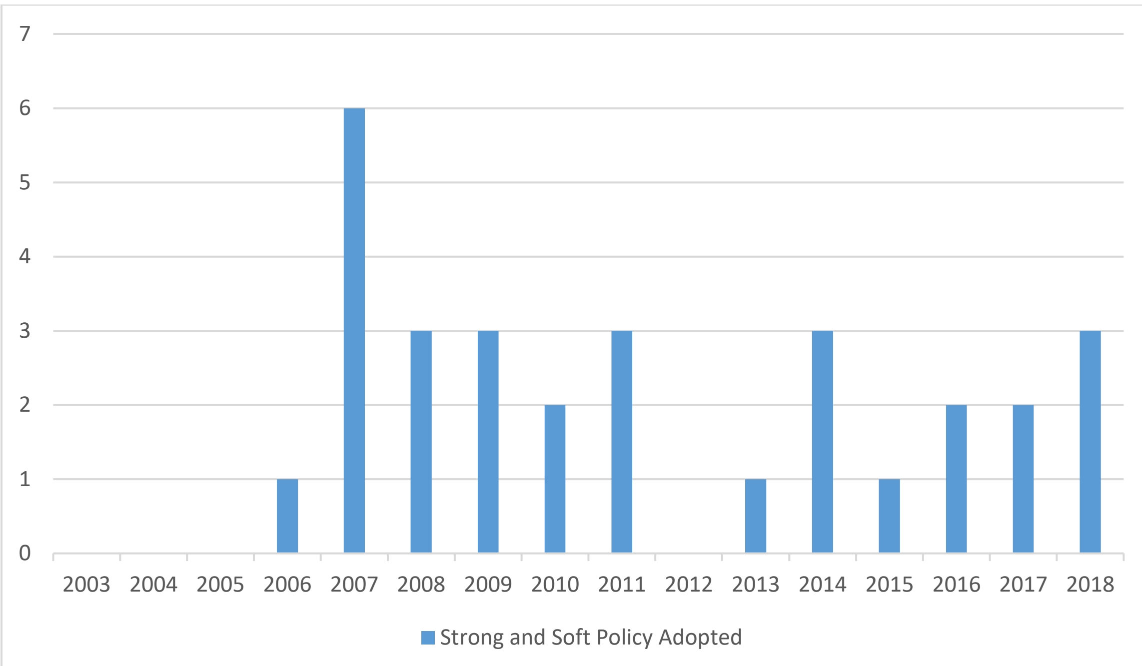

Figure 5.2 Number of states adopting any type of supportive nuclear energy policy

Adoption of supportive policy is relatively constant over time with the exception of a surge of policy adoption in 2007, and no policy adopted in 2012, the first year after the Fukushima Daiichi accident. The results for the complementary log-log event history model for Case 1 (all states that adopt supportive policies) are reported in Table 5.1.

Table 5.1 Strong and soft supportive policy adopted by any state (Case 1)

	Coefficient (Standard Error)	Probability
Economic variables		
Number of Nuclear Plants	-0.011 (0.099)	0.904
Coal Extraction	0.000 (0.000)	0.868
Unemployment	-0.041 (0.109)	0.708
RTO/ISO	-0.942 (0.550)	0.110
Allow customer choice	0.874 (0.546)	0.691
Nuclear universities	0.439 (0.381)	0.249
National Laboratories	-0.000 (0.000)	0.512
Attitudes and Public Opinion		
Citizen Ideology	-0.052 (0.023)	0.025*
Renewable Portfolio Standard	0.266 (0.327)	0.415
US Climate Alliance member	1.865 (0.974)	0.056*
Post Fukushima accident	0.700 (0.693)	0.313
Nuclear news	0.018 (0.006)	0.003*
State Structure		
Initiatives	-0.916 (0.518)	0.077*
General Fund/Capita	0.255 (0.161)	0.112
Controls		
Population Density	-0.000 (0.001)	0.832
College graduates	0.005 (0.037)	0.880
Diffusion		
Neighbor Diffusion	0.958 (0.689)	0.164
Trend	-0.642 (0.340)	0.059*
Number of cases	601	
Wald Chi^2	28.77	0.052*
Log Psuedolikelihood	-106.72233	

*p < 0.100

The baseline's model fit statistics indicate the model performs well. This model benefits from a trend impact variable, which stabilizes the hazard rate. States that are U.S. Climate Alliance members and have more news on nuclear plants were more likely to adopt supportive policy.

States that are more liberal and those that have citizen initiatives were less likely to adopt supportive legislation.

Model Results, Strong and Soft Policy

Having reported baseline results, results of models reflecting more fidelity by distinguishing between strong and soft policy adoption are evaluated. First, Case 2 represents all states adopting strong policy. The year each state adopted strong policy is shown in Figure 5.3.

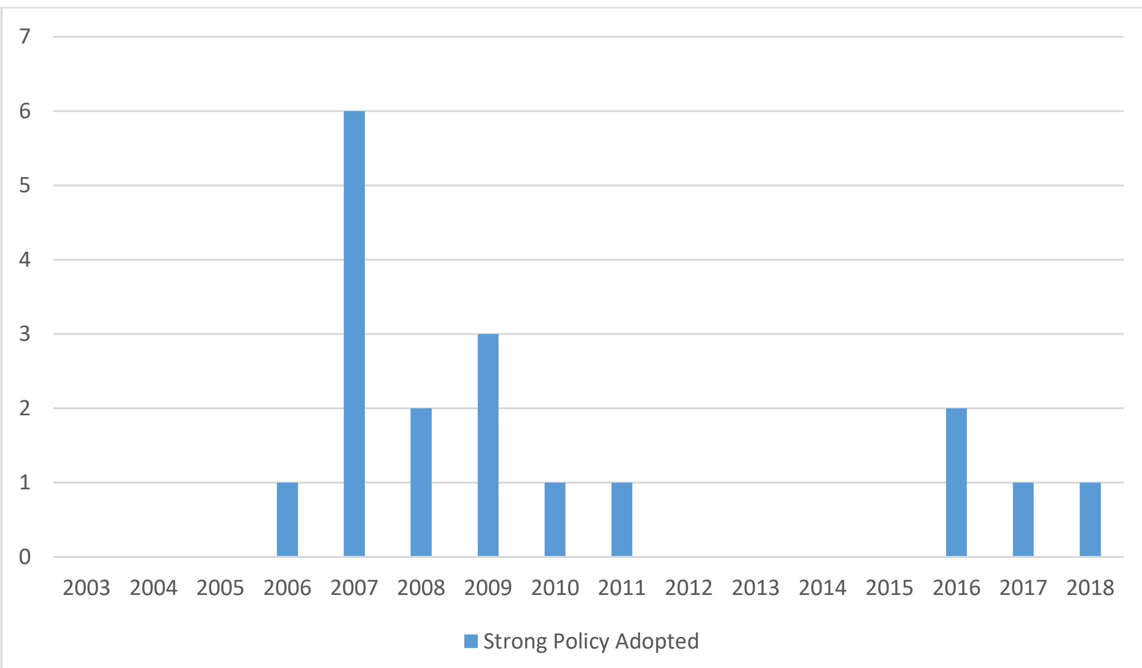

Figure 5.3 Number of states adopting strong supportive nuclear energy policy

Figure 5.3 indicates that most adoption of strong supportive nuclear energy policy occurred after the Energy Policy Act of 2005 and before 2012, the year following the Fukushima Daiichi accident. The event history analyses results are reported in Table 5.2.

Table 5.2 Strong supportive policy adopted by any state (Case 2)

	Coefficient (Standard Error)	Probability
Economic Variables		
Number of Nuclear Plants	0.022 (0.161)	0.888
Coal Extraction	-0.000 (0.000)	0.348
Unemployment	-0.205 (0.178)	0.251
RTO/ISO	-0.390 (0.830)	0.638
Allow customer choice	-0.082 (0.949)	0.931
Nuclear universities	0.383 (0.555)	0.490
National Laboratories	-0.000 (0.000)	0.101
Attitudes and Public Opinion		
Citizen Ideology	-0.025 (0.026)	0.348
Renewable Portfolio Standard	-0.031 (0.440)	0.943
US Climate Alliance member	3.395 (1.466)	0.021*
Post Fukushima accident	-2.713 (1.259)	0.031*
Nuclear news	0.027 (0.008)	0.002*
State Structure		
Initiatives	-1.973 (0.845)	0.020*
General Fund/Capita	-0.146 (0.382)	0.703
Controls		
Population Density	0.000 (0.001)	0.542
College graduates	-0.028 (0.051)	0.568
Diffusion		
Neighbor Diffusion	-3.276 (3.162)	0.300
Trend	-1.174 (0.633)	0.064*
Number of cases	655	
Wald Chi^2	32.66	0.018*
Log Psuedolikelihood	-62.587842	

*p < 0.100

The model fit statistics for complementary log-log event history analysis reveal the model performs well. This model benefits from a trend impact variable, which stabilizes the hazard rate. States with U.S. Climate Alliance memberships, and states with more nuclear energy news were more likely to adopt strong supportive policy. States were less likely to adopt strong policy after the Fukushima Daiichi accident. States with citizen initiatives were less likely to adopt strong supportive policy.

Next, results for all states adopting soft nuclear energy policy, or Case 3, are reported. Figure 5.4 indicates how many states adopted soft policy in which year.

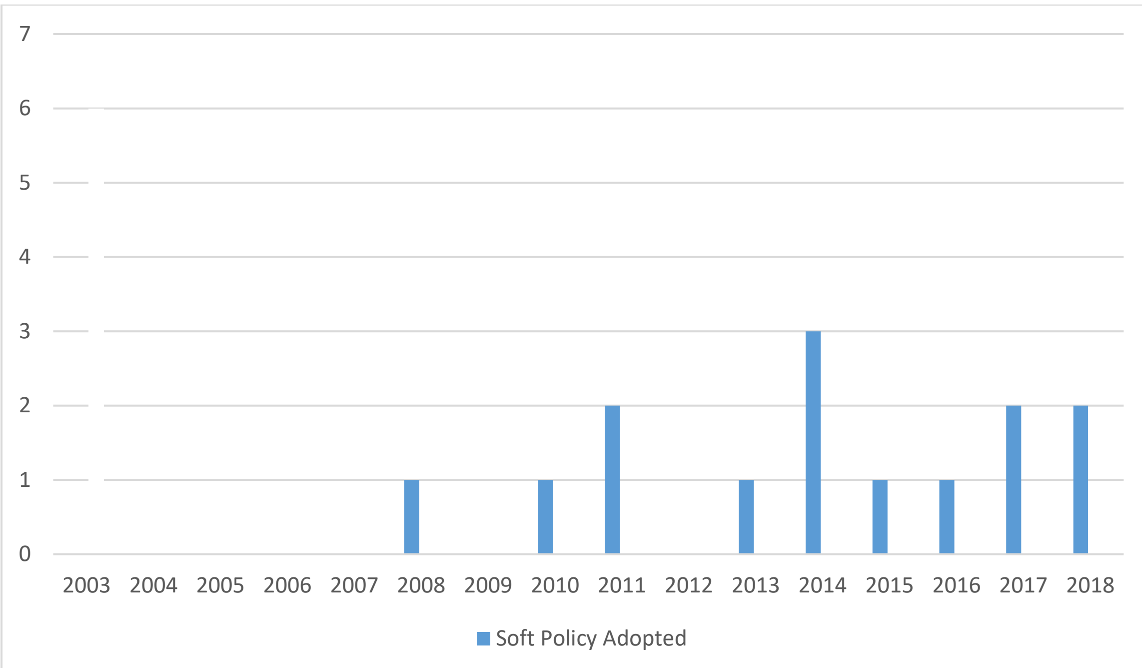

Figure 5.4 Number of states adopting soft supportive nuclear energy policy

Rate of policy adoption is relatively flat, with more soft policy adopted after 2011. The results for Case 3 are reported in Table 5.3.

Table 5.3 Soft supportive policy adopted by any state (Case 3)

	Coefficient (Standard Error)	Probability
Economic Variables		
Nuclear Plants	0.274 (0.136)	0.045*
Coal Extraction	0.000 (0.000)	0.131
Unemployment	-0.069 (0.188)	0.712
RTO/ISO	-0.163 (0.805)	0.839
Allow customer choice	0.312 (1.067)	0.770
Nuclear universities	0.092 (0.609)	0.879
National Laboratories	0.000 (0.000)	0.027*
Attitudes and Public Opinion		
Citizen Ideology	-0.014 (0.035)	0.687
Renewable Portfolio Standard	-0.204 (0.491)	0.677
US Climate Alliance member	3.018 (1.500)	0.044*
Post-Fukushima accident	0.761 (1.140)	0.504
Nuclear news	-0.018 (0.023)	0.437
State Structure		
Initiatives	1.128 (0.903)	0.160
General Fund/Capita	0.343 (0.166)	0.039*
Controls		
Population Density	-0.005 (0.004)	0.258
College Graduates	-0.009 (0.081)	0.905
Diffusion		
Neighbor Diffusion	-2.125 (2.340)	0.364
Trend	-0.917 (0.492)	0.063*
Number of cases	747	
Wald Chi^2	26.92	0.080*
Log Psuedolikelihood	-53.549139	

*p < 0.100

Model fit statistics suggest the model performs well. States with more nuclear plants, larger DOE national laboratories, U.S. Climate Alliance memberships, and greater general revenue per capita were more likely to adopt soft supportive policy. Note that the statistically significant relationships when dependent variables are divided into strong and soft policy adoption differ from the relationships developed in the baseline case, all policy adopted. This suggests that the subdivision of dependent variables is providing fidelity to the analysis.

Model Results, Moratoriums in 2003

Case 4 represents states with moratoriums in 2003 that adopted strong or soft policy. Figure 5.5 indicates which years states with moratoriums adopted either strong policy or soft policy.

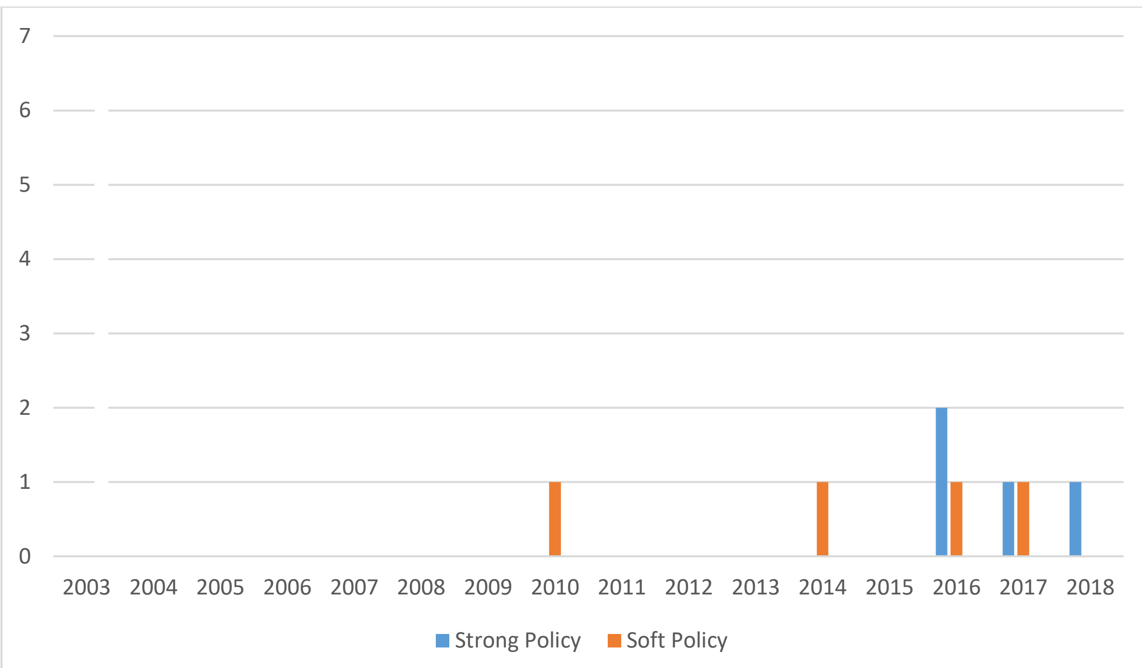

Figure 5.5 States with moratoriums on new nuclear plants adopting supportive nuclear energy policy

States with moratoriums did not adopt policy early in the study duration, after the Energy Policy Act of 2005. Instead, most adopt policy after 2012. Strong policy adoption by states with moratoriums is more recent, occurring in 2014 to 2018. The regression results are reported in Table 5.4.

Table 5.4 Supportive policy adopted by states with moratoriums (Case 4)

	Coefficient (Standard Error)	Probability
Economic Variables		
Number of Nuclear Plants	0.484 (0.242)	0.045*
Coal Extraction	0.000 (0.000)	0.560
Unemployment	0.201 (0.367)	0.583
Nuclear universities	-1.350 (1.016)	0.184
Attitudes and Public Opinion		
Renewable Portfolio Standard	-0899 (0.862)	0.277
US Climate Alliance member	1.835 (1.602)	0.252
Post-Fukushima accident	1.235 (2.305)	0.592
Nuclear news	0.021 (0.011)	0.061*
State Structure		
Initiatives	-0.653 (1.823)	0.720
General Fund/ capita	0.696 (0.226)	0.002*
Controls		
Population Density	0.000 (0.001)	0.632
College graduates	0.049 (0.121)	0.684
Diffusion		
Neighbor Diffusion	4.240 (2.605)	0.104
Trend	-1.038 (0.789)	0.188
Number of cases	782	
Wald Chi^2	21.23	0.095*
Log Psuedolikelihood	-22.599761	

*p < 0.100

The model fit statistics of this event history analysis indicate the model performs well. Note that the preceding event history analysis models were able to accommodate all the baseline independent variables, but some independent variables are eliminated for this case to assure a Wald Chi2 above 0.10. Recall that this is sometimes necessary with rare events, so a methodical approach is used as described in Chapter 4 to eliminate variables objectively. The remaining independent variables result in statistically significant relationships indicating that states with moratoriums were more likely to either lift their moratorium or adopt policy if states have existing nuclear plants, had more nuclear plant news, and greater general revenue per capita.

The seven states adopting supportive policy despite moratoriums on new nuclear plants are further subdivided into adoption of strong policy or lifting moratoriums. (The three states lifting moratoriums did not adopt strong policy as defined for this study, so in these models lifting moratoriums is interchangeable with adopting soft policy.) Event history analysis of these cases produces unacceptable error, as the events become extremely rare. These subsets are analyzed for 2018 data only. Results for a complementary log-log regression of Case 5, states with moratoriums adopting strong policy, are listed in Table 5.5.

Table 5.5 States with moratoriums adopting strong policy (Case 5)

	Coefficient (Standard Error)	Probability
Economic Variables		
Number of Nuclear Plants	2.623 (0.641)	0.000*
Coal Extraction	-0.000 (0.000)	0.000*
Attitudes and Public Opinion		
Nuclear news	-0.012 (0.015)	0.413
State Structure		
General Fund/ capita	1.060 (0.412)	0.010*
Controls		
Population Density	0.016 (0.005)	0.003*
Number of cases	50	
Wald Chi^2	31.73	0.000*
Log Psuedolikelihood	-2.554386	

*p < 0.100

Model fit statistics indicate the model performs well. States with more existing nuclear plants and higher general fund revenues were more likely to adopt strong policy despite moratoriums on new plants. States maintaining moratoriums with more coal extraction were less likely to adopt supportive policy. Additionally, states with greater population densities were more likely to maintain their moratorium yet adopt strong legislation.

Case 6 represents the three states lifting moratoriums. Results for Case 6 are shown in Table 5.6.

Table 5.6 States with moratoriums adopting soft policy (Case 6)

	Coefficient (Standard Error)	Probability
Economic Variables		
Number of Nuclear Plants	0.468 (1.407)	0.739
Coal Extraction	-0.000 (0.000)	0.700
Unemployment	1.312 (0.475)	0.006*
RTO/ISO	-0.508 (2.855)	0.859
Attitudes and Public Opinion		
Citizen Ideology	0.034 (0.121)	0.774
Nuclear news	-0.291 (0.524)	0.579
State Structure		
Initiatives	-2.984 (0.897)	0.001*
General Fund/ capita	1.667 (2.292)	0.467
Controls		
Population Density	-0.014 (0.016)	0.381
College graduates	-0.201(0.638)	0.753
Number of cases	50	
Wald Chi^2	33.24	0.000*
Log Psuedolikelihood	-6.4432633	

*p < 0.100

States with higher unemployment rates were more likely to lift moratoriums; states with initiatives were less likely.

Next, results for states with moratoriums in 2003 are reported. These results become important for comparison with 2018 results when event history analysis is not possible for a particular dependent variable, either because events are too rare, or no events occur due to states maintaining status quo regarding nuclear energy policy. A logistic regression model of these 17 states in 2003 is reported in Table 5.7, States with Moratoriums in 2003, Case 7.

Table 5.7 States with moratoriums in 2003 (Case 7)

	Coefficient (Standard Error)	Probability
Economic Variables		
Number of Nuclear Plants	0.133 (0.178)	0.455
Coal Extraction	0.000 (0.000)	0.027*
Unemployment	2.004 (1.494)	0.180
RTO/ISO	0.687 (2.231)	0.758
Allow customer choice	-3.097 (1.599)	0.053*
Nuclear universities	-0.948 (0.765)	0.215
National Laboratories	-0.000 (0.000)	0.016*
Attitudes and Public Opinion		
Citizen Ideology	0.300 (0.105)	0.004*
Renewable Portfolio Standard	1.309 (0.622)	0.035*
Nuclear news	0.039 (0.024)	0.106
State Structure		
General Fund/Capita	2.900 (1.106)	0.009*
Controls		
Population Density	-0.002 (0.001)	0.169
Number of cases	50	
Wald Chi^2	23.25	0.025*
Psuedo R^2	0.651	

*p < 0.100

Model fit statistics suggest the model performs well. States with more coal extraction, more liberal citizen ideologies, more aggressive Renewable Portfolio Standards, and greater general revenue per capita were more likely to have moratoriums on new plants. States allowing customer energy source choice and larger DOE national laboratories were less likely to have moratoriums.

Model Results, Status Quo

Finally, results of two status quo cases are reported. Between 2002 and 2019, 10 states maintained their moratoriums without adopting any supportive nuclear energy policy. Results of the Case 8 complementary log-log regression for 2018 are listed in Table 5.8. Model fit statistics indicate the model performs well. States with moratoriums in 2003 and 2018 with more nuclear plants were less likely to maintain status quo.

Table 5.8 States with moratoriums in 2003 maintaining status quo through 2018 (Case 8)

	Coefficient (Standard Error)	Probability
Economic Variables		
Number of Nuclear Plants	-1.042 (0.574)	0.070*
Coal Extraction	0.000 (0.000)	0.215
Unemployment	0.930 (1.346)	0.489
RTO/ISO	2.198 (2.077)	0.290
Allow customer choice	-1.606 (1.980)	0.417
Nuclear universities	0.390 (0.806)	0.629
National Laboratories	-0.000 (0.000)	0.208
Attitudes and Public Opinion		
Citizen Ideology	0.040 (0.051)	0.430
Renewable Portfolio Standard	2.041 (2.208)	0.355
Nuclear news	0.027 (0.024)	0.263
State Structure		
Initiatives	0.529 (0.874)	0.545
General Fund/Capita	0.981 (1.238)	0.428
Controls		
Population Density	-0.004 (0.008)	0.597
College graduates	-0.029 (0.106)	0.781
Number of cases	50	
Wald Chi^2	30.16	0.007*
Log Psuedolikelihood	-13.531537	

*p < 0.100

The other status quo model reflects nine states without moratoriums that did not adopt any supportive policy between 2002 and 2019. Results of Case 9, a complementary log-log regression for 2018 are listed in Table 5.9. Model fit statistics indicate the model performs well. States without moratoriums but with more aggressive Renewable Portfolio Standards were more likely to take no policy action.

Table 5.9. States without moratoriums in 2003 maintaining status quo through 2018 (Case 9)

	Coefficient (Standard Error)	Probability
Economic Variables		
Number of Nuclear Plants	0.697 (0.859)	0.418
Coal Extraction	-0.000 (0.000)	0.011*
Unemployment	1.421 (1.074)	0.186
RTO/ISO	0.496 (1.930)	0.797
Allow customer choice	3.075 (2.598)	0.237
Nuclear universities	-2.591 (1.707)	0.129
Attitudes and Public Opinion		
Citizen Ideology	-0.305 (0.131)	0.021*
Renewable Portfolio Standard	2.549 (1.300)	0.050*
Nuclear news	-0.162 (0.145)	0.264
State Structure		
Initiatives	-0.612 (1.337)	0.647
Controls		
Population Density	0.002 (0.001)	0.187
Number of cases	50	
Wald Chi^2	24.23	0.011*
Log Psuedolikelihood	-10.871276	

*p < 0.100

States with more coal extraction and more liberal citizen ideologies were less likely to take no legislative action.

This Chapter reports the results of four event history analyses, four complimentary log-log regression analyses, and one logistical regression analysis. Statistically significant relationships with economic, attitudes and public opinion, state structure, and diffusion variables are realized collectively in the models, but when delineated by type of policy and whether or not states have moratoriums, results differ. These differences in results between models will inform the research questions. Analysis of the results and implications for the findings are discussed in Chapter 6, Conclusion.

Chapter VI

Conclusion

At the turn of the century the U.S. was emerging from a period of stagnation for the nuclear energy industry. The Nuclear Regulatory Commission was receiving construction and license applications for new plants, and public opinion polls indicated rising support for nuclear energy. It is possible this interest was driven by considering nuclear energy as relief for both energy security and climate change concerns. States adopted supportive policy, especially after passage of the Energy Policy Act of 2005 offering incentives for new nuclear power plants. Then a tsunami in Japan resulted in steam explosions at a nuclear power plant, and public support for nuclear power declined. Supportive policy adoption stalled for a few years, but then increased, even as public support declined.

The purpose of this study was to understand why states continued to adopt supportive policy after public support declined. This study began by introducing the topic describing a wave of state adoption that is supportive of nuclear energy after decades of little interest. Chapter 2 provided background important for appreciating how nuclear energy has developed on a unique path, contributing to politicization and state government involvement. Events formed attitudes that impact the nuclear energy industry for decades. Policy theory was explored in Chapter 3 to suggest what is most likely to impact energy policy adoption by states and identify possible determinants. Chapter 4 describes a quantitative analytical approach applying event history analysis and regression techniques to seek relationships that are not otherwise obvious. Results are reported in Chapter 5 noting statistically significant relationships and comparisons between time frames.

Quantitative analysis of states both with and without moratoriums adopting different types of policy provide fidelity that should lead to insight into the research questions. By defining adopted policy as either strong or soft, the results have a tiered approach. States adopting strong policy are seeking substantive change; these states are likely true nuclear energy supporters. Soft supportive policy is also positive, but is more symbolic and therefore may not represent as strong of a commitment to nuclear power. Some states were clearly unsupportive, having adopted moratoriums on new nuclear plants before 2000, but adopted supportive policy despite moratoriums. Analyzing the type of policy adopted (or not adopted) by states with and without moratoriums, adds nuance in understanding the research questions beyond what analyzing only all states adopting any type of supportive policy could provide.

Four research questions are addressed to determine what conclusions might be drawn:

1. How do economic considerations influence state nuclear energy policy adoption?
2. How do attitudes and public opinion influence state nuclear energy policy adoption?
3. How do government structures influence state nuclear energy policy adoption?
4. How does policy diffusion influence nuclear energy policy adoption?

The quantitative results reported in Chapter 5 may add theoretical understanding of state policy adoption. Each question is addressed individually using the corresponding hypothesis, and the results of the event history and regression analyses.

Analysis

H1. Economic considerations will influence state nuclear energy policy.

States are developmental actors (Hwang and Gray 1991; Peterson 1981). Legislators will seek opportunities and adopt policy that will provide economic growth. Strong policy, defined as policy either approving siting or operation of a specific nuclear plant, or offering a financial incentive specific to nuclear energy, should reflect economic influences. States are more likely to offer financial incentives if they believe they will recover those costs either directly through revenue or indirectly with economic growth (Jaro and Baer 1976). Consequently, this analysis begins with economic influences on strong policy adoption.

Multiple measures were identified to assess economic influences. The number of existing nuclear plants in each state and short tons of coal extraction represents industry economic interests, and number of universities with nuclear engineering programs and size by employment of DOE national laboratories measures professional interests. Unemployment rate provide a gauge of economic health and need for legislators to create jobs. To measure market structure impacts, whether or not a state's service area was largely in RTO or ISO markets, and whether or not the states allowed consumer choice of energy provider, are included.

The statistical models use independent variables of number of nuclear plants, coal extraction, universities with nuclear engineering programs, and DOE national laboratories as measures of business and professional interest group influences. Unemployment rates measure concern for job creation, and RTO and ISO membership and customer choice of energy source represent market structure challenges. Of these influences, business interests are the only economic predictors of strong supportive policy adoption, as reported in Chapter 5 (Table 5.2, Case 2), and states with moratoriums adopting strong policy (Table 5.5, Case 5).

Before discussing the model results, the timing of policy adoption is revisited to aid the analysis of strong policy adoption. Returning to Figure 5.2 from Chapter 5, there was a surge in strong policy adoption after the Energy Policy Act of 2005. No strong policy was adopted the four years following the Fukushima Daiichi accident, but adoption resumed in 2016. Closer inspection reveals that all the states adopting strong policy before 2012 do not have moratoriums, while all the states adopting after 2012 do, as shown in Figure 6.1.

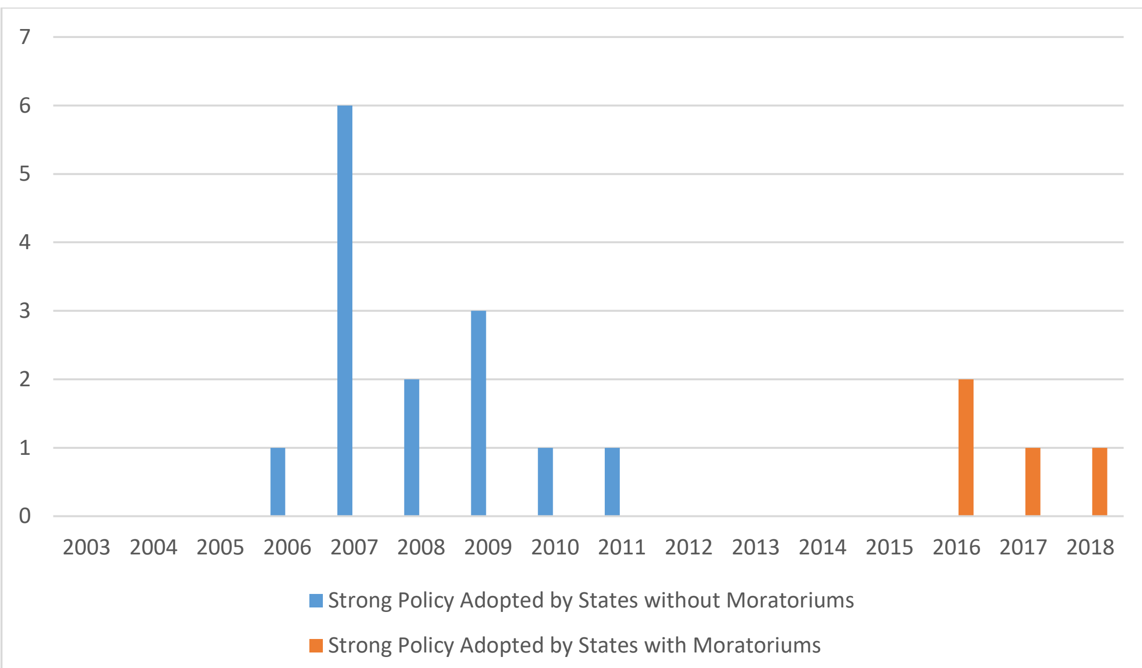

Figure 6.1 Number of States Adopting Strong Policy by Moratorium

This temporal distribution suggests that the states without moratoriums may have responded to the Energy Policy Act incentives of 2015 despite newly achieved energy independence. These states align with public opinion as they adopt policy while public support is rising, which is expected given theoretical alignment between policy adoption and public opinion. Reviewing policy content reveals that these policies adopted prior to 2012 are oriented toward attracting new nuclear plants. Only four states adopted strong policy after 2011 when public support is declining; all are states with existing moratoriums. Unlike the earlier surge, these states are not pursuing new plants, because they maintain their moratoriums.

Reviewing the model results, no economic variables predict all strong policy adoption. However, when strong policy adopters are partitioned into those with moratoriums on new plants, two economic measures indicate statistically significant relationships. First, short tons of coal extracted relates negatively to supportive policy adoption as expected. If states with large coal mining industries with interest groups view nuclear energy as a competitor, legislators may avoid passing substantive nuclear energy policy. Second, the number of nuclear plants predicts strong policy adoption for the four states with moratoriums. These states may be responding to the influence of nuclear industry interest groups seeking favorable policy. As these states were initially unsupportive of nuclear power (moratoriums), this makes a strong argument that these states are adopting policy for economic reasons. They may be motivated to save their existing plants in the interest of maintaining electrical production capacity. A review of the policy synopsis provided by the NEI report (NEI 2019) on supportive policy adoption supports this assertion, because all four states are offering pricing policies to make existing nuclear plants more competitive with other energy sources.

Another economic variable, RTO and ISO membership, was expected to develop statistically significant relationships as real-time market pricing should make it more difficult for nuclear energy to compete with other energy sources, and states might be seeking relief for their nuclear industries (APPA 2019; Shea and Hartman 2007; WNA 2020). This is not indicated in the results for all strong policy adoption, and states with moratoriums adopting strong policy. In fact, the variable for RTO or ISO markets develops a negative relationship for all states adopting any type of supportive policy (Table 5.1, Case 1). RTO and ISO market structure may not be as great of threat to the nuclear industry as believed. Perhaps the soft policy adoption results will indicate different results that will aid the analysis.

It is argued that states adopting soft policy are supporting nuclear energy more symbolically, than substantively. These states are not incurring cost by offering direct financial incentives so these states may not be as committed to nuclear energy as states adopting strong policy. Revisiting Figure 5.3 from Chapter 5 indicating the temporal adoption of soft legislation, most states that adopted soft policy did so after 2012. This right temporal skew for soft policy adoption contrasts with the left skew for strong policy adoption (Figure 5.2). Unlike strong policy adoption, more soft policy was adopted post-Fukushima when public support is declining. This indicates states may be responding to a less supportive public by favoring symbolic legislation over substantive. These states may be reassuring the nuclear energy industry but not committing resources to invest in nuclear power that could be unpopular with the public.

Results for all states adopting soft policy are reported in Chapter 5, Table 5.3. The number of nuclear plants, and the presence of larger DOE national laboratories are both economic predictors. More nuclear plants represent more industry interest groups, for whom states might seek policy that will reassure these groups as public support declines. National laboratories are likely to be educating citizens and legislators on emerging nuclear energy or waste management technologies, an important interest group function. Relationships with larger DOE national laboratories suggests these states may be influenced by information on new reactor technologies that might relieve concerns for nuclear safety and waste management. For example, of the states adopting soft policy, Idaho's and New Mexico's policies specifically express interest in emerging reactor technologies. By adopting policy content on new, improved technologies, legislators can be reassuring industry and professional interest groups, without offending a less supportive public.

The only other economic variable that develops a statistically significant relationship specific to soft policy adoption occurs for states lifting moratoriums but not adopting specific financial incentives (Table 5.6, Case 6). A positive relationship with unemployment rate is indicated, suggesting these states may be reacting to declining jobs and economic indicators. These states may be seeking new industry for employment, or increased energy production capacity to boost economic growth. But without financial investment, this may be a gesture to keep options open, rather than fully commit to nuclear energy development.

In summary, economic variables do not appear to influence adoption of strong supportive nuclear energy policy, with the exception of states with moratoriums protecting existing electrical capacity. In contrast, economic variables of both professional and industry interests, and unemployment rates, do appear to influence adoption of soft supportive policy. However, soft policy may not be as impactful as strong policy, indicating less state commitment than adopting strong policy. This result suggests that states are aware that nuclear energy may not resonate with the public since most soft policy is adopted after the Fukushima Daiichi accident, but may also believe that nuclear energy may have value in the future, passing just enough policy to keep options open. Perhaps analysis of attitudes and public opinion measures will add explanation when coupled with the economic influences.

H2: Environmental attitudes and public opinion will influence state nuclear energy policy.

Three attitude predictors are included in the models. State citizen ideology measures an overall attitude toward nuclear energy, as more liberal citizens are less likely to trust government institutions to keep nuclear plants and wastes safe. More conservative citizens are likely to factor in economic costs of environmental protection, and are more likely to trust government to keep them safe (Leiss 2003; Sjoberg et al. 2004). This assertion is supported with public opinion polls (Funk and Hefferon 2019; Pew 2015). This alignment may be validated by results for 17 states with moratoriums evaluated for just 2003 data (Table 5.7, Case 7). The results of this model indicate that states with more liberal citizenry are more likely to have moratoriums on new nuclear plants, suggesting more liberal citizens are less supportive of nuclear energy, as expected.

States with more conservative citizen ideology are expected to be more supportive of nuclear energy policy. In fact, this is indicated not only in states with moratoriums in 2003 results, but for all states adopting supportive policy (Table 5.1, Case 1). Curiously, a relationship to citizen ideology does not appear in any other cases when policy adoption is subdivided into strong and soft by states with and without moratoriums. Perhaps collectively, all 31 states tend to be more conservative, but when separated into strong and soft policy adopters, ideology is more mixed. This could indicate that more conservative states adopting supportive nuclear energy policy are joined by more liberal states concerned for climate change, making nuclear energy more acceptable.

The second variable measuring attitudes is rigor of Renewable Portfolio Standards. Level of rigor is indicated by either no standards, voluntary standards, or mandatory standards (Carley and Miller 2012). This variable is intended to indicate environmental protection values as Renewable Portfolio Standards promote low-polluting energy sources, but typically do not include nuclear energy. This assumption may be validated as states in 2003 with more aggressive Renewable Portfolio Standards are more likely to have moratoriums on new nuclear plants. However, Renewable Portfolio Standards fail to predict policy adoption in any of the other cases with the exception of status quo states without moratoriums (Table 5.9, Case 9). This suggests that environmental protection concerns are not preventing 33 states from adopting supportive nuclear policy, but might in the nine status quo states.

The third attitude measure is intended to indicate climate change concern specifically. Whether or not a state has joined the U.S. Climate Alliance adopting goals for net zero carbon emissions should reflect an attitude of concern for climate change, which more nuclear energy production could alleviate. This membership is a strong predictor, indicating positive relationships for all states adopting supportive nuclear energy policy, and the subsets of strong policy and soft policy. These relationships suggest that nuclear energy might be viewed as a climate change solution in most states.

Reviewing the results of the first status quo model (Table 5.8, Case 8), indicates that of the ten states maintaining their moratoriums and not adopting any supportive legislation by

2019, the only significant relationship is that these states have fewer nuclear plants. Of interest is the lack of relationships. Unlike states with moratoriums in 2003, coal extraction, Renewable Portfolio Standards, and citizen ideology are not potential predictors in 2018. It would be expected that states maintaining moratoriums with no adoption of supportive nuclear energy policy would still view nuclear energy as either an environmental risk or a threat to coal mining industries. This does not appear to be the case. These results may indicate that opposition to nuclear energy may becoming less strongly aligned with more liberal ideology or Democratic party orientation than in the past (Lee 2011). It is possible that nuclear energy with zero emissions potential, is seen as a possible climate change solution.

The other status quo model reflects the nine states without moratoriums in 2003, adopting no nuclear energy policy before 2019. These results can be compared to 2003 using Table 5.7 results by reversing the positive or negative coefficient signage to represent the 33 states without moratoriums in 2003. Like status quo states with moratoriums, citizen ideology does not have a statistically significant relationship, meaning that these nine states may be less conservative than the aggregate 33 states without moratoriums in 2003. However, as mentioned above, although they were less likely in 2003 to have more aggressive Renewable Portfolio Standards, in 2018, they are more likely. This is probably explained by more states adopting Renewable Portfolio Standards over the duration of the study because only 12 states had in 2003, but a majority of states have in 2018. It is also possible these states are not facing pressures to protect nuclear power industries, but are embracing environmental or climate change protection, indicating a shift in attitudes.

Continuing with analysis of attitude and public opinion predictors, a dummy variable to capture whether a state adopted policy before or after the Fukushima Daiichi accident in 2011 captures whether policy was adopted during increasing public support, or decreasing. Public opinion is argued to be a predictor of policy adoption, especially if it is salient (Burstein 2003; Goss and Kamieniecki 1983; Page and Shapiro 1983). In the four event history analyses (Cases 1-4), the timing of the accident is a predictor for strong policy adoption as anticipated. Although more soft supportive policy is adopted after 2011 than before (see Figure 5.3), the Fukushima variable is not a predictor for soft policy adoption. This may be the result of the four year lapse in strong policy adoption (see Figure 5.2), while soft policy adoption continues at a more level pace.

Public opinion is more likely to influence policy adoption if it is salient. The measure to assess the salience of nuclear energy is included as nuclear news. States with more news stories about nuclear plants (negative or positive) are expected to be more likely to adopt supportive policy, especially if citizen ideology is more conservative (Lee 2011; Pew 2105). Statistically significant relationships between the number of news items on nuclear plants appear for states adopting strong policy, and the states with moratoriums adopting supportive policy. This would be expected as so many states adopted strong policy while public opinion was increasing. If legislators were sensing public support for nuclear energy, such as through news items, they are more likely to pursue policy (Burstein 2003; Page and Shapiro 1983). However, a statistically significant relationship with news items does not appear for states adopting soft policy. This suggests that nuclear energy may not be as salient in these states so only soft policy is adopted, and as more symbolic, may be targeting a specific group without making substantive change

(Elelman 1964). The statistically significant relationship with news items in states with moratoriums adopting policy is more curious, although it is possible the policy adoption itself is generating news, after decades of moratoriums.

In summary, analyzing the quantitative results finds that attitudes and public opinion appear to influence state adoption of supportive nuclear energy policy. More conservative ideology is an overall predictor, but there is evidence that more liberal states may be appreciating nuclear energy for zero emission qualities. Climate change concern is a predictor for both strong and soft policy adoption. In addition, strong policy adoption appears to align with public support and salience. Having analyzed economic, attitude and public opinion influences, state government structures are assessed for impact.

H3: State government structure will influence state nuclear energy policy

The state structure predictors of citizen initiatives and general fund revenues indicate statistically significant relationships across the range of policy adoptions. All states adopting policy (Case 1), states adopting strong policy (Case 2), and states repealing moratoriums (Case 5) develop negative relationships with citizen initiatives. In theory, this suggests that state legislators may take more risks with legislation because they do not fear citizens overriding or forcing adoption of other legislation (Gerber 1998). However, this relationship may actually be reflecting whether or not a state has nuclear power industry interest groups representing the industry. Most nuclear plants are east of the Mississippi River, and most states with citizen initiatives are in the western U.S. Consequently, this result may not add much value to the analysis.

General fund revenue, the other state government structure measure, should theoretically align with strong policy adoption because financial incentives are involved. However, of the event history analyses, general fund revenue did not develop statistically significant relationships. Relative general fund revenue potentially represents other internal determinants besides budget discretion, so the lack of relationship with this independent variable may not add much understanding of why states adopt supportive nuclear energy policy.

State government structures do not appear to contribute meaningfully to this study. Either the measures used are not effective for the models, or this suggests that both economics and the public opinion and attitude factors are such strong indicators that state structures do not matter to nuclear energy policy outcomes. This leaves the last hypothesis to provide any remaining insight into the research questions.

H4: Diffusion of policy between states may influence state nuclear energy policy.

Chapter 3 includes a discussion of possible policy diffusion mechanisms including vertical, bottom-up, leader-laggard, and neighbor (Berry and Berry, 2007). To determine if there is quantitative evidence of policy diffusion, an independent variable representing neighbor diffusion is included in the event history analyses.

The neighbor diffusion variable measures whether a state shares borders with other states adopting policy. Neighboring states could be competing for new plants because electricity is sold to surrounding states as utility cooperatives and RTOs and ISOs serve multiple states. However, no relationships with the neighbor diffusion variable are indicated in any model. Consequently, the assertion in the Chapter 3 discussion that states adopting financial incentives could be competing with each other for new nuclear plants is not supported with quantitative analysis.

Summary

This study has reviewed the background regarding the development of nuclear energy in the U.S., describing the optimism for nuclear energy after World War II followed by concern for radiation from waste and accidents, and loss of trust in the ability of the government to regulate nuclear energy safely. Yet, nuclear energy once again came in to favor with concerns for energy security and climate change in the 2000s. A case is made that nuclear energy was politicized much differently than other electrical energy fuels, reflected by 17 states adopting moratoriums on new nuclear plants in the 20th century, while only 3 states (just in the last few years) have adopted moratoriums on even less popular new coal fired plants.

The background discussion is followed by a review of literature and policy, which informs the research questions and the subsequent statistical models and analysis. Four research questions result:

1. How do economic considerations influence state nuclear energy policy adoption?
2. How do attitudes and public opinion influence state nuclear energy policy adoption?
3. How do state government structures influence state nuclear energy policy adoption?
4. How does policy diffusion influence nuclear energy policy adoption?

Chapter 4 covers the analytical approach for quantitative analysis and Chapter 5 reports results. With the benefit of the above analysis, the findings are summarized for each question.

How do economic considerations influence state energy policy adoption?

Recall that the first hypothesis is that economics will influence state energy policy. This study finds evidence that states have adopted supportive nuclear energy policy between 2002 and 2019 for economic reasons likely influenced by business and professional interests. In addition, there is anecdotal evidence that states adopted supportive policy in response to incentives provided in the Energy Policy Act of 2005. Most states do not appear to be adopting supportive nuclear energy policy to solve unemployment. Likewise, RTO and ISO market structures, and offering customers energy source choices, do not appear to influence policy as expected. Interest group influence appears to be the primary economic influence on policy adoption.

How do attitudes and public opinion influence state energy policy adoption?

The second hypothesis is that attitudes and public opinion influence supportive nuclear energy policy adoption. This study finds evidence that attitudes are likely influential. First, adopting any type of supportive policy toward nuclear energy is more likely in more conservative states. More conservative ideology is connected to more trust in government and institutions to regulate nuclear energy and provide for safety. In addition, attitudes toward climate change may enable adoption of supportive nuclear energy policy. States with evidence of concern for climate change were more likely to adopt both strong (substantive) and soft (symbolic) policy. This may reflect a changing attitude toward nuclear energy as a climate change solution, more than as an environmental threat, especially considering that the measure for environmental protection attitudes was not a predictor of policy adoption.

How do state structures influence state energy policy adoption?

The third hypothesis is that state structure will influence supportive nuclear energy policy. There is evidence that lack of citizen initiatives may influence policy adoption. This is theoretically explained with legislators not fearing direct citizen action on nuclear energy issues. However, this is more likely explained with the prevalence of citizen initiatives in western states with considerably fewer commercial nuclear plants. The other state structure measure, general fund revenue, appears to influence only symbolic (soft) policy adoption. This contrasts to theory that states with greater general fund revenue are more likely to adopt substantive (strong) policy due to greater ability to absorb financial incentive costs. Evidence for this did not materialize. In general, state structure is not a strong predictor of supportive nuclear policy adoption, as results are not supported by theory.

How does policy diffusion influence state energy policy adoption?

Finally, diffusion mechanisms are evaluated for influence. Policy diffusion theories abound in contemporary research explaining state policy adoption, with considerable evidence that diffusion is often a predictor. Multiple diffusion mechanisms are often identified to explain policy adoption.

Because policy adoption followed the Energy Policy Act of 2005, it is possible vertical policy diffusion occurred, but this is only an observation that would be expected, and does not provide nuance to the research question. In addition, it is possible leader-laggard mechanisms may have occurred as leader states originated policies such as recognizing nuclear energy as zero carbon emitting, which other states emulated. This observation also would be expected without adding much understanding. A more meaningful mechanism for this study would be existence of neighbor diffusion mechanisms to indicate market conflict or cooperation. However, the quantitative analysis provided no evidence that neighbor policy diffusion occurred, which is unexpected. Perhaps this is the product of adding fidelity to the study by subdividing a generalized definition of supportive nuclear policy into types of policy adopted by states with and without moratoriums. This may indicate that diffusion mechanisms are more likely to indicate results in generalized policy studies.

The overall conclusion is that as long as nuclear energy is not life-cycle cost competitive with other energy sources, the best economic explanations for supportive policy is influence from business and professional groups to maintain existing nuclear energy production capacity, or to plan ahead for new, improved technologies. State structures and policy diffusion mechanisms may not matter much, but attitudes and public opinion do. The models provide evidence that states risking losing nuclear energy generation capacity are saving their industries by appealing to citizen concerns for climate change. In addition, some evidence exists that attitudes are shifting to acknowledging that nuclear energy as zero emitting despite perceptions of nuclear energy as risky and polluting. Providing economic incentives by identifying nuclear energy as eligible for zero emission pricing may serve as a way to protect the nuclear industry in a way that is acceptable to the public. However, the states that adopted zero emissions financial incentives are maintaining moratoriums, indicating the future for new plants is more uncertain. After all, despite the surge of substantive supportive nuclear energy policy designed to attract new construction, only one state has a plant under construction, more than ten years later.

Adoption of supportive nuclear energy policy appears to be within Burstein's (2003) assertion that 75% of adopted policy reflects public opinion. On the surface, this did not appear to be the case because roughly half of the supportive policy was adopted while public opinion was declining. However, by identifying policy as either strong or soft, and therefore more substantive versus more symbolic, there is evidence that policy tends to be substantive while public support is on the rise, but shifts to symbolic once public support drops, perhaps as states may need to reassure industry interest groups without offending the public. One last observation is that the states with moratoriums adopt strong policy late in the study, between 2016 and 2018. Recall from the Gallup Poll results (Figure 1.1) that in 2019, public support for nuclear energy may once again be increasing. More poll results and trends in further nuclear energy policy adoption may indicate yet another trend for the industry.

Future Research

As with any study, there are imperfections in assumptions, and data limitations. It is argued throughout the study that public opinion matters in policy adoption. Nuclear energy's history provides evidence that it is particularly sensitive to public opinion. Unfortunately, nuclear energy is not a topic that appears in state level public opinion surveys, so a surrogate of citizen ideology was utilized. At best, citizen ideology reflects trust in government. Trust in government is an important indicator of nuclear energy support, but trust in government regardless of ideology has been declining for decades. Improving this measure of public opinion of nuclear energy could provide better results, but is unlikely to materialize without adequate state level opinion polls.

Additional data that could better predict public opinion at the state level might be provided with content analysis of nuclear news stories. It is argued that the media reflects what issues people are thinking about, but not necessarily what their opinion on an issue is. If content and publishing source of news stories is tabulated, it might be possible to better understand how it impacts policy adoption. For example, if the news stories are NRC bulletins that do not appear in local papers or in social media feeds, the bulk number of news stories used in this study could be indicating more salience than exists. There is some confidence that the measure used in this study of number of news stories regardless of type or source is an adequate measure of salience, as only the states adopting strong policy or lifting moratoriums were associated with more news stories. This would be expected because these are either policy reversals or substantive policy – the state really means it. Soft policy adoption, the more symbolic policy measure, does not indicate a relationship with number of new stories, which would be expected if it is merely symbolic. More fidelity in measuring news stories than used in this study could provide additional nuance in understanding the role of state level salience and public opinion on policy adoption.

No direct economic measures for nuclear power are included in this study. This is because cost data is too dependent on lifecycle, making it too difficult to quantify in a year to year time period. Direct production comparison with other energy sources is also not included. Comparing actual kilowatt-hours of energy produced by nuclear plants to coal fired, natural gas, and solar and wind installations causes collinearity problems. This is because electrical energy production is zero sum where production is instantaneous with consumption. If one plant is producing less, another plant must make the difference at any given time. Comparing kilowatt-hours directly, or even as a percent of total state energy production, would create significant error due to collinearity. Adequate direct economic measures, if possible, could improve the study results.

Future research could also benefit with more fidelity in policy content. Although policies are unlikely to replicate another state word for word, it would be possible to sort policy into more distinct types than the “strong” and “soft” designations used in the quantitative analysis. With considerable more time, the policy language could be recovered from each state (as opposed to using NEI report synopses) and binned into other policy types, such as non-electrical applications like process heat, or treatment as zero emitting. This additional effort could provide more nuance to results.

This study was limited to supportive nuclear policy. If unsupportive policy other than existing moratoriums are identified, more understanding of what is influencing both supportive and unsupportive policy may be revealed. However, despite months of internet searches on state nuclear energy policies, very little appeared in the form of unsupportive policy adoption for the study duration. This does not mean it is not out there, with more work, it could materialize to make future research more revealing.

Finally, 31 states have adopted supportive nuclear policy since 2005, but only one state had new units under construction in 2019. Research is needed on why even strong, substantive state policy has not led to more nuclear plant projects. States clearly have the power to prevent nuclear energy expansion; research is needed on why supportive state policy is not more effective.

Implications

This study has both theoretical and practical implications. The contribution to theory is that although policy adoption did not appear to respond to public opinion when viewed as an aggregate, defining policy as either more substantive or more symbolic clearly did. It may be important to include fidelity in specific policy content when considering whether policy adoption reflects public opinion.

The practical implications for nuclear energy are that there is evidence that attitudes and public opinion appear to be stronger predictors than economic or other factors of supportive nuclear policy adoption by states. Nuclear energy is more likely to expand if attitudes shift, regardless of economic opportunities. This study provides preliminary quantitative evidence outside of opinion polls to support anecdotal evidence that nuclear is becoming accepted as a zero emissions energy solution for climate change concerns. However, nuclear energy in the U.S. is a story of trust in government and industry. The future of nuclear energy depends on the ability to repair the public's lack of trust. Emerging technology may address safety and waste management concerns, which is important for changing attitudes, but if government and industry promoters are not trusted, technical advances may not matter. Continued safe operation of existing plants, demonstration of new technologies, and plenty of transparency may help restore trust with the public, if nuclear energy is to contribute to climate change concerns.

States legislators may indicate more commitment with substantive policy when the public is more approving, but back off to more symbolic policy when the public is not. This may not bode well for an industry that is much less popular than solar or wind industries. However, attitudes that shape public opinion may be shifting toward perceiving nuclear energy as a climate change solution. Growing concern for climate change may help the nuclear industry, but increased trust in government and industry may be necessary. Building trust is tough, and takes time.

REFERENCES

Ambrose, Stephen E., and Douglas G. Brinkley. 2011. *Rise to Globalism: American Foreign Policy Since 1938*. London: Penguin Books.

American Public Power Association (APPA). 2019. "Wholesale Electricity Markets and Regional Transmission Organizations Issue Brief." *American Public Power Association* https://www.publicpower.org/policy/wholesale-electricity-markets-and-regional-transmission-organizations

Amir, On, Dan Ariely, Alan Cooke, David Duning, Nicholas Epley, Uri Gneezy, Botond Koszegi, Donald Lichtenstein, Nina Mazar, Sendhil Mullainathan, Dazen Prelec, Eldar Shafir, and Jose Silva. 2005. "Psychology, Behavioral Economics, and Public Policy." *Marketing Letters* 16(3-4): 443-454.

Andris, Clio, David Lee, Marcus Hamilton, Mauro Martino, Christian E. Gunning, and John Amistead Selden. 2015. "The Rise of Partisanship and Super-Cooperators in the US House of Representatives." *Plos one* 10(4).

Bache, Ian and Jan Olsson. 2001. "Legitimacy through Partnership? EU Policy Diffusion in Britain and Sweden." *Scandinavian Political Studies* 24(3): 215-237.

Balogh, Brian. 1991. *Chain Reaction, Expert Debate and Public Participation in American Commercial Nuclear Power, 1945-1975*. Cambridge: Cambridge University Press.

Banducci, Susan A. 1998. "Ideological Consistency on the Ballot Propositions – Should We Expect It?" In *Citizens as Legislators: Direct Democracy in the United States*. Columbus: Ohio State University Press, 135-148.

Baumgartner, F.R., and Jones. B.D. 1993. *Agendas and Instability in American Politics*. University of Chicago Press, Chicago.

Baumgartner, Frank R., and Beth L. Leech. 2001. "Interest Niches and Policy Bandwagons: Patterns of Interest Group Involvement in National Politics." *The Journal of Politics* 63(4): 1191-1213.

Beck, Nathaniel, Jonathan N. Katz, and Richard Tucker. 1998. "Taking Time Seriously: Time-Series-Cross-Section Analysis with a Binary Dependent Variable." *American Journal of Political Science* 42(4): 1260-1288.

Becker-Blease, John R., Lawrence G. Goldberg, and Fred R. Kaen. 2008. "Mergers and Acquisitions as a Response to the Deregulation of the Electric Power Industry: Value Creation or Value Destruction?" *Journal of Regulatory Economics* 33 (1): 21-53.

Bekareva, Svetlana V., Ekaterina N. Meltenisova, and J.G. Abo Gsysa. 2017. "Evaluation of the Role of Renewables Consumption on Economic Growth of the U.S. Regions." *International Journal of Energy Economics and Policy* 7(2): 160-171.

Berry, Frances Stokes, and William D. Berry. 2014. "Innovation and Diffusion Models in Policy Research." In Paul A. Sabatier and Christopher M. Weible (Eds.), *Theories of the Policy Process*, Third edition. Boulder, CO: Westview Press (788-796).

Berry, William D., Richard C. Fording, Evan J. Ringquist, Russell L. Hanson, and Carl Klarner. 2013 "A New Measure of State Government Ideology, and Evidence that both the New Measure and an Old Measure are Valid." *State Politics & Policy Quarterly* 13 (2): 164-182.

Bisconti, Ann S. 2016. Public Opinion on Nuclear Energy: What Influences It. https://thebulletin.org/2016/04/public –opinion-on-nuclear-energy-what-influences-it/ April 27, 2016.

Bowler, Shaun, Todd Donovan, and Caroline J. Tolbert. 1998. *Citizens as Legislators: Direct Democracy in the United States*. Columbus: Ohio State University Press.

Bowling, Cynthia J., and Margaret R. Ferguson. 2001. "Divided Government, Interest Representation, and Policy Differences: Competing Explanations of Gridlock in the Fifty States." *Journal of Politics* 63: 182-206.

Box-Steffensmeier, Janet M., and Bradford S. Jones. 2004. *Event History Modeling: a Guide for Social Scientists*. New York: Cambridge University Press.

Buckley, Jack, and Chad Westerland. 2004. "Duration Dependence, Functional Form, and Corrected Standard Errors: Improving EHA Models of State Policy Diffusion." *State Politics and Policy Quarterly* 4(1): 94-113.

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

Butler, Catherine, Karen A. Parkhill and Nicholas F. Pidgeon. 2011. "Nuclear Power after Japan: The Social Dimensions." *Environment: Science and Policy for Sustainable Development* 53(6).

Calfano, Brian Robert. 2010. "The Power of Brand: Beyond Interest Group Influence in U.S. State Abortion Politics." *State Politics & Policy Quarterly* 10(3): 227–47.

Camden, Jim. 2005. "Hanford Illness Claims Split Jury." *The Spokesman-Review*. https://www.spokesman.com/stories/2005/may/20/hanford-illness-claims-split-jury/ May 20, 2005.

Carley, Sanya. 2011. "The Era of State Energy Policy Innovation: a Review of Policy Instruments." *Review of Policy Research* 28(3): 265-294.

Carley, Sanya, and Chris J. Miller 2012. "Regulatory Stringency and Policy Drivers: a Reassessment of Renewable Portfolio Standards." *Policy Studies Journal* 40 (4): 730-756.

Clark, Andrew E., and Andrew J. Oswald. 1994. "Unhappiness and Unemployment." *The Economic Journal* 104 (424): 648-659.

Clawson, Rosalee A., and Zoe M. Oxley. 2013. *Public Opinion: Democratic Ideals, Democratic Practice.* Los Angeles: Sage CQ Press.

Cleveland, Megan. 2019. "States' Renewable Energy Ambitions." *Our American States, NCSL Podcast National Conference of State Legislatures* https://www.ncsl.org/research/energy/states-renewable-energy-ambitions.aspx February 2019

Code of Federal Regulations (CFR). 1978-2020. 10 C.F.R. 30-34, 40, 50, 51, 55, 73, 100

Cohen, Jeffrey E., and James D. King. "Relative Unemployment and Gubernatorial Popularity." *The Journal of Politics* 66 (4): 1267-1282.

Crosby, Alfred W. 2006. *Children of the Sun: a History of Humanity's Unappeasable Appetite for Energy*. New York: W.W. Norton & Company, Inc.

Cruz, Shannon M. 2017. "The Relationships of Political Ideology and Party Affiliation with Environmental Concern: A Meta-analysis." *Journal of Environmental Psychology* 53: 81-91.

Curseu, Daniela, Monic Popa, Dana Sirbu, and Ion Stoian. 2010. "Potential Impact of Climate Change on Pandemic Inlfuenza Risk." In *Global Warming,* Springer: Boston*.*

Danielian, Lucig H., and Benjamin I. Page. 1994. "The Heavenly Chorus: Interest Group Voices on TV News." *American Journal of Political Science* (1994): 1056-1078

Davis, Lucas W. 2012. "Prospects for Nuclear Power." *Journal of Economic Perspectives* 26(1): 49-66.

Department of Energy (DOE). 2017. "US Energy and Employment Report." https://www.energy.gov/sites/prod/files/2017/01/f34/2017%20US%20Energy%20and%20Jobs%20Report_0.pdf January 2017

Department of Energy (DOE). 2019. "Department of Energy National Laboratories." https://www.energy.gov/maps/doe-national-laboratories

Department of Energy (DOE). 2020. *Restoring America's Competitive Nuclear Energy Advantage: A Strategy to Assure US National Security.* Nuclear Fuels Working Group Report.

Druckman, James N. 2001. "On the Limits of Framing Effects: Who Can Frame?" *Journal of Politics* 63: 1051.

Dunlap, Riley E. 2001. "Politics and Environment in America: Partisan and Ideological Cleavages in Public Support for Environmentalism." *Environmental Politics* 10(4):23-48.

Edelman, Murray. 1964. *The Symbolic Uses of Politics.* Urbana: University of Illinois Press.

Energy Information Agency (EIA). 2020. "Annual Energy Outlook 2020." https://www.eia.gov/outlooks/aeo/ January 29, 2020.

Energy Information Administration (EIA). 2019a. *Electric Power Monthly: Capacity Factors for Utility Scale Generators Not Primarily Using fossil Fuels, January 2013-May 2019.* www.eia.gov/electricity/monthly/epm_table_grapher.php?=epmt_6_07_b

Energy Information Agency (EIA). 2019b. "Renewable Energy Explained." https://www.eia.gov/energyexplained/renewable-sources/portfolio-standards.php

Energy Information Agency (EIA). 2019c. "US Coal Production Employment has Fallen 42% since 2012." *Today in Energy, US Energy Information Administration.* https://www.eia.gov/todayinenergy/detail.php?id=42275 December 11, 2019.

Energy Information Administration (EIA). 2019d*. U.S. Electricity Generation by Source, Amount, and Share of Total in 2018.* https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

Energy Services Group International (ESGI). 2017. "Do You Know How the Federal and State Governments Regulate Nuclear Power?" https://www.esgi.net/2017/04/ April 17, 2017

Erikson, Robert S., Gerald C. Wright, and John P. McIver. 1989. "Political Parties, Public Opinion, and State Policy in the United States." *American Political Science Association*. https://doi.org.libpublic3.library.isu/10.2307/1962058 September 1989

Erikson, Robert S., Gerald C. Wright, and John P. McIver. 1993. *Statehouse Democracy: Public Opinion and Policy in the American States*. Cambridge, UK: Cambridge University Press.

Eyestone, Robert. 1977. "Confusion, Diffusion, and Innovation." *American Political Science Review* 71(2): 441-447.

Feinstein, Jonathan S. 1989. "The Safety Regulation of U.S. Nuclear Power Plants: Violations, Inspections, and Abnormal Occurrences." *Journal of Political Economy* 97(1): 115-154.

Fleisher, Richard, and John Bond. 2004. "The Shrinking Middle in the US Congress." *British Journal of Political Science* 34(3): 429-451.

Forza, Teri. 2010. "Will California be Frozen Out of Obama's Nuclear Future?" *Orange County Register* March 2, 2010.

Funk, Cary, and Meg Hefferon. 2019. **"**U.S. Public Views on Climate and Energy" Pew Research Center https://www.pewresearch.org/science/2019/11/25/u-s-public-views-on-climate-and-energy/ November 25.

Gerber, Elisabeth R. 1998. "Pressuring Legislatures through the use of Initiatives: Two Forms of Indirect Influence." In *Citizens as Legislators: Direct Democracy in the United States*. Columbus: Ohio State University Press: 191- 208.

Goss, Carol, and Sheldon Kamieniecki. 1983. "Congruence Between Public Opinion and Congressional Actions on Energy Issues, 1973-74." *Energy Systems and Policy* 7: 149-147.

Gray, Virginia, and David Lowery. 1995. "Interest Representation and Democratic Gridlock." *Legislative Studies* Quarterly 20: 531-552.

Hall, Bob, and Mary Lee Kerr. 1991. *1991-1992 Green Index: a State-by-State Guide to the Nation's Environmental Health.* Washington: Island Press.

Harding, Jim. 2007. "Economics of Nuclear Power and Proliferation Risks in a Carbon-Constrained World." *The Electricity Journal* 20 (10): 65-76.

Hartman, Devin. 2016. “Traditionally Regulated vs. Competitive Wholesale Markets.” RStreet https://www.rstreet.org/2016/08/18/traditionally-regulated-vs-competitive-wholesale-markets/ August 18, 2016.

Heiman, Michael and Barry D. Solomon. 2008. “Power to the People: Electric Utility Restrcturing and the Commitment to Renewable Energy.” *Annals of the Association of American Geographers* 94(1). https://www.tandfonline.com/doi/abs/10.1111/j.1467-8306.2004.09401006.x

Helbling, Marc, and Anke Tresch. 2011. “Measuring Party Positions and Issue Salience from Media Coverage: Discussing and Cross-validating New Indicators” *Electoral Studies* 30 (1): 174-183.

Hogan, Robert E. 2008. “Policy Responsiveness and Incumbent Reelection in State Legislatures.” *American Journal of Political Science* 42: 858-873.

Homer-Dixon, Thomas F. 2004. “Environmental Scarcities and Violent Conflict: Evidence from Cases.” *Green Planet Blues*, ed. K. Conca and G.D. Davelko. Boulder : Westview Press.

Hopkins, John. 2018. *The Potential for Small Modular Reactors in Alaska.*NuScale Power, https://www.akrdc.org/assets/Conference2018/Hopkins.pdf November 15

Hwang, Sung-Don, and Virginia Gray. 1991. “External Limits and Internal Determinants of State Public Policy.” *Western Political Quarterly* 44(2): 277-298.

Hrynowski, Zack. 2020 “Several Issues Tie as Most Important in 2020 Election.” https://news.gallup.com/poll/276932/several-issues-tie-important-2020-election.aspx January 13, 2020.

Idaho National Laboratory (INL). 2019. “FY18 Idaho National Laboratory Economic Summary.” https://public.inl.gov/public/FY18EconomicSummary/index.aspx. February 2019.

Intergovernmental Panel on Climate Change (IPCC). 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). 2018. “Special Report: Global Warming of 1.5 C.” https://www.ipcc.ch/sr15/ October 2018.

International Atomic Energy Agency (IAEA). 2001. “IAEA Releases Nuclear Power Statistics for 2000.”https://www.iaea.org/newscenter/pressreleases/iaea-releases-nuclear-power-statistics-2000 May 3, 2001

Jell, Scott, and Michelle Bowman. 2018. “Almost all Plants that were Retired in the Past Decade were Powered by Fossil Fuels.” *Today in Energy, US Energy Information Administration.* https://www.eia.gov/todayinenergy/detail.php?id=34452# January 9, 2019.

Kantieniecki, Sheldon. 1995 “Political Parties and Environmental Policy.” *Environmental Politics and Policy: Theories and Evidence*: 146.

Karch, Andrew. 2007. "Emerging Issues and Future Directions in State Policy Diffusion Research." *State Politics and Policy Quarterly* 7(1): 54-80.

Kauffman, Clark. 2016. "Idaho Bill Preventing Plastic-Bag Ban is About Helping Business." *Idaho Statesman* February 20.

Kennedy, Peter. 2003. *A Guide to Econometrics*, 5th Edition. Cambridge, MA: MIT Press.

Kharecha, P. and J. Hansen. 2013. "Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power." *Environmental Science Technology* 47(9): 4889-489.

Klinsky, Sonja, and Hadi Dowlatabadi. 2009. "Conceptualizations of Justice in Climate Policy." *Climate Policy* 9 (1): 88-108.

Konisky, David M. and Neal D. Woods. 2018 "Enviornmental Policy." In *Politics in the American States.* Ed. By V. Gray, R. Hanson and T. Kousser. Thousand Oaks: SAGE CQ Press.

Kraft, Michael E., Rosa, Eugene, and Riley E. Dunlap. 1993. "Public Opinion and Nuclear Waste Policy Making." From *Public Reactions to Nuclear Waste: Citizens' Views of Repository Siting.* Ed. by R. Dunlap, M. Kraft, and E. Rosa. Duke University Press.

Kuklinski, James H., Daniel S. Melay, and W. D. Kay. 1982. "Citizen Knowledge and Choices on the Complex Issue of Nuclear energy." *American Journal of Political Science* 26: 615-42.

Lax, Jeffrey, and Justin Phillips. 2012. "The Democratic Deficit in State Policymaking." *American Journal of Political Science* 56: 148-166.

Lee, Matilda. 2011. "Big Divide: is Ideology Holding Back Greens from Embracing Nuclear Power?" *Ecologist* https://theecologist.org/2011/jul/20/big-divide-ideology-holding-back-greens-embracing-nuclear-power July 20, 2011.

Leiss, William. 2003. "Searching for the Public Policy Relevance of the Risk Amplification Framework. In *The Social Amplification of Risk* ed. by Nick Pidgeon, Roger E. Kasperson, and Paul Slovic. Cambridge, MA: Cambridge University Press.

Linder, Fridolin, Bruce Desmarais, Matthew Burgess, and Eugenia Giraudy. 2018. "Text as Policy: Measuring Policy Similarity through Bill Text Resuses." *Policy Studies Journal.*

Meseguer, Covadonga. 2006. "Rational Learning and Bounded Learning in the Diffusion of Policy Innovations." *Rationality and Society* 19(1): 35-66.

Miller, Joanne, and Jon Krosnick. 2000. "News Media Impact on the Ingredients of Presidential Evaluations." *American Journal of Politcal Science* 44(2): 301-315.

Miller, Joanne M., Jon A. Krosnick, and Leandre R. Fabrigar. 2016. "The Origins of Policy Issue Salience: Personal and National Importance Impact on Behavioral, Cognitive, and Emotional Issue Engagement." *Political Psychology* 2016: 139-185.

Morgan, M. Granger, Ahmed Abdulla, Michael J. Ford, and Michael Rath. 2018. "US Nuclear Power: The Vanishing Low-carbon Wedge." *Proceedings of the National Academy of Science of USA* https://www.pnas.org/content/115/28/7184 July 10, 2018.

Mumpower, Jeryl L., Liu Shi, James W. Stoutenborough, and Arnold Vedlitz. 2013. "Psychometric and Demographic Predictors of the Perceived Risk of Terrorist Threats and the Willingness to Pay for Terrorism Risk Management Programs." *Risk Analysis* 33(10): 1802-1811.

National Conference of State Legislatures (NCSL). 2017. "State Restrictions on New Nuclear Power Facility Construction." .aspx May 2017.

Newmark, Adam J., and Anthony J. Nownes. 2018. "Interest Groups in States." *Politics in the American States.* Ed. By V. Gray, R. Hanson and T. Kousser Thousand Oaks: SAGE CQ Press.

Nichols, Elizabeth, and Aaron Wildavsky. 1987. "Nuclear Power Regulation: Seeking Safety, Doing Harm." *Regulation* 11 (1987): 45.

Nuclear Energy Agency Organisation for Economic Co-operation and Development (NEA). 2018. "Measuring Employment Generated by the Nuclear Power Sector." NEA No. 7204 https://www.oecd-nea.org/ndd/pubs/2018/7204-employment-nps.pdf

Nuclear Energy Institute (NEI). 2019. "State Legislation and Regulations Supporting Nuclear Energy." https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/STATUS-REPORT-State-Legislation-Regulations-Supporting-Nuclear-Energy.pdf January 2019.

Nuclear Regulatory Commission (NRC). nd. "Federal, State and Local, and Tribal Responsibilities." https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/federal-state-local.html

O'Brien, Cheryl. 2018. "Is Bad Performance the Answer to Saving the Nuclear Power Industry?" *Electricity Journal*, https://doi.org/10.1016/j.tej.2018.11.002.

O'Brien, C., and J. Stoutenborough. 2018. "Where Citizens Turn When Seeking Information on Energy Pollution Issues," Presented at the annual meeting of the Midwest Political Science Association.

Olson, Mancur. 1965. *The Logic of Collective Action; Public Goods and the Theory of Groups.* Cambridge: Harvard University Press.

O'Neill, Dan. 1994. *The Firecracker Boys: H-bombs, Inupiat Eskimos and the Roots of the Environmental Movement.* New York: Basic Books.

Oxley, Douglas R., and James W. Stoutenborough. 2012. "Policy Learning, Problem Solving, and Analogical Reasoning: An Individual-Level Theory of Policy Diffusion." Presented at the annual meeting of the Southern Political Science Association.

Page, Benjamin I., and Robert Y. Shapiro. 1983. "Effects of Public Opinion on Policy." *American Political Science Review* 77: 175-190.

Parenti, Christian. 2011 “Nuclear Dead End: It’s the Economics, Stupid.” *The Nation* April 18.

Peterson, Paul E. 1981. *City Limits*. Chicago: University of Chicago Press.

Pew Research Center. 2015. “Wide Party and Ideology Differences in Support for Building More Nuclear Power Plants. 2015. https://www.pewresearch.org/science/2015/07/01/americans-politics-and-science-issues/pi_2015-07-01_science-and-politics_2-29/ July 1, 2015.

Pew Research Center. 2016 “The Politics of Climate.” https://www.cpp.edu/~skboddeker/301/misc/PS_2016.10.04_Politics-of-Climate_FINAL.pdf October 4, 2016.

Pew Research Center. 2019. “Climate Change and Russia are Partisan Flashpoints in the Public’s Views of Global Threats.” ttps://www.people-press.org/2019/07/30/climate-change-and-russia-are-partisan-flashpoints-in-publics-views-of-global-threats/

Phillips, Justin H. 2018. “Public Opinion and Morality.” *Politics in the American States.* Ed. By V. Gray, R. Hanson and T. Kousser Thousand Oaks: SAGE CQ Press.

Rabe, Barry G. 2004. *Statehouse and Greenhouse: The Emerging Politics of American Climate Change Policy.* Washington, DC: Brookings.

Ramana, M. V. 2011. “Nuclear Power and the Public.” *Bulletin of the Atomic Scientists*. https://journals.sagepub.com/doi/full/10.1177/0096340211413358 July 1, 2011.

Reinhart, R. J. 2019. 40 Years after Three Mile Island, Americans Split on Nuclear Power. https://news.gallup.com/poll/248048/years-three-mile-island-americans-split-nuclear-power.aspx. March 27, 2019.

Revkin, Andrew. 2018. “Climate Change First Became News 30 Years Ago. Why Haven’t We Fixed it? *National Geographic* July 2018

Ringquist, Evan J. 1993. "Does Regulation Matter?: Evaluating the Effects of State Air Pollution Control Programs." *The Journal of Politics* 55 (4): 1022-1045.

Roberts, Marilyn, Wayne Wanta, and Tzong-Horng Dzwo. 2002. “Agenda Setting and Issue Salience Online.” *Communication Research* 29 (4): 452-465.

Rogelj, Joeri, Michel Den Elzen, Niklas Hohne, Taryn Fransen, Hanna Fekete, Harald Winkler, Roberto Schaeffer, Fu Sha, Keywan Riahi, and Malte Meinshausen. 2016. “Paris Agreement Climate Proposals Need a Boost to keep Warming Well Below 2 C.” *Nature* 534 (7609): 631

Rosa, Eugene A., and William R. Freudenburg. 1993. “Historical Development of Public Reactions to Nuclear Power: Implications for Nuclear Waste Policy.” *Public Reactions to Nuclear Waste: Citizens’ Views of Repository Siting.* Ed. by R. Dunlap, M. Kraft, and E. Rosa. Duke University Press.

Samuel, Molly. 2017. “How the Dream of America’s ‘Nuclear Renaissance’ Fizzled.” National Public Radio. https://www.npr.org/2017/08/06/541582729/how-the-dream-of-americas-nuclear-renaissance-failed-to-materialize August 6

Schattschneider, E. E. 1975. *The Semisovereign People: A Realist's View of democracy in America*. Boston: Wadsworth Cengage Learning.

Schlozman, Kay Lehmman and John T. Tierney. 1983. "More of the Same: Washington Pressure Group Activity in a Decade of Change." *Journal of Politics* 45(2): 351-377.

Sharp, Elain B., and Yvette M. Alex-Assensoh. 2005. *Morality politics in American cities*. University Press of Kansas.

Shea, Daniel, and Kristy Hartman. 2017 "State Options to Keep Nuclear in the Energy Mix." National Conference of State Legislatures http://www.ncsl.org/research/environment-and-natural-resources/states-restrictions-on-new-nuclear-power-facility.aspx May 2017

Shipan, Charles R., and William R. Lowery. 2001. "Environmental Policy and Party Divergence in congress." *Political Research Quarterly* 52 (2): 245-263.

Sjoberg, Lennart, Bjorg-Elin Moen and Trobjorn Rundmo. 2004. *Explaining Risk Perception, an Evaluation of the Psychometric Paradigm in Risk Perception Research.* Trondheim, Norway: Rotunde Publisher.

Sjoberg, Lennart, and Britt-Marie Drottz-Sjoberg. 1991. "Knowledge and Risk Perception among Nuclear Power Plant Employees." *Risk Analysis* 11 (4): 607-618.

Slovic, Paul, James H. Flynn, and Mark Lyman. 1991. "Perceived Risk, Trust, and the Politics of Nuclear Waste." *Science* 254(5038): 1603-1607.

Slovic, Paul. 1987. "Perceptions of Risk." *Science* 236: 280-285.

Somander, Tanya. 2016. "Today, the US Joined China in Taking a Major Step Forward in the Global Effort to Combat Climate Change." *The White House President Barack Obama* https://obamawhitehouse.archives.gov/blog/2016/09/03/president-obama-united-states-formally-enters-paris-agreement September 3, 2016.

Steele, Fiona. 2005. "Event History Analysis." NCRM Review Paper NCRM/004 http://www.ncm.ac.uk/publications/index.php

Stigler, George J. 1973. "General Economic Conditions and National Elections." *The American Economic Review* 63 (2): 160-167.

Stoutenborough, James W., Shelbi G. Sturgress, and Arnold Vedlitz. 2013. "Knowledge, Risk, and Policy Support: Public Perceptions of Nuclear Power." *Energy Policy* 62(11): 176-184.

United Nations Framework Convention on Climate Change (UNFCCC). 2016. "Report on the Conference of the Parties on its Twenty-first Session, held in Paris from 30 November to 13 December 2015." https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf January 2016.

Vavreck, Lynn. 2015. "The Long Decline of Trust in Government, and Why That Can Be Patriotic." *The New York Times* https://www.nytimes.com/2015/07/04/upshot/the-long-decline-of-trust-in-government-and-why-that-can-be-patriotic.html?referringSource=articleShare July 3, 2015.

Wellock, Thomas R. 1998. *Critical Masses: Opposition to Nuclear Power in California*, 1958-1978. University of Wisconsin Press.

Williams, James C. 2001. *Energy and the Making of Modern California*. Akron: University of Akron Press.

Wlezien, Christopher. 2005. "On the Salience of Political Issues: The Problem with 'Most Important Problem'." *Electoral Studies* 24 (4): 555-579.

Woodward, Maggie. 2019. "Record U.S. Electricity Generation in 2018 Driven by Record Residential, Commercial sales." *Today in Energy, US Energy Information Administration.* https://www.eia.gov/todayinenergy/detail.php?id=38572

World Nuclear Associaton (WNA). 2020. "Nuclear Power in the USA." *World Nuclear Association Library* https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx January 2020.

Yackee, Susan Webb. 2009. "Private Conflict and Policy Passage: Interest-Group Conflict and State Medical Malpractice Reform." *Policy Studies Journal* 37: 213-231.

Zaretsky, Natasha. 2018. *Radiation Nation: Three Mile Island and the Political Transformation of the 1970s*. New York: Columbia University Press.

Appendix A

State Policy Content Synopses

Source: Nuclear Energy Institute (NEI). 2019. "State Legislation and Regulations Supporting Nuclear Energy." https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/STATUS-REPORT-State-Legislation-Regulations-Supporting-Nuclear-Energy.pdf January 2019.

Strong Policy

Connecticut, 2017, S.B. 106/H.B. 1501

"This legislation allows for the Millstone nuclear power plant to participate in the state's zero-carbon procurement program, an established program eligible to other clean technologies such as solar and Canadian hydro."

Florida, 2006, S.B. 888

"This legislation includes several provision to support construction of nuclear plants in Florida.

Exempts new nuclear power plant projects from the mandatory competitive bidding process.

Instructs the PSC to establish alternate cost recovery mechanisms that allow recover of preconstruction costs and the carrying costs on the projected construction cost through the capacity cost recover clause."

Georgia, 2009, S.B. 31

"The Georgia Nuclear Energy Financing Act amends existing Georgia law to allow a utility to recover from its customers the costs of financing associated with the construction of a nuclear plant that has been certified by the Georgia Public Service Commission."

Illinois, 2016, S.B. 2814

"Defines zero emission facility to mean a facility that: (1) is fueled by nuclear power; and (2) is interconnected with PJM Interconnection or the Midcontinent Independent System Operator.

Allows electric utilities to recover through tariff charges all the costs associated with the purchase of zero emission credits from zero emission facilities and allows recover of certain other costs provided that certain crater are satisfied."

Indiana, 2011, S.B. 251

"This wide-ranging energy legislation provides for, among other things, financial incentives to assist electric companies with nuclear generating facilities to recover costs and expenses incurred during comprehensive life cycle management upgrades to existing facilities."

Iowa, 2010, H.F. 2399

“The law is designed to help electric utilities determine the feasibility of clean sources of energy: HF 2399 encourages utilities to perform studies, at a limed cost to ratepayers and with the oversight of the Iowa Utilities Board, on expanding nuclear power in Iowa.

Utilities will be allowed to raise rates to pay for investments that may lead to lower carbon emissions from current plants.”

Kansas, 2007, H.B. 2038

“This legislation would exempt from state property taxes any property purchased, constructed or installed to expand capacity at an existing nuclear plant or to build a new nuclear plant.”

Louisiana, 2007, Regulation: Docket No. R-29712

“The Incentive Cost Recovery Rule for Nuclear Power Generation requires three phases of certification covering 1) siting and licensing, 2) design and development, and 3) construction to commercial operation. Once a phase is certified costs will be reviewed and approved on an annual basis for future recovery in rates when the plant is either canceled or begins commercial operation.”

Maryland, 2009, Regulation: Case No. 9127

“On November 13, 2007, UniStar Nuclear Energy, LLC and UniStar Nuclear Operating Services, LLC filed a joint application with the Maryland Public Service Commission for a Certificate of Public convenience and Necessity to construct a new nuclear plant at Calver Cliffs in Calver County.”

Mississippi, 2008, S.B. 2793

“This legislation authorizes the Public Service Commission (PSC) to utilize an alternative method of cost recovery for certain base load generation. The PSC is authorized to include in an electric utility’s rates certain pre-construction, construction work in progress, operating and other costs incurred in connection with certain new baseload generation facilities, including nuclear.”

New Jersey, 2018, A.B. 3724/S.B. 2313

“Early in Governor Phil Murphy’s administration, he signed into law multiple bills creating a comprehensive clean energy program, including legislation establishing a Zero Emissions Certificate program. The Legislation allows the Board of Public Utilities to award payments to electricity generators to compensate them for their non-emitting attribute.”

Note: this synopsis does not include the word “nuclear” but because New Jersey has nuclear power plants, it is assumed that nuclear plants are considered zero emitting.

New York, 2016, Regulation: Cases 15-E-0302 and 16-E-0270

“To preserve a “public necessity,” the state requires all New York utilities, the New York Power authority and long island power Authority to purchase Zero-Emission credits (ZEC), which compensate New York’s upstate nuclear plants for their carbon-free generation.”

North Carolina, 2007, S.B. 3

“This legislation supports the construction of nuclear plants by establishing a utility’s ability to have incurred costs reviewed by the North Carolina Utilities commission (NCUC) periodically and added to the rate base in a general rate case even if that facility is not yet complete.”

Ohio, 2008, S.B. 221

“The bill defines “advanced energy projects” to include “advanced nuclear energy production, Generation III technology, or significant improvements to existing (nuclear) facilities.” In addition, the legislation directs the Public Utility Commission of Ohio to adopt rules prescribing “Advanced Energy Portfolio Standards” requiring 25 percent of electricity sourced form alternative energy resources.”

South Carolina, 2007, H. 3499 and S. 431

“A project development order, applicable only to nuclear plants, allows preconstruction and development costs and an allowance for funds used during construction (AFUDC) associated with those costs to be included in the rate increase when the plant goes into service.”

Texas, 2007, H.B. 2994

“This legislation expands existing legislation that enables local taxing authorities to grant property tax abatements adding new nuclear plants and IGCC facilities as eligible projects.”

Utah, 2009, H.B. 430

“Utah passed the Renewable Energy Development Act to provide incentives to develop renewable energy projects, including nuclear energy generation facilities.”

Virginia, 2007, H.B. 3068/S.B. 1416

“The SCC can include performance incentives in general rates and must apply enhanced rates of return to construction of new baseload facilities, specifically nuclear, coal and combined cycle combustion turbines.”

<u>Soft Policy</u>

Alaska, 2010, S.B. 220

“Repeals Alaska’s moratorium on nuclear electric power.

Levels the playing field for nuclear energy projects o they may be considered along with other energy sources.

Allows small-scale nuclear reactor developers to apply for funding from Alaska’s Power Project Fund.”

Arkansas, 2013, S. B. 246

“The report will also incorporate research and data on the costs of additional energy production facilities, including nuclear power, and other information such as each energy source’s environmental challenges and impact and possible tax incentives or government policies to promote an increase in energy production capacity.”

Colorado, 2018, S.B. 18-003

“Among other changes, S.B. 3 adds nuclear power as a preferred energy source that the office is tasked to promote.”

Idaho, 2018, H.B. 591; H.B. 592

“Idaho adopted legislation to provide tax exemptions for new capital investments and sales and use tax exemptions for Idaho National Laboratory to yield present value tax savings for research and development activities related to Small Modular Reactors.”

Idaho, 2018 Executive Order No. 2018-07

Governor Butch Otter issued Executive Order No. 2019-07, “Establishing a Policy for Nuclear Energy Promotion and Manufacturing in Idaho,” which supports the continued promotion, advancement and deployment of advanced reactor technologies, including small modular reactors, in Idaho.”

Illinois, 2014, House Resolution 1146

“The resolution also directs Illinois state agencies to protect the nuclear facilities and to study market-based solutions, the societal costs of increased greenhouse gas emissions, and the economic and reliability impacts of closing plants.”

Kentucky, 2017, S.B. 11

“After ten years of considering similar bills, the Kentucky legislature adopted the Leeper Act, lifting the moratorium on the construction of new nuclear facilities.”

Michigan, 2008, H.B. 5524

“Regulatory reform is addressed in U.B. 5524, including the creation of a certificate of necessity for large capital investments, which will support construction of nuclear plants.”

New Mexico, 2014, House Memorial 57

“This resolution of the New Mexico House of Representatives directs the state’s Department of Energy, Minerals and Natural resources to include, as part of its development of a state energy plan, an evaluation of the feasibility and economic benefits of constructing and operating a small modular reactor.”

North Dakota, 2011, H.B. 1221

“North Dakota passed this legislation to allow public utilities to apply for advance determination of prudence for construction of “resource additions” such as renewable energy facilities, transmission facilities, demand response, and energy conversion facilities. Existing North Dakota law (North Dakota code 499-22-03) defines “energy conversion facility” as any plant designed for or capable of, among other things, generating more than 50 megawatts of electricity or enrichment of uranium minerals.”

Pennsylvania, 2017, S.B. 227/H.B. 576

“In response to developments at the federal level, the Pennsylvania Legislature passed S.B. 227/H.B. 576, which urges FERC to implement policies to ensure fuel-secure generation resources like nuclear energy receive proper compensation for the positive attributes thy provide nation’s electric system.”

Tennessee, 2015, Senate Joint Resolution 92

“This resolution encourages the Nuclear Regulatory commission to support the license application of the Tennessee Valley Authority related to the safe operation of Watts Bar Unit 2.”

Washington, 2014, S.B. 6002

“The legislation establishes and funds a Joint Select task Force on Nuclear Energy to study the generation of energy in the region through the use of nuclear power.”

Wisconsin, 2016, Act 344

“In April 2016, Wisconsin repealed its 33-year-old moratorium on new nuclear power plants.”

Wyoming, 2011, H.B. 129

“This legislation creates a task force on nuclear energy production to study ways to encourage nuclear power in Wyoming including tax incentives, water rights, public private partnerships, state laws, storage and reprocessing technologies and higher education."

APPENDIX B

Code Book

Variable	Code units	Source/notes
Economics and Interest Groups		
Number of nuclear plants	None = 0 Plants = number	U.S. Energy Information Administration
Coal extraction	Short tons	U.S. Energy Information Administration Coal Mine productive capacity by state per year
Unemployment	Rate	U.S. Bureau of Labor Statistics Expanded State Employment Status Demographic Data Annual rates per state
RTO/ISO	No = 0 Yes = 1	U.S. General Accounting Organization Most of area of state part of a Regional Transmission Organization or Independent System Operator
Allow customer choice	No = 0 Yes = 1	American Public Power Association
Nuclear Universities	None = 0 Universities = number	https://yescollege.com/degrees/bachelors-in-nuclear-engineering/
DOE National Laboratories	None = 0 Labs = average number of employees per lab	https://www.energy.gov/maps/doe-national-laboratories Summary descriptions use the word "nuclear"
Attitudes and Public Opinion		
Citizen Ideology	Value	Berry et al. 2013
Renewable Portfolio Standards	None = 0 Voluntary = 1 Mandatory = 2	National Conference of State Legislatures. http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx
U.S. Climate Alliance membership	None = 0 Member = 1	U.S. Climate Alliance
Post Fukushima Daiichi accident	Adopted policy before 2012 = 0 Adopted policy in 2012 or later = 1	
Nuclear News	Hundreds of news	Search on Nexis Uni for News Nuclear and plant and "state" Number of hits from 2003-2018 counted for each state, each year

		Note: Washington count likely low due to search on "Washington state" instead of "Washington"
Government structures		
Citizen initiatives	None = 0 Initiatives = 1	National Conference of State Legislatures, Initiative and Referendum States Initiatives for Statutes, direct or indirect
General Fund per capita	Millions of $/ population	The Council of State Governments http://knowledgecenter.csg.org/kc/category/content-type/content-type/book-states General fund from Book of the States Chapter 7: State Finance, General Fund, Actual. Revenues. (FY04 used for 2003; FY18 preliminary actuals used for 2008) State population from Book of the States, Chapter 10: State Pages Table 10.4 Personal Income, Population and Per Capita Personal Income by State
Demographics		
Population Density	Population/square miles	The Council of State Governments http://knowledgecenter.csg.org/kc/category/content-type/content-type/book-states State population from Book of the States, Chapter 10: State Pages Table 10.4 Personal Income, Population and Per Capita Personal Income by State
College graduates	Percent	U.S. Census Bureau American Community Survey: Educational Attainment (High School, Bachelor's, Advanced Degree, ...) https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml (2017 data used for 2018)
Policy Diffusion		
Number of Neighboring States	None = 0 Neighbors = number	Algorithm provided by J. Stoutenborough
Trend variable		
Trend	Calculated value	Square root of number of years occurring before or after the year of most events
Dependent variables		
States with supportive policy	No = 0 Yes = 1	Nuclear Energy Institute (NEI). 2019. "State Legislation and Regulations Supporting Nuclear Energy." https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/STATUS-REPORT-State-Legislation-Regulations-Supporting-Nuclear-Energy.pdf January 2019. The three states with lifted moratoriums, Alaska, Kentucky, and Wisconsin, are included.
States with strong supportive policy	No = 0 Yes = 1	Nuclear Energy Institute (NEI). 2019. "State Legislation and Regulations Supporting Nuclear Energy." https://www.nei.org/CorporateSite/media/filefolder/resources/

		reports-and-briefs/STATUS-REPORT-State-Legislation-Regulations-Supporting-Nuclear-Energy.pdf January 2019. Strong = language specific to nuclear energy and offering specific financial incentive
States with soft supportive policy	No = 0 Yes = 1	Nuclear Energy Institute (NEI). 2019. “State Legislation and Regulations Supporting Nuclear Energy.” https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/STATUS-REPORT-State-Legislation-Regulations-Supporting-Nuclear-Energy.pdf January 2019. Soft = language not specific to nuclear, or if nuclear is included, does not include a specific financial incentive
States w/moratoriums	No = 0 Yes = 1	National Conference of State Legislatures (NCSL). 2017. “State Restrictions on New Nuclear Power Facility Construction.” http://www.ncsl.org/research/environment-and-natural-resources/states-restrictions-on-new-nuclear-power-facility.aspx May 2017.