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Examining the Target Levels of State Renewable Portfolio Standards

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EXAMINING THE TARGET LEVELS OF STATE

RENWABLE PORTFOLIO STANDARDS

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ABSTRACT

Examining the Target Levels of State Renewable Portfolio Standards

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At present 37 U.S. states have passed Renewable Portfolio Standards (RPS) or have a legislative driven goal that supports investment in renewable energy (RE) technologies. Previous research has identified economic, governmental, ideological and infrastructural characteristics as key predictors of policy adoption and renewable energy deployment efforts (Carley, 2009; Davis & Davis, 2009; Bohn & Lant, 2009; Lyon & Yin, 2010). To date, only a few studies have investigated the target levels of renewable portfolio standards. Carley & Miller (2012) found that policies of differing stringencies were motivated by systematically different factors that included governmental ideology. The purpose of this dissertation is to replicate and expand upon earlier models that predicted RPS adoption and RE deployment efforts by adding regulatory, infrastructural and spatial characteristics to predict RPS target levels. Hypotheses were tested using three alternative measurements of RPS target level strength to determine to what extent a combination of explanatory variables explain variation in policy target levels. Multivariate linear regression and global spatial autocorrelation results indicated that

multiple state internal determinants influenced RPS target level including average electricity price, state government ideology and to a lesser extent actual RE potential capacity. In addition, some diffusion effects were found to exist that indicated that states are setting their RPS target levels lower than their neighboring states and a local geo-spatial clustering effect was observed in the target levels for a grouping of northeastern states.

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DEDICATION

To my parents,

Douglas and Jessie Helwig

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CHAPTER 1: INTRODUCTION

A Renewable Portfolio Standard or RPS is a state-mandated policy that obligates electrical energy providers, namely public and privately owned energy utilities to generate a specified percentage of their electricity from renewable sources by a specified target date. Information from the 2013 Database of State Incentives for Renewables and Efficiency (DSIRE) indicates that there are currently 37 U.S. states with an RPS in place or with an RE goal. According to Rabe (2004), state renewable portfolio standards are currently the main driver of U.S. efforts to develop and integrate renewable energy generation sources. Since each state sets its own RPS target levels and target dates, these standards vary widely in terms of their stringency (Carley & Miller, 2012, p. 732). Wide variation in state RPS target levels would be expected, given that each state is unique in terms of its renewable energy potential, however this variation is inconsistent and it is suspected that RPS target levels have been influenced by other factors. A better understanding of the factors that have influenced the design of state renewable portfolio standards, particularly the setting of their targets and goals is crucial as it can provide some very useful insight that ultimately leads to the design of more effective climate change policy instruments.

According to Menz & Vachon (2006), the origins of state level policies that encourage renewable energy targets can be traced back to earlier policies at the federal level. The key federal laws that facilitated this restructuring were the 1978 Public Utility Regulatory Policies Act (PURPA) which required energy providers to purchase electricity produced by non-utility entities, and the Energy Policy Act of 1992 (EPACT) which required energy providers to open their transmission lines to all producers and generators of electricity, including renewable sources (Menz & Vachon, 2006, p. 1788). The authors indicate that the pace of renewable energy development was influenced by regulatory changes, particularly those that restructured the electricity industry (Menz & Vachon, 2006, p. 1788).

Due to a growing body of recent research, the factors influencing climate change policy adoption are now well documented along with barriers known to influence the deployment and integration of RE sources. Recent studies of the adoption of state policy tools addressing climate change undertaken by Matisoff (2008) who examined regional diffusion and internal determinants, and Chandler (2009) who utilized innovation and diffusion theories have identified multiple predictors of state RPS adoption which included affluence, governmental ideology and citizen demands. In addition, studies of climate change policy innovation by Lyon & Yin (2010) and Carley (2009) identified key economic and ideological factors influencing policy adoption such as the dominant political party in the State and the cost of electricity.

Other branches of research into renewable energy deployment initiatives have identified certain infrastructural factors as barriers to RE deployment efforts. Studies by Davis & Davis (2009), Bohn & Lant (2009) and Alagappan et al (2011) demonstrated that infrastructural barriers such as the capacity and proximity of electrical transmission lines and the availability of land influence efforts to deploy renewable energy generation sources. In addition, Staudt (2008) described the lowered power densities and larger land requirements of renewable generation sources as potential systemic barriers. Finally, Davis & Davis (2009) found that renewable energy sources are inhibited by a lack of energy storage systems and transmission line capacity.

A relatively small but growing number of studies have investigated the factors that influence and predict the stringency of the target levels of state climate change policies. In their examination of renewable portfolio standards in 32 U.S. States, Carley and Miller (2012) found that policies of differing stringency levels are motivated by systematically different underlying factors, (i.e. state level citizen political ideology for weaker policies and government level ideology for strong policies). While much is known about the factors contributing to RPS adoption and the barriers to RE infrastructure integration, less is known about how these factors influence RPS target levels.

The primary purpose of this study was to replicate and expand upon earlier models that predicted RPS adoption and RE deployment efforts by adding regulatory, infrastructural and spatial characteristics to predict RPS target levels. This was accomplished by examining the extent to which a combination of known policy adoption factors and infrastructural barriers predicted RPS target level. This study tested theories from both the economics and political science disciplines. From economics, this study utilized the public interest theory of regulation and the theory of infrastructure-led development. From political science, this study utilized the policy innovation models of internal determinants and regional diffusion. The data for this study were drawn from publically available U.S. state RE policy information and from a variety of other sources. Hypotheses were tested using three alternative measurements of RPS target level strength to determine to what extent a combination of explanatory variables explain variation in policy target levels. These explanatory variables were divided into groupings of geographic factors, economic factors, regulatory factors, infrastructural barriers and political ideology factors.

This study also examined the role played by diffusion and spatial characteristics in predicting RPS target levels. Two methods were employed for the diffusion analysis portion of this study: a nearest-neighbor model and a geo-spatial econometric model. The presence of a regional diffusion effect was tested for by examining the degree of emulation and competition in RPS target levels among neighboring states. In addition, tests for local spatial effects were performed to isolate any localized geographic patterns contributing to the overall geospatial autocorrelation outcome.

This study begins with a literature review chapter that describes the theories that were utilized in terms of their origins and development and presents current empirical research relevant to and contributing to the central topic. The literature review describes the economic market model, political science models and the overall research design model that was utilized in the study and concludes with research questions and hypotheses. A methodology chapter describes the design and development of the dependent variables that measured RPS target level, independent variables and the statistical models. The empirical results chapter describes preliminary data tests, presents regression analysis results and global and local geospatial data analysis results. Finally, the conclusions chapter discusses the implications of the results of the study, provides a number of practical lessons-learned in its undertaking, describes the overall contributions that this research makes and concludes with potential directions for future research.

CHAPTER 2: REVIEW OF LITERATURE

The following chapter reviews literature on a wide range of issues that are relevant to this study of state renewable portfolio standards and their target levels. The review is divided into six sections which describe the main theoretical frameworks, case-specific literature related to renewable energy, climate change policy and the methodological approaches that were applied. The first section describes the public interest theory of regulation in terms of facilitating a policy response to market failures and externalities in the form of regulation. A second section describes the economic theory of infrastructure-led economic development and highlights research that describes the contributions of infrastructure to economic development and the alternative role that infrastructure can play as a barrier to the integration and deployment of renewable energy sources. Policy innovation theory and its internal determinants and regional diffusion models are described in the third section. This section also presents climate change policy innovation empirical research and highlights the factors known to influence policy adoption. The fourth section of the literature review presents policy design related research with a focus on studies that investigated the stringency of RPS target levels. Current studies for each of the empirical research themes are summarized in Tables 1, 2, 3 and 4. The fifth section of the literature review provides case-specific literature including a description of the economic model that was utilized, a summary of renewable energy costs and benefits, a summary of U.S. renewable energy policy mechanisms and finally a description of geo-spatial methods and their growing use as an analytical tool in the social sciences. The final section of the literature review provides a description of the main research model, summarizes the research gaps and controversies and presents research questions and hypotheses analyzed by this study.

2.1 Public Interest Theory of Regulation

According to Posner (1974), the public interest theory of regulation hypothesizes that public regulation is supplied as a response to demands made by the public for corrections of inefficient or inequitable market practices (Posner, 1974, p. 335). The first section of this portion of the literature review will present a historical overview of the regulation of the practice of electricity generation in the United States and an overall description of the structure of the industry. The second section will describe the origins of the public interest theory of regulation by presenting the seminal studies conducted by the first pioneers in the field. A third section will describe current research and studies that describe the effect that governmental regulation has on climate change policy innovation and RE deployment efforts. A final section will offer a brief outline of the contributions that this study will make to contemporary research investigating the effects of governmental regulation.

The business of electric power provision in the United States has its origins in the late 19th century and since that time electricity providing entities have come to be commonly designated as "public utilities". According to Koontz and Gable (1956), the origins of the public utility concept can be found in the doctrine of affectation with the public interest concept which came to be the basis upon which state power over a large number of businesses was upheld by the Supreme Court case of Munn v. Illinois (1877)

(Koontz & Gable, 1956, p. 200). In this case, the attorneys for Munn and Scott, owners of a grain warehouse in Chicago relied on a treatise by Lord Hale a former Lord Chief Justice of England. Hale had indicated that "when private property becomes clothed with a public interest and affects the community at large that the owner of the property has in effect granted the public an interest in that use and must submit to be controlled by the public for the common good" (Koontz & Gable, 1956, p. 199). Koontz and Gable (1956) further attributed that the application of regulation is primarily to promote the safety, health and welfare of the public and that a public utility is expected serve all at reasonable rates without discrimination (p. 197). As a result a public utility's rates, services, finances, accounting, and all other activities usually regarded as private are carefully regulated (Koontz & Gable, 1956, p. 197). Trachsel (1947) offered the following definition of public utility regulation: "When dealing with the problems of public utility regulation it is essential to recognize the fundamental difference between a public utility and a private business. The public character of the business conducted by the utilities and the privileges under which they operate combine to emphasize the fact that such business might well be performed by the state itself. Those engaged in furnishing public utility services might well be considered as agents performing a function for the state" (p. 51).

The structure of present electric utility regulation was greatly shaped by the Public Utility Holding Company Act of 1935 (PUHCA). Tucker (1938) described the Act as follows: "Broadly stated, the purposes of the act are to simplify the corporate structure of gas and electric holding companies doing business in more than one state; to prevent over-capitalization and other questionable practices; to regulate the sale and transmission of electric energy in interstate commerce; to aid and strengthen state regulation by providing a national clearing house of information; and to encourage the creation of economically and geographically integrated utility systems." (p. 428). Contemporary electricity providers in the United States can be broadly divided into four distinct categories: investor-owned utilities (IOU's), public utilities (municipal), rural cooperatives and federal electric utilities. With the exception of federal electric utilities, all of these entities are regulated by some form of regulatory commission at the state level.

At present, electricity providers in the United States are regulated at the State or Federal level and primarily consist of a mix of private and public entities. According to the American Public Power Association (2013), publically-owned utilities comprise 61.5% of the total number of electricity providers in the United States with cooperatives and investor-owned utilities comprising 26.8% and 5.9% respectively. The remaining 5.8% is comprised of federal power agencies and power marketers. In terms of actual Megawatt-Hours of power generation, investor-owned utilities comprise the largest share of total generated power at 38.9% with non-utility generators and publically-owned utilities comprising 38.8% and 10.4% respectively. These figures indicate that while the number of publically-owned utilities is very large, the majority of electricity produced in the United States is by investor-owned, non-governmental private generators.

The public interest theory of regulation can be traced back to Arthur Cecil Pigou (1932) who illustrated governmental intervention using purchasers' associations "voluntary groups of purchasers undertaking for themselves the supply of the goods and services they need." (p. 283). Pigou contended that "over the large field of industry, where voluntary Purchasers' Associations are not an adequate means of overcoming those failures in industrial adjustment which occur under the more ordinary business forms, the question arises whether the magnitude of the national dividend might not be increased by some kind of governmental intervention, either by the exercise of control over concerns left in private hands or by direct public management." (p. 293). One of the first studies to focus on the effect of regulation on an industry was conducted by Averch and Johnson in 1962. In their study of the U.S. telephone and telegraph industry where prices and rates of return were controlled by a regulating agency, the authors found that regulated firms would expand their rate bases by substituting capital for labor and often expand into unprofitable ventures in order to satisfy regulators (Averch & Johnson, 1962, p. 1068). According to Averch and Johnson (1962), firms would also accumulate excessive capital and grow their rate bases in ways that make it difficult for the regulating agency to detect (p. 1068). According to Posner (1974), the public interest theory of regulation holds that "regulation is supplied in response to the demand of the public for the correction of inefficient or inequitable market practice" (p. 335). This theory had its origins in the work of Stigler (1971) who in his study of the state regulation of the trucking industry and occupational licensing formulated a theory of the supply of regulation that posited "every industry or occupation that has enough political power to utilize the state will seek to control entry." (p. 5). Stigler (1971) also points out that regulation also can have the effect of limiting entry and stifling competition in the market "the regulatory policy will often be so fashioned as to retard the rate of growth of new firms" (p. 5).

The public interest theory of regulation is not without opposition from several scholars. Posner (1974) argued that the public interest and interest group theories of regulation are unacceptable in their present form (p. 356). Posner (1974) however, was optimistic that the public interest economic theory would eventually jell and concluded that "that human behavior can best be understood as the response of rational self-interested beings to their environment must have extensive application to the political process" (p. 356). Some scholars have argued that regulation of industries does not improve overall efficiency. In his study of the electric utility industry, Courville (1974) confirmed the Averch-Johnson effect that stated that "the regulated monopolist will not be efficient in choosing its inputs" (p. 53). The author also concluded that rate of return regulation induced overcapitalization in electric utilities (Courville, 1974, p. 72).

In addition to studying the effect of regulation has on efficiency some scholars have investigated its effect as an inducement and creator of market opportunities. Researchers have identified that one potential side effect of the supply of regulation to an industry is the creation of rent and rent-seeking opportunities. Buchanan (1980) defines rent as receipt in excess of opportunity cost or "that part of the payment to an owner of resources over and above that which those resources could command in any alternative use" (p. 2). Buchanan (1980) further defines rent-seeking as the behavior in institutional settings where individual efforts to maximize value generate social waste rather than social surplus (p. 4). According to Buchanan (1980), the creation of these economic rents, in turn has the potential to create opportunities for profit-seeking entrepreneurs that might not have existed in a previously ordered market structure. (p. 5). Buchanan further posits that rent seeking activities emerge as a result of this political interference with markets which creates advantageous positions for some persons who secure access to valuable "rights" (p. 11). McChesney (1987) supports this view and adds that "because political action can redistribute wealth generally, it is now seen that private interest groups other than producers have an incentive to organize, both to obtain the gains and to avoid the losses from a whole menu of governmental enactments" (p. 179). According to Buchanan (1980), rent-seeking activity is directly related to the scope and range of governmental activity in the economy, to the relative size of the public sector (p. 9). If supply is arbitrarily restricted and price is allowed to rise, rent will accrue to those who secure the "rights" to engage in the activity (Buchanan, 1980, p. 9).

2.11 Empirical Studies of Governmental Regulation

This study will place its focus on the application of state level climate control regulation on electricity providers, specifically renewable portfolio standards. Renewable portfolio standards offer opportunities for new RE providers to enter the electricity market and compete with established providers that primarily utilize fossil fuel resources in a manner similar to the opportunities that Buchanan (1980) describes for profit-seeking entrepreneurs (p. 5). In the previously ordered market structure, RE providers would have had little incentive for entry into the electricity market due to their lower power density in comparison to fossil fuel derived energy. In this case the establishment of RE target levels created opportunities for private and public RE providers to enter markets with little opposition and contribute to each state's established target. Ideally, the scale of opportunities created for RE energy providers should be proportional to the level of governmental regulation activity in keeping with Buchanan's notion that rent-seeking activity is directly related to the scope and range of governmental activity in the economy and to the relative size of the public sector. In this study it will be assumed that the RPS target RE percentage levels that are established by each state are directly impacted by degree to which the electricity market is regulated and consequently more highly regulated states will set higher RPS target levels and those that are less regulated will set lower or more moderate RPS incentive targets.

Previous studies of policy innovation have found that dominant political party in a state influences RPS adoption. Studies by Huang, Alavalapati, Carter and Langholtz (2007), Chandler (2009) and Matisoff (2008) have all found that political party dominancy; particularly citizen liberalism had a positive impact on the probability of RPS adoption. In addition, Lyon and Yin (2010) found that the adoption of an RPS is much more likely in states with a strong Democratic presence in their legislature. This study expands upon prior research by examining the effect that political ideological factors have on RPS target levels. Variables representing political ideology will include both state citizen and state governmental ideology.

In addition to studies that measure the effect of political ideology on RPS adoption, other studies have found that state RE deployment efforts can be predicted by state population, regulatory environment and political institutions. Bacot and Dawes (1997) in their examination of state environmental effort expenditures found that state population was a key factor that influenced a state's environmental expenditures and initiatives. The authors attribute this to the notion that "larger populations yield more citizens who concurrently accept the policies and subsidize the requisite resources, legal and fiscal, to execute a commendable environmental effort" (p. 362). A study of the effectiveness of different policy regimes promoting wind power development by Menz &

Vachon (2006) found that the pace of renewable energy development was influenced by regulatory changes, particularly those that restructured the electricity industry (p. 1788). The authors point specifically to two federal laws that facilitated electricity market restructuring including the 1978 Public Utility Regulatory Policies Act (PURPA) and the Energy Policy Act of 1992 (EPACT). Menz and Vachon (2006) attribute this to the fact that PURPA required that utilities purchase electricity from non-utility entities, encouraging the development of small scale generation facilities and EPACT further opened the market to competitive wholesale generation by its requirement for utilities to open their transmission lines to all electricity providers (p. 1788). Finally, Carley (2009) in her study of the effectiveness of state energy programs found that political institutions were significantly related to the level of renewable energy generation deployment. Of the three variables that Carley (2009) utilized to represent political institutions one of particular note was the number of natural resource employees per capita and was found to be highly significantly associated with the percentage of RE generation in a state (p. 3077).

This study will test the public interest theory of regulation to determine if the amount of regulation provided by the state has any impact on RPS target levels. In general terms, Public Interest Theory posits that regulation is provided in the form of a policy response to market failure and negative externalities. With the combined known effects that population, regulatory change and political institutions have on RE development levels, it could be argued that governmental and regulatory organizational factors at the state level matter in predicting RPS target levels. It is therefore expected that more highly populated states with larger numbers of regulated electricity providers and larger public utility commission staffing levels would set more stringent RPS target levels correct market failures and mitigate the negative externalities associated with pollution and climate change. In addition it could be expected that states that impose more regulation on their electricity providers in terms of higher public utility commission staffing level per state generation capacity would set more stringent RPS target levels. Finally, it could be argued that renewable portfolio standards and their associated targets have the potential to create economic rents and hence opportunities for renewable energy development companies and entrepreneurs. As a direct result, some states might be motivated set their RPS target levels higher in order to attract such profit-seeking entrepreneurs. Table 1 provides a summary of governmental regulation theory literature arranged by thematic component, authors, area studied and the conclusions and contributions of each research study.

2.2 Theory of Infrastructure-Led Economic Development

The theory of infrastructure-led development hypothesizes that development of infrastructure has a positive effect on economic growth. According to Agenor (2006), this effect is primarily due to the fact that services are often supplied through networked delivery system that has been designed to serve a multitude of users (p. 4). The first portion of this section will provide a historical overview of the theory and a second section will present literature specific to the role infrastructure plays as a potential barrier to renewable energy technology deployment efforts. The section will then conclude with a brief outline of the contributions that this study will make to contemporary research efforts.

One of the first research studies to quantify the relationship between infrastructure and economic growth was conducted by Aschauer (1989) who found that core public infrastructure consisting of streets, highways, airports, electrical and gas facilities, mass transit, water systems and sewers possess strong explanatory power for aggregate total factor productivity (p. 193). In addition, Aschauer (1989) attributed the decline in the rate of growth of U.S. productivity that arose in the 1970's to a decrease in productive government services (p. 179). A subsequent study by Munnell (1992) that summarized several related analyses of the effect of public capital on economic activity, output, investment and employment growth concluded that public infrastructure investment provided immediate economic stimulus and had a positive effect on all of these factors (p. 197). In their study of telecommunication infrastructure, Roller and Waverman (2001) discovered that infrastructure investment had a positive effect on economic output and growth, especially when a critical mass of infrastructure was present (p. 909). Subsequent studies of infrastructure-led economic development have augmented the theory with the introduction of additional factors that explain the effect of infrastructure. In his study of U.S. transportation and vehicular roadways, Fernald (1999) found that growth in road infrastructure benefited vehicle-intensive industries but that the return was often one time and eventually diminished "the interstate system was highly productive, but a second one would not be" (p. 619). Similarly, Fernald (1999) concludes that "the evidence suggests that the massive road-building of the 1950's and 1960's which largely reflected construction of the interstate highway network offered a one-time increase in the level of productivity, rather than a continuing path to prosperity" (p. 632-633). In their study of public infrastructure capital on economic output supply, Demetriades and Mamuneas (2000) found that public capital had a positive long-run effect on output supply and input demand that declined over time and observed lower mean short-run rates of return (p. 687). The authors stressed the importance of "considering the effects of public capital not only on current producer decisions but also on future producer decisions" (Demetriades & Mamuneas, 2000, p. 710).

Several alternative studies of infrastructure-led development have placed their focus on the role played by telecommunications and computer and information technology infrastructure. In his investigation of telecommunication networks, Hardy (1980) conducted a cross-sectional analysis of 29 nations to test the catalytic effect of business and residential telephones on economic development and found that there was evidence that the telephone does contribute to economic development. Hardy (1980) also added that the effect was primarily due to the structure of the communication system "this contribution appears to be made not in the transfer of information about production techniques, but through information flows which have impact on the way in which economic activity is organized" (p. 285-286). In his study of transaction costs, telecommunications, and macroeconomic growth in developing countries, Norton (1992) found that low telecommunications infrastructure was a primary reason why some parts of the world have not developed. The author concluded that telephones provide substantial growth and investment-enhancing activity that in turn facilitate economic growth (p. 192). Finally, Roller & Waverman (2001) found that there was a significant positive causal link between telecommunication infrastructure and economic growth especially when a critical amount of infrastructure was present (p. 909). Roller & Waverman (2001) also pointed out that researchers must be careful to control for two potential bias issues that were present in previous studies: reverse causality and spurious correlation. The authors distinguished between two forms of reverse causality, first the increase in economic growth attributable to increases in telecommunications infrastructure and services development, and second increases in demand for telecommunication services that are attributable to increases in economic growth, (p. 910). The second issue that Roller & Waverman (2001) identify is the spurious correlation that can arise as a result of the fact that regional infrastructure investments could be correlated with other growth promoting measures such as research and development investments, investments in human capital and taxes (p. 910). Finally, Roller & Waverman (2001) identify network externalities as another issue that emerges in studies of telecommunication networks and particularly with IT technologies. The authors describe this effect in the following way "the more users, the more value is derived by those users" (p. 911). This congestion phenomenon does not exist with most infrastructure networks, but unfortunately does exist in electrical and computer networks.

The body of research in the field of infrastructure-led economic development indicates that infrastructure does indeed have a positive effect on economic growth and development. It is apparent that the presence of a robust network in the physical form of roadways and commodity transportation channels or in the form of telecommunications and computer network infrastructure has a positive effect on economic activity and growth. The next section will discuss the potential barriers to RE deployment efforts and the effect of infrastructure.

2.21 Renewable Energy Infrastructural Barriers

According to Mendonca et al (2010), the free market of electricity has been distorted by more than one hundred years of decisions for and government subsidies of conventional energy technologies (p. 129). The authors add that "every single energy system in use today has required government intervention to overcome a web of obstacles, barriers, impediments and challenges" (p. 129). In addition Brown et al (2008) point out that that transaction costs in the form of gathering and processing information, patent development and the procurement of permits can be prohibitive during the early stages of development for RE generation deployment efforts. In their assessment of barriers to RE deployment Mendonca et al (2010) found that these barriers fell into four broad categories: financial and market impediments, political and regulatory obstacles, cultural and behavioral barriers and aesthetic and environmental challenges (p. 130).

The major financial and market impediments revolve around lack of information, misinformation and information asymmetry existed where the negative experiences with unconventional energy sources were the best known to stakeholders (p. 131). Economic barriers existed in the form of principal-agent problem where those making investment decisions (principals) did not have to live with the results experienced by the agents primarily where initial costs are over-emphasized rather than longer term life cycle costs (p. 132). Finally the authors posit that smaller scale RE resources threaten the market share of incumbent electric utilities, energy companies and power operators who dominate the industry (p. 133). Mendonca et al (2010) feel that large energy companies have used their power of incumbency to mould government regulations in favor of large centralized plants and in direct opposition to smaller decentralized units (p. 133).

In terms of political and regulatory obstacles Mendonca et al (2010) draw attention to the variability and lack of consistency of policies relating to RE technologies as an impediment (p. 134). The authors feel that these inconsistencies create uncertainty for entrepreneurs who require constant conditions for decision making. (p. 133). Another regulatory obstacle for RE projects, according to the authors arrives in the form of administrative barriers "the large number of authorities that have to be contacted for a large variety of permits, including industrial plant procedure, the grid connection procedure and the environmental assessment" (p. 134). Finally Mendonca et al (2010) point out that existing government energy research subsidies heavily favor nuclear power and fossil fuels and that these subsidies artificially lower the cost of producing the dirtiest forms of electricity, muddle market signals and encourage the over-consumption of resources (p. 138).

The existence of physical barriers to RE deployment have also been documented by several researchers. According to Mendonca et al (2010), one major obstacle that RE deployment faces is the challenge of the siting of power plants. These challenges are primarily due to the immobility of renewable resources. The authors point out that "wind and sunlight differ from conventional fuels because they cannot be extracted and transported for use at a distant site" (p. 145). The site specific nature of wind, solar and geothermal RE resources creates and invites conflict with existing and planned land uses (p. 145). Solar and wind farms also require large portions of land to maximize efficiency and are often located in remote regions far away from urban developments. This usually necessitates expensive land purchase initial capital costs and very long and prohibitively expensive high voltage electrical transmission lines. Land use and acquisition is a major issue for larger wind farms. According to Staudt (2008), "Wind energy does not have a high power density, and so wind farms of comparable power rating to conventional power stations require large land areas. A 100 megawatt wind farm might be spread across 8 square kilometers of land" (p. 108). Davis & Davis (2009) found that the most serious barriers to clean energy policies are resource-related and comprised of the lack of energy storage and transmission capacity. It should also be noted that large scale solar and wind projects can also be subject to costly and time consuming environmental impact studies, reviews and assessments and are often dependent on the governmental permitting process. These resource factors can translate into a more costly, complicated and slower transition to renewables and ultimately higher energy production costs that energy providers must pass on to local governmental agencies, ratepayers and consumers.

According to Bohn and Lant (2009), the U.S. geography of wind energy development is largely determined by the distribution of human population and therefore electricity demand and proximity to transmission lines (p. 98). In addition, they found that procedures for siting and permitting wind farms that minimized opportunities for local opposition resulted in increased wind energy development, (p. 98). According to Nelson (2009), "A major problem for wind farm development is that many load centers are far away from the wind resource, and wind farm projects can be brought online much faster than new transmission lines can be constructed" (p. 240). Hoppock and Patino-Echeverri (2010) argue that the most favorable wind sites often lack transmission access as they are usually located far from electricity demand centers. In their research they found that local, lower capacity wind sites are actually the lowest cost option (as opposed to distant higher quality wind sites) for meeting RPS standards. Alagappan et al (2011) found that renewable energy development has been more successful in markets that employ transmission planning and in those that have end-users pay for most; if not all transmission interconnection costs (p. 5099). It appears that effective transmission system planning is of vital importance in the integration of renewable energy generation sources.

One of the major systemic disadvantages of renewable energy sources is that they are inefficient and not as capable of generating as large amounts of power as conventional fossil fuel based energy sources are (Staudt, 2008, p. 108). Large solar plants and wind farms typically have power outputs in the kilowatt and low megawatt range, while moderately sized coal and natural gas sourced generation facilities can produce several hundred or even thousands of megawatts with infrastructure that utilizes significantly smaller area footprints. Another systemic disadvantage of solar and wind energy sources is their intermittent output. According to Lenard (2009), renewable sources raise reliability issues due to the fluctuations in wind and solar resources (p. 10). To mitigate the effects of the intermittent supply issue utilities and those who control the electricity grid will have to keep existing energy generation sources in standby or rapid start mode or invest in additional infrastructure such as capacitor banks, reactors or large battery storage systems to keep these interruptions in service to a minimum. Crabtree et al (2011) found that energy storage systems could manage transmission capacity for intermittent RE resources located in remote areas by storing energy during peak production periods and releasing it during peak demand periods (p. 393). Staudt (2008) stated that the technical issues associated with the integration of wind energy projects on the grid will continue to rise in prominence. Staudt also felt that it will come down to a question of economics, namely that the cost of RE to a grid is the generation cost plus the cost of the integration technique chosen, (e.g. the shifting of supply/demand imbalances, energy storage and demand side management). Only as fossil-fuel prices rise, these measures that facilitate increased wind penetration will be justified (Staudt, 2008, p. 102). Adamczyk et al (2010) found that the growing number of wind turbines are changing the electricity profile around the world and bring challenges to power system operation. They explain that the current power system that is designed and developed around conventional power plants with synchronous generators and that wind power plants possess very different characteristics and affect system stability in adverse ways (p. 3724). This necessitates the addition additional infrastructure in the form of Flexible AC Transmission Systems (FACTS) which dynamically control, stabilize and enhance power system performance. According to Kundur (1994), in a system that supplies power to a large number of loads and fed from a wide range of generating units, voltage and reactive power control become critical. Since reactive power cannot be transmitted over very long distances, voltage control must be accomplished by using special devices throughout the system, (e.g. shunt reactors and capacitors, series capacitors for passive compensation and static var compensators and synchronous condensers for active compensation). (Kundur, 1994, p. 628). Unfortunately this infrastructure can be quite expensive and may often not be considered in the planning stages and development of renewable energy business cases as it could necessitate a detailed analysis of the power system. Rabe (2010) explains that as the share of renewable electricity sources grows, it will underscore some of these above-mentioned inadequacies of the existing grid system, and that this situation will likely intensify as electricity is generated from more diverse and decentralized resources (p. 358). Rabe (2010) further points out that a large scale overhaul of the current grid system looms over any large scale transition to alternative energy sources (p. 359). The nascence of RE generation technologies contributes to their higher initial capital costs. According to Rahm, (2006), cost is the most significant barrier to the widespread use of renewables, followed by the lack of public awareness of sustainable technologies, government subsidies to the fossil fuel and nuclear industries, the immaturity of renewable energy technologies and the overall lack of appreciation for the environmental consequences for the use of fossil fuels (p. 23).

Proponents of renewable portfolio standards feel that innovation in RE technologies will play a key part in lowering the costs of generation infrastructure. According to Menz and Vachon (2006), the cost of generating wind power has declined over the last several decades primarily due to greater efficiencies and lower production costs for wind turbines (p. 1788). In addition, Klare (2009) predicts that the cost of renewable energy generation infrastructure is likely to fall as a result of continuing technological innovation (p. 253). It is evident that two key forces are working against one another. As the cost of RE infrastructure decreases and more of it is brought online, it ultimately affects electric power system stability and requires more compensation equipment and further necessitates an overhaul of the national electricity grid. This issue will likely remain as long as RE sources continue to be integrated into the mix of electricity generation sources.

By utilizing the known infrastructural barriers to RE deployment efforts and market penetration as independent variables, this study will determine if the target levels for renewable portfolio standards, a proposed driver to stimulate RE economic growth, have been influenced by the amount of available electricity transmission infrastructure. It could be expected that states with higher amounts of existing infrastructure and a more robust network for the transport of electricity that is conducive to RE integration might set their targets higher. It should be noted that the measures of the existing infrastructure serve a dual purpose in this study as they can also be utilized in the analysis of internal determinants. This study will attempt to investigate whether existing network infrastructure in the form of transmission lines and transmission line density (i.e. total circuit miles and circuit miles of transmission lines per square mile) have an effect on the RPS target levels set by policymakers. Table 2 provides a summary of infrastructure-led economic growth theory and infrastructural barriers to RE literature arranged by thematic component, authors, area studied and the conclusions and contribution of each research study.

2.3 Policy Innovation Theory

2.31 Internal Determinants and Regional Diffusion Models

This section will describe the theoretical framework of policy innovation, the use of internal determinants and diffusion models in policy research and their more recent use in predicting climate change policy innovation. The first portion of the section will begin with an overview of the origins of policy innovation theory and research that tests whether policy innovation is driven by factors internal to the state or by regional diffusion, a theoretical framework developed by Berry and Berry (1990). A second section will discuss more recent research that has investigated the effects of internal determinants and regional diffusion on climate change policy innovation, particularly state RPS adoptions. At present the majority of this research has concluded that internal determinants, particularly those associated with citizen political ideology, affluence and a region's renewable resource potential are stronger predictors of climate change policy innovation than regional diffusion effects.

In their examination of innovation and diffusion models in policy research, Berry & Berry (2007) differentiated policy innovation from policy invention or "the process through which original policy ideas are conceived" (p. 223). The authors clarified and illustrated this point by drawing upon Walker's (1969) definition of innovation as "a program or policy which is new to the states adopting it", (p. 881). Berry and Berry (2007) further stated "that a governmental jurisdiction can innovate by adopting a program that numerous other jurisdictions established many years ago" (p. 223). Several scholars have investigated the nature of the diffusion of innovations. Rogers (2003) describes the characteristics of innovations as follows "innovations that are perceived by individuals as having greater relative advantage, compatibility, trialability, and observability and less complexity will be adopted more rapidly than other innovations." (p. 16). Rogers (2003) also pointed out that the concept of reinvention or the degree to which an innovation is changed or modified by the user in the process of adoption and innovation has a positive effect as adopters want to actively participate in customizing innovations to suit their unique situation (p. 17). The change in RPS target levels could be considered a form of policy reinvention. Using a criterion of innovativeness, Rogers

(2003) categorized adopters into five distinct categories or ideal types based on observations. These types included innovators, early adopters, early majority, late majority and laggards.

According to Berry and Berry (1990), there were two principal forms of the explanation for the adoption of new programs or state government innovation: internal determinants and regional diffusion (p. 395). The internal determinants model posits that that factors that lead a jurisdiction to innovate are political, economic or social characteristics internal to the state (Berry & Berry, 2007, p. 224). In contrast, diffusion models posit that policy adoption occurs across intergovernmental boundaries as emulations of previous adoptions by other states (Berry et al., 2007, p. 224). According to Berry and Berry (2007), internal determinants models presume that the factors that cause a state to adopt a new program, innovation or policy are the political, economic and social characteristics of the state and preclude diffusion effects (p. 231). The authors point out that while it is likely that a state will be made aware of policy adoptions by other states via standard communications channels, its internal characteristics are what ultimately determine what course of action it takes in terms of policy adoption (p. 232). The authors also assert that a given state's proclivity to innovate can be based on multiple internal factors including problem severity, a policy's popularity with the electorate and the closer in time it is to the next state election and the availability of financial resources (p. 236).

Two of the most common diffusion models are the national interaction model and the regional diffusion model (Berry et al., 2007, p. 226). In the national interaction model it is assumed that there is a national communication network among state officials where they freely interact and learn about new programs from their peers (Berry et al., 2007, p. 226). Alternatively, the regional diffusion model assumes that states are primarily influenced by states that are geographically proximate or direct neighbor states, and hypothesizes that the probability that a given state will adopt a policy is directly and positively related to the number of bordering states that have already adopted it (Berry et al., 2007, p. 229). Berry & Berry (2007) offered that learning and competition can be considered as a basis for assuming that diffusion channels are regional in nature, and that states are more likely to learn from close neighbors than from those that are distant because they can analogize to their more proximate states (p. 229). In this study the latter (neighbor) diffusion model was utilized.

In testing regional diffusion models, Berry (1994) pointed out that some of the earlier methodologies that were employed had a tendency to produce false positives in terms of finding evidence of regional diffusion where it did not exist. In order to improve diffusion analysis techniques, Berry & Berry (1990) utilized event history analysis (EHA) which they describe as a form of pooled cross-sectional time series analysis (p. 395). In the EHA model, Berry & Berry (1990) conceived of a "risk set" of states that are at risk of adopting a certain policy which decreases over time as more states adopt a given policy (p. 398). In their model, the authors employed the hazard rate or probability that a state in the risk set would adopt a policy during a given year that the state was at risk as a dependent variable determined by a set of independent variables representing the whole number or percentage of neighbor states that had previously adopted a given policy (p. 398). According to Berry & Berry (2007), EHA has now become a standard tool employed across a wide variety of policy arenas to test models of state innovation that reflects both internal determinants and regional diffusion (Berry & Berry, 2007, p. 243).

More recent studies of policy diffusion have employed new and innovative techniques and methodological approaches. Berry & Baybeck (2005) employed a spatial approach and utilized geographic information systems (GIS) tools to test for interstate competition and found that in the case of lottery adoptions diffusion is primarily due to competition. The authors concluded that variables representing the number of neighbors do not suffice for testing for the presence of economic competition, but when inter-state competition exists, state's influence on each other vary depending on the size and locations of specific competing entities (p. 505). In subsequent studies of the mechanisms of policy diffusion, Shipan & Volden (2008) found evidence for four mechanisms of policy diffusion: learning from early adopters, economic competition (among proximate cities), imitation (of larger cities) and coercion (by state governments) (p. 840). In their study of antismoking policies, the authors acknowledged that coercion seldom occurs across states but can occur vertically (or from the top down) from U.S. federal to state level, (p. 843). This is particularly relevant in the case of state level renewable portfolio standards whose development was induced by previous policies at the federal level and where the choice to adopt or adhere to a policy is influenced by the threat of penalties.

2.32 Empirical Studies of Climate Change Policy Innovation

Several researchers have found that political ideology plays a part in predicting state RPS adoption. Huang, Alavalapati, Carter and Langholtz (2007) found that political party dominancy and gross state product had an impact on the probability of RPS adoption (p. 5571). Overall they concluded that to optimally promote renewable portfolio standards the focus should be on states with lower education levels, lower GSP's and higher growth rates. Matisoff, (2008) found that internal factors, particularly citizen liberalism, renewable resources and air quality were significant predictors of RPS adoption. Chandler (2009) found that government ideology, affluence and regional neighbor diffusion played a significant role in RPS adoption (p. 3274). Chandler also found that diffusion, particularly among similar states and among state neighbors played an important role in state adoptions of renewable portfolio standards (p. 3280). Fowler (2010) utilizing Daniel Elazar's three aspects of political culture, found that political culture played a significant role in the adoption of renewable development policies at the state level. Some research has demonstrated that the predominance of a particular political party in a given state can influence policy adoption. Lyon and Yin (2010) found that the adoption of an RPS was more likely in states with a strong Democratic presence in their legislature.

Others have found that climate change policy adoption is influenced by state economic factors. According to Villaire (2008), the RPS impact on state economic development and available renewable energy resource capacity are vital factors that affect RPS success. Utilizing an internal determinants model, he found that states innovate and adopt policies according to their endowments of attributes and resources, (p. 544). Carley (2009) found that a number of factors influenced renewable energy development including gross state product per capita, political institutions and electricity use per person. Physical and geographic factors have also been found to exert a measurable influence on climate change policy adoption. Bacot and Dawes (1997) in their research on state environmental efforts found that state size, and pollution severity were key factors that influenced a state's environmental initiatives. Menz and Vachon, (2006) found that the development of wind generation capacity was dependent upon the state's natural endowment of wind capacity potential.

A considerable amount of state innovation policy research has been conducted through the combined theoretical lenses of internal determinants and regional diffusion, often in order to see which has a greater effect. To date, a number of these studies have placed their focus on climate change policy innovation with results that are currently mixed. Two previous studies by Matisoff (2008) and Wiener and Koontz (2010) ultimately found that internal determinants have been stronger predictors of state climate change policy innovation than the effects of regional diffusion while Chandler (2009) found evidence that both models were at play. Matisoff (2008) found that internal factors, particularly citizen's demands were considerably stronger predictors of state's climate change policies than the diffusion effect from neighboring states (p. 544). In their analysis of the variation in state policies to promote small scale wind energy, Wiener and Koontz (2010) found that the role played by internal determinants was most applicable but also acknowledged that some evidence of regional diffusion was evident. Their results indicated that the factors that influenced a state's level of support for small scale wind energy differed for each state and ultimately found that citizen ideology was a good predictor especially for states located at either end of the political spectrum (p. 645). The authors felt that variables highlighted by the regional diffusion model were significant in some but not all cases. Chandler (2009) in his study of state adoptions of sustainable energy portfolio standards discovered that the role played by internal determinants, namely affluence and governmental ideology was significant. The author also found that the role played by regional diffusion was also significant especially among similar states (geographically and isomorphs) (p. 3280).

Current policy innovation research appears to indicate that the role played by internal determinants is stronger that regional diffusion in predicting RPS adoption and innovation. It is however not known if RPS target levels can be predicted by similar factors. It is evident that renewable energy policy adoption is influenced by several factors internal to a given state; these include the state's natural endowment or potential capacity of renewable energy, political ideology and state affluence. In this study several internal determinants were tested and a regional diffusion analysis was performed to determine which has the greater ability to predict RPS target levels. Internal determinants were comprised of a combination of geographic, economic, regulatory, political ideology and infrastructural barriers. Table 3 provides a summary of policy innovation literature arranged by thematic component, authors, area studied and the conclusions and contributions of each research study.

2.4 RPS Design and Development

The proper design of a renewable portfolio standard is crucial if it is to be effective in encouraging the utilization of renewable energy sources and in reaching specified target levels. Wiser, Namovicz, Gielecki and Smith (2007) acknowledged that "Comparative experience from states that have and have not achieved substantial renewable generation growth highlight the importance of design details in achieving stated policy objectives" (p. 20). Researchers have found that there are multiple factors that contribute to the development of effective renewable portfolio standards. This section will present more recent research that describes policy design factors that lead to a more effective RPS. A second portion of this section describes the importance of policy target levels and the various methods that have been utilized to measure the stringency of these target levels.

2.41 Effective RPS Design

Several researchers have found that the choice of policy target levels, incentives and penalties influence overall policy effectiveness. Berry and Jaccard (2001) explored RPS implementation issues in three European countries, nine U.S. states, and Australia, and found that the key considerations in the design of an RPS included the selection of the target or quota for energy production, the selection of ideal eligible energy resources, geographic applicability, flexibility mechanism and the assignment of administrative responsibility (p. 265-268). In their study of RPS implementation in several states, Wiser et al (2007) noted that not all states are on a current trajectory towards meeting their RPS mandates because of overly-aggressive RPS benchmarks, inadequate policy enforcement, policy duration uncertainty, and too many exemptions offered to utilities (p. 13). The authors further state that the "Comparative experience from states that have and have not achieved substantial renewable generation growth highlight the importance of design details in achieving stated policy objectives" (p. 19). Mahone, Woo, Williams and

Horowitz (2009) utilized the state of California's RPS in their study and found that in cases where renewable energy was more expensive when compared to conventional energy sources, increasing the RPS target percentage raised the cost effective level of the overall investment in energy efficiency (EE) programs provided the avoided generation costs due to reduced demand were taken into account (p. 774). In addition, the authors felt that renewable portfolio standards could be more effective if their targets were coordinated and combined with existing or planned energy efficiency programs (p. 774). Finally Carley (2009) in a study that utilized U.S. state level RPS data concluded that the standards are encouraging total renewable investment and deployment but are not increasing the percentage of renewable generation in states' portfolios. Carley attributes this to poorly structured policy design features and weak enforceable penalty mechanisms (p. 3079). In their study of 32 states with a mandatory RPS, Fischlein and Smith (2013) conclude that policy design is important, but the role renewable portfolio standards play can be more complex as several external factors can influence their effectiveness. The authors state that an RPS may not be the sole factor that influences renewable energy deployment and that renewable portfolio standards typically interact with other state and federal policies, resource endowment and existing infrastructure, and other political and social factors (p. 305). Fischlein and Smith (2013) also assert that "once other design aspects are taken into account, it appears that the policy goal can in actuality be much lower, because loopholes often exist that weaken stringency" (p. 304).

Other research has pointed to the influence that other design factors including incentives for compliance and the coordination of existing state climate change policies have on RPS effectiveness. According to Yin and Powers (2010), renewable portfolio standards have had a significant and positive effect on in-state renewable energy development. Utilizing a new and improved measurement of the stringency of an RPS they also found that allowing the free trade of renewable energy credits can significantly weaken the impact of an RPS. Carley's (2011) review of climate change policies found that it was often beneficial if two or more states, or an entire region coordinates their policy efforts (p. 298). It appears that target level selection is a very important design factor influencing RPS effectiveness and ultimate success. It also appears that climate change policies may be more effective if they are combined or coordinated with other existing programs and policies such as those that encourage and promote energy efficiency.

State public utility commissions are the governmental entities that are charged with overseeing the implementation of an RPS, including the administration of renewable energy credits. According to Gormley (1983), the two leading models of the regulatory process are the capture model and the interest group model. The capture model views regulatory agencies as the captives of the industries they are supposed to regulate, (i.e. public and privately-owned utilities), (Gormley p. 133). The interest group model views regulatory agencies as the targets of competing pressure groups and characterizes administrative decisions as compromises designed to balance competing interests and values (Gormley p. 134).

It is important to consider that the slow progress of the transition to renewable energy generation sources could be a strategy employed by politicians, regulators and policymakers. According to Kingdon (1994), incrementalism could be considered to be a purposeful strategy that one might utilize to manipulate outcomes (p. 84). Individuals are reluctant to take large risk-laden steps in the beginning as there is a sense of apprehension that results from being unable to calculate the potential political fallout from a decision (Kingdon, 1994, p. 84). In this study, two regulatory-based factors that could be considered important in influencing the development and design of an RPS are the numbers of state commission regulatory staff and the number of state energy providers that the regulators must regulate.

2.42 Measuring RPS Target Levels

Typically an RPS defines a percentage goal of renewable generation sources and a target end date, or a graduated series of target levels over time. Shirmali et al (2012) point out that in early studies, an RPS had been represented by a dummy variable that accounted for either policy existence or its absence (p. 7). The authors add that Yin and Powers (2010) quantified RPS impact as a count variable for the years since policy implementation and the yearly RPS requirement as a percentage and also introduced a more nuanced instrument, the incremental share variable for policy stringency (p. 7). The incremental share (IS) variable developed by Yin and Powers (2010) took into account the heterogeneity in policy coverage of load-serving entities (e.g. exemptions for some load serving entities) and existing RE capacity (e.g. allowing existing generation infrastructure to fulfill the RPS requirement). (Yin Powers, 2010, p. 1142). Yin & Powers (2010) felt that their incremental share variable "represents the incremental percentage requirement or mandated increase in renewable generation in terms of the percentage of all generation" (p. 1142). Overall, Yin and Powers (2010), contest that their measurement technique was a better indicator of the magnitude of the incentive provided by an RPS because it accounted for several key RPS design features that impact RPS strength and can better differentiate between aggressive policies with weak incentives and seemingly moderate policies that are actually quite ambitious, (p. 1149).

In subsequent studies, researchers have measured RPS target level stringency by expressing it as the percentage change in target level per unit time. Efforts have been made to enhance this method of measurement by using more comprehensive approaches that take into account RPS-specific factors including exiting renewable capacity, policy areas of coverage and carve-outs for different renewable sources. In their study of regulatory stringency and policy drivers Carley & Miller (2012) employed an approach that accounted for the share of a given state's electrical load to which the RPS applied. Their approach produced a prorated average annual level of change that accounted for exclusions for specific industries or publically-owned utilities that diluted the overall scope of the policy (p. 15). Table 4 provides a summary of policy design and stringency literature arranged by thematic component, authors, area studied and the conclusions and contribution of each research study. In this study three measures of RPS target level or stringency were utilized. The first measure included existing RE capacity to provide a measure level of ambition or effort, the second measure took into account policy coverage and the third provided a measure of absolute target level. These measurements of target level stringency will be described in greater detail in the methodology chapter.

Table 1 *Summary of Governmental Regulation Theory Literature by Theme*

Theme	Author(s)	Area Studied	Major Contribution or Conclusion
Regulation Theory	Averch & Johnson	U.S. Telephone and Telegraph Industry	Conducted one of the first studies to evaluate on the effect of regulation on an industry. The authors found that regulated firms would expand their rate bases by substituting capital for labor and often expand into unprofitable ventures in order to satisfy regulators (p. 1068).
	Stigler, (1971)	U.S. Trucking Industry and Occupational Licensing	Development of a general theory of regulation and accompanying theory of regulatory capture. Central thesis of paper was as a regulation is acquired by a given industry and is designed and operated for its benefit (p. 3). Also indicated that "every industry or occupation that has enough political power to utilize the state will seek to control entry" (p. 5).
	Posner, (1974)		Coined the definition of Public Interest Theory holding that "regulation is supplied in response to the demand of the public for the correction of inefficient or inequitable market practice" (p. 335). Later disputed the theory stating that regulation is not always supplied in highly concentrated industries where the danger of monopoly is greatest (p. 336).
	Courville, (1974)	U.S. Electric Utilities	Confirmed the Averich-Johnson effect stating that "the regulated monopolist will not be efficient in choosing its inputs" (p. 53). Concluded that rate of return regulation induced overcapitalization in U.S. electric utilities.
	Buchanan (1980)		Defined rent as the receipt in excess of opportunity cost or "that part of the payment to an owner of resources over and above that which those resources could command in any alternative use" Defined rent-seeking as the behavior in institutional settings where individual efforts to maximize value generate social waste rather than social surplus.
Climate Change Policy and Political Ideology	Huang et al, (2007)	U.S. States	Education, political party dominancy, GSP, population growth rate had a positive effect on RPS adoption.
	Matisoff (2008)	U.S. States	State political ideology and political party dominancy influence renewable energy policy adoption.
	Chandler (2009)	U.S. States	Found multiple predictors of state RPS adoption including governmental ideology.
	Lyon & Yin, (2010)	5 U.S. States	Found that the adoption of an RPS is much more likely in states with a strong Democratic presence in their legislature.
	Fowler, (2010)	39 U.S. States	Found that political culture plays a significant role in the adoption of renewable development policy at the state level.
Renewable Energy Deployment and Governmental and Regulatory Environment	Bacot & Dawes, (1997)	U.S. States	State population was a key factor that influenced a state's environmental expenditures and initiatives
	Menz & Vachon, (2006)	U.S. States	The pace of renewable energy development was influenced by regulatory changes, particularly those that restructured the electricity industry
	Villaire, (2008)	U.S. States	RE Policy success influenced by RPS impact on state economic development.
	Carley, (2009)	42 U.S. States	Political institutions significantly related to the level of renewable energy generation deployment

Table 2 *Summary of Infrastructure-Led Economic Development Literature by Theme*

Theme	Author(s)	Area Studied	Major Contribution or Conclusion
Infrastructure and Economic Growth	Aschauer, (1989)	U.S. States	Core public infrastructure consisting of streets, highways, airports, electrical and gas facilities, mass transit, water systems and sewers possess strong explanatory power for aggregate total factor productivity.
	Munnell, (1992)	U.S. States	Internal determinant of citizen ideology was significant. Some regional diffusion was somewhat evident.
	Fernald (1999)	U.S. Transportation	Growth in road infrastructure benefited vehicle-intensive industries but that the return was often one time and eventually diminished.
	Demetriades & Mamuneas (2000)	U.S. Public Infrastructure	Public capital had a positive long-run effect on output supply and input demand that declined over time and observed lower mean short-run rates of return.
	Agenor, (2006)		Summarized several related analyses of the effect of public capital on economic activity, concluded that public infrastructure investment provided immediate economic stimulus and had a positive effect on output, investment and employment growth.
Telecommunications Infrastructure and Economic Growth	Hardy, (1980)	29 Countries	Found that there was evidence that the telephone does contribute to economic development.
	Norton, (1992)	Developing Countries	Low telecommunications infrastructure was a primary reason why some parts of the world have not developed. Telephones provide substantial growth and investment-enhancing activity that in turn facilitate economic growth.
	Roller & Waverman (2001)	U.S. States	There was a significant positive causal link between telecommunication infrastructure and economic growth especially when a critical amount of infrastructure was present.
Infrastructural and Systemic Barriers to Renewable Energy Development and Deployment Efforts	Kundur, (1994)		Voltage and reactive power control are critical. Compensation infrastructure is necessary.
	Rahm, (2002)		Cost, lack of public awareness of sustainable technologies, government subsidies to the fossil fuel/nuclear industries, maturity of technologies, lack of appreciation for the consequences of fossil fuel use.
	Staudt, (2008)	U.S. States	Low power density of renewable sources, large land area requirement.
	Bohn & Lant, (2009)	37 U.S. States	Renewable development determined by electricity demand, proximity to transmission lines.
	Davis & Davis, (2009)	U.S. States	Identified the lack of energy storage systems and inadequate transmission capacity as barriers.
	Nelson (2009)		Found that the major problem for wind farm development was that load centers are far away from the wind resources, and wind farm projects can be brought online much faster than new transmission lines can be constructed.
	Mend et al, (2010)	U.S. States	Major obstacle or barrier that RE deployment faces is the challenge of the siting of power plants. These challenges are primarily due to the immobility of renewable resources.
	Hoppock & Patino-Echeverri (2010)		Found that the most favorable wind sites often lack transmission access as they are usually located far from electricity demand centers. In their research they found that local, lower capacity wind sites are actually the lowest cost option.
	Rabe, (2010)		Predicted that a large scale overhaul of the current grid system looms over the transition to alternative energy sources.
	Adamczyk et al (2010)		Wind power plants affect system stability in adverse ways necessitating the addition additional infrastructure to dynamically control, stabilize and enhance power system performance.
	Crabtree et al, (2011)		Stressed the importance of energy storage systems.
	Alagappan et al, (2011)	14 U.S. States	Stressed the importance of transmission planning.

Table 3 *Summary of Policy Innovation Theory Literature by Theme*

Theme	Author(s)	Area Studied	Major Contribution or Conclusion
Policy Innovation Theory	Walker (1969)	U.S. States	Postulated the key factors affecting the adoption of innovations at the state level, namely emulation and competition.
	Berry & Berry, (1990)	U.S. State Lottery Adoptions	Developed the internal determinants and regional diffusion models for explaining the adoption of new programs or state government innovation.
	Rogers (2003)		Described several characteristics of innovation including relative advantage, compatibility, trialability, and observability and less complexity. Classified types of innovators, early adopters, early majority, late majority and laggards.
	Berry & Baybeck (2005)	U.S. States	Used geographic information systems (GIS) to test for interstate competition
	Shipan & Volden (2008)	U.S. Cities' Anti-Smoking Policies	Found evidence for four mechanisms of policy diffusion: learning, economic competition, imitation and coercion (by state governments)
Predicting Climate Change Policy Innovation	Bacot & Dawes, (1997)	U.S. States	State's environmental expenditures and initiatives predicted by pollution severity, environmental groups and state size
	Menz & Vachon, (2006)	39 U.S. States	Wind generation capacity deployment influence by internal factors: natural endowment of wind potential and on the existence of an RPS
	Huang et al, (2007)	U.S. States	Policy innovation influenced by education, political party dominancy, GSP, population growth rate.
	Matisoff (2008)	48 U.S. States	Internal factors, particularly citizen liberalism, renewable resources and air quality were significantly significant predictors of RPS adoption.
	Villaire, (2008)	5 U.S. States	RPS impact on state economic development and available renewable energy resource capacity are vital factors that affect RPS success. found that states innovate and adopt policies according to their endowments of attributes and resources.
	Chandler (2009)	34 U.S. States	Government ideology, affluence and regional neighbor diffusion played significant parts in RPS adoption. Also found that diffusion, particularly among similar states and among state neighbors played an important part in state adoption of renewable portfolio standards.
	Carley, (2009)	U.S. States	Political institutions, resource endowment, deregulation, GSP per capita, electricity use, presence of regional RPS influence RE deployment.
	Fowler, (2010)	42 U.S. States	Political culture plays a significant role in the adoption of certain policies.
	Wiener & Koontz (2010)	3 U.S. States	Internal determinants were most applicable. Acknowledged that some evidence of regional diffusion was evident. Found that factors that influenced a state's level of support for small scale wind energy differed for each state and that citizen ideology was a good predictor.
	Lyon & Yin, (2010)	U.S. States	RPS adoption influenced by a strong Democratic party presence in state legislature

Table 4 *Summary of Policy Design and Stringency Literature by Theme*

Theme	Author(s)	Area Studied	Major Contribution or Conclusion
Effective RPS Design Factors	Berry & Jaccard, (2001)	3 EU Countries, 9 U.S. States, Australia	Goal selection, selection of eligible energy resources, geographic applicability, flexibility mechanisms, assignment of administrative responsibility
	Wiser et al, (2007)	U.S. States	Inadequate policy enforcement, policy duration uncertainty, overly-aggressive RPS benchmarks, too many exemptions or flexibility offered to providers
	Mahone et al, (2009)	California	Increasing the RPS target raised the cost effectiveness level of investments in energy efficiency (EE) programs.
	Carley (2009)	U.S. States	Renewable portfolio standards are encouraging total renewable investment and deployment but not increasing the percentage of renewable generation in states' portfolios. The author attributes this to poorly structured policy design features and weak enforceable penalty mechanisms.
	Yin & Powers (2010)	U.S. States	Found that the impact of an RPS can be weakened if the free trade of renewable energy credits is allowed.
	Carley (2011)	U.S. States	Author reviewed current RPS's and found that it was often beneficial if two or more states or an entire region coordinates their policy efforts.
	Fischlein & Smith	32 U.S. States	Stressed the importance of policy design. Several external factors can influence RPS effectiveness as RPS's typically interact with other state and federal policies, resource endowment and existing infrastructure, and other political and social factors.
RPS Stringency Measurement	Yin and Powers, (2010)	16 U.S. States	Stringency calculated as "Incremental Share" which included ratio of total generation/existing RE capacity, RPS coverage and existing renewable capacity factors.
	Carley & Miller, (2012)	32 U.S. States	Stringency calculation included RPS coverage and existing renewable capacity factors.

2.5 Case-Specific Literature

The third section of the literature review presents case-specific literature and is divided into four sub-sections. Its first section describes the economic model that will be utilized in this study. The second sub-section describes the benefits and costs of renewable energy and which underscores the need to place a focus on the cost-intensive infrastructural barriers affecting RE deployment efforts. The third sub-section provides a historical summary of climate change and renewable energy policy mechanisms in the United States which have lead to the present state renewable portfolio policy mechanisms and state-mandated RE goals that are now in effect. A fourth sub-section describes geo-spatial analysis techniques and their increasing use as quantitative analysis tools in the social sciences.

2.51 Economic Market Model

In the U.S. electricity market public and private energy providers (or utilities) either generate electric power or purchase it from independent power producers (IPP's) and sell it to their residential, commercial and industrial customers. These energy providers are regulated by state public utility commissions and in most cases operate as natural monopolies providing electric power to their customers as an excludable and non-rivalrous club good. The original and historical reason for the application of regulation was to prevent the monopolistic pricing of electricity. State regulators set the market price of electricity at a level that assures that energy providing utilities remain in business and provide affordable service to all of their customers.

The electric power that is supplied to customers is derived from multiple generation sources depending on their cost and availability. The most recent (2012) data from the U.S. Energy Information Administration (EIA) indicates that 67% of U.S. electricity is derived from fossil fuel resources and 5% is derived from renewable generation sources, (wind, solar, geothermal and biomass). Fossil fuels comprise the largest generation source primarily because they are priced lower that competing sources and have higher energy conversion efficiencies. The increasing returns to scale phenomenon associated with large fossil fuel generators creates barriers to entry for smaller scale alternative renewable energy (RE) generation sources. This phenomenon ultimately results in an imperfect competitive market and a market failure that contributes to the formation of a natural monopolistic environment for fossil fuel generation resources.

One negative externality and social cost associated with the utilization of fossil fuel sources to generate electricity is air pollution in the form of greenhouse gases (GHG's). Some consider this production of GHG's to be an unsustainable market activity that necessitates the need for some form of governmental intervention. Several policy responses have emerged to encourage and promote RE generation sources that either eliminate or mitigate the negative externality of air pollution. The expectation of such policies promoting investment in the private good of RE is that they will stimulate growth of the RE industry, advance RE technologies and eventually reduce the cost of RE generation to a point where it becomes cost competitive with conventional fossil fuel sources.

In the U.S. electricity market the primary governmental intervention mode is state level policy responses in the form of Renewable Portfolio Standards. These standards are command and control instruments that utilize performance standards and targets. According to the National Association of Regulatory Utility Commissioners (NARUC), these policies obligate regulated energy providers to include in their generation portfolios a certain amount of electricity derived from renewable resources. Policymakers are hopeful that renewable portfolio standards will advance the reliance of U.S. energy suppliers on RE by maintaining and incrementally increasing the quantity of RE over a specified period of time and thus allowing the market to decide if they remain a viable electricity generation source. In addition to setting performance standards, renewable portfolio standards also promote the growth of RE by imposing penalties on energy suppliers for non-compliance in meeting specified RE targets. Policymakers hope that the investment in the private good of RE ultimately results in growth in its market share of the U.S. generation mix and in the growth of RE technologies. In addition, policymakers hope that a decreased reliance by the market on fossil fuel sources will result in the mitigation of and eventual correction of air pollution externalities. The need for a policy response is twofold: first to correct the failure of the market to provide a competitive market that allows RE to compete with fossil fuels and second to remove or at least mitigate the negative externality of air pollution. Using the market model described above, this study will utilize public interest theory of regulation to determine the effect of the degree of regulation provided by the state has on RPS target levels.

In addition to public interest theory, this study will also test the economic theory of infrastructure-led development. Previous empirical studies in this area have determined that infrastructure investment has had a positive effect on economic output and growth. In applying this theory to climate change efforts, we look toward the effect of infrastructure on renewable energy deployment efforts. Several researchers have found that there are several infrastructural barriers to renewable energy (RE) infrastructure deployment namely in the form of the lack of an adequate electricity transmission network. Utilizing the known infrastructural barriers to RE market penetration, this study will determine if the target levels of state renewable portfolio standards, a proposed driver to stimulate RE development and economic growth, are influenced by the amount of available electricity transmission infrastructure.

2.52 Renewable Energy Benefits and Costs

In order to gain an understanding of the motivations behind the policies that drive U.S. efforts to promote the use of renewable energy generation sources it is necessary to understand the benefits and costs associated with them. Renewable energy sources provide an alternative to conventional electricity generation sources derived from fossil fuels. The use of fossil fuels in the pursuit of energy has had and will continue to have a profound effect on the earth. Current studies by the Intergovernmental Panel on Climate Change (IPCC, 2007) have provided strong evidence that anthropogenic greenhouse gas emissions and aerosols are contributing factors to climate change in the form of recent global warming trends. According to the U.S. Department of Energy's Energy

Information Administration (2008), energy-related carbon dioxide emissions account for more than 80 percent of U.S. greenhouse gas emissions. In addition, growth in these emissions since 1990 has resulted largely from increases associated with electric power generation and transportation fuel use (EIA, 2008). Despite efforts to increase the amount of energy generated from renewable sources, (e.g. solar, wind and geothermal), the current percentage of energy produced in the United States derived from fossil fuel sources such as coal, natural gas and petroleum, stands at nearly 80% while renewables constitute only 8% of the total (EIA, 2010). In terms of future demand, Klare (2008) predicts that the worldwide energy requirements are expected to rise by 57% between 2004 and 2030 and that this will subsequently require a substantial boost in the output of every source of energy, including fossil fuels, nuclear, hydropower, and renewable sources (p. 11). Klare (2008) also indicated that petroleum, which accounts for approximately 40% of world energy use is the energy source most likely reach peak a maximum or peak level and subsequently dwindle in the next few decades (p. 14).

The National Association of Regulatory Commissioners (2001) has articulated several benefits associated with renewable energy. One of the primary benefits associated with renewable energy resources mentioned are their low impact on the environment in terms of air pollution, climate change, degradation of land and water, water use, wildlife impacts and radioactive wastes (p. 3). Second, they feel that renewable sources increase the diversity of energy resources which in turn contributes to price stability, improves the reliability of the electrical system and promotes competition (p. 4). Third, they feel that prolonged policy support for renewables will ultimately result in the further advancement of renewable energy technologies and will render them more cost effective (p. 4). Fourth, they feel that in-state economic development benefits will be derived from the development of renewable power plants especially in areas with abundant renewable resources (e.g. solar, wind, biomass). Finally, the authors point out that political benefits will be gained as policymakers respond to their constituents expressed support for renewable energy (p. 5).

Olz (2007) and the International Energy Agency (IEA) described the enhancement of energy security as a primary benefit associated with the derivation of energy from renewable sources. The European Commission (2000) defined energy security as "The uninterrupted physical availability of energy products on the market, at a price which is affordable to all customers, private and industrial" (p. 13). Olz (2007) also described the role of RE in enhancing energy security as a risk mitigating agent and describes three energy security risk types. The author first described the energy security risk of energy market instabilities caused by unforeseen changes in geopolitical or other external factors which can occur due to political unrest, conflict or trade embargos (p. 13). Second, Olz described technical failures such as power outages caused by grid or generation plant malfunctions, human error, accidents and offered that these failures have sharp and wide ranging effects due to the inherent complexity of power system networks (p. 14). The third type of security risk that Olz, (2007) described was physical security threats which include terrorism, sabotage, theft and natural disasters. These risks can ultimately affect power substations and transmission lines, oil and gas exploration, resource extraction and refining installations and transportation networks and infrastructure (p. 14).

There is a growing body of research that indicates that the initial cost of RE is higher than conventional fossil fuel generation sources. Studies by Staudt (2008) and Davis & Davis (2009) indicated that the costs of energy derived from RE sources are higher than conventional fossil fuel energy generation sources because of their lowered efficiencies and the incremental costs associated with their integration into exiting electric power systems. The overall lower power densities and larger land requirements of renewable generation sources when compared to fossil fuel derived sources have also been described by Staudt (2008). In addition, Davis & Davis (2009) found that one of the most serious added costs associated with renewable energy sources are associated with their intermittent output and the lack of energy storage and transmission capacity. The intermittent nature of renewable sources is also a concern in terms of the maintenance of gird stability. Finally, Lenard (2009) indicated that wind and solar renewable energy sources raise reliability issues due to the fluctuations in their supply (p. 10).

Previous research indicates that the costs associated with the integration of RE will be immediate but the benefits may not. This further underscores the need to place a focus on the infrastructural barriers to RE development as predictors of RPS target level. In this study these barriers will include the number of circuit miles of electric power transmission lines and a measure of the density of transmission lines in a given state (circuit miles per square mile). The average price of electricity (in cents/kWh) will also be included as a variable that is representative of the cost of electric power for each state.

2.53 Renewable Energy Policy Mechanisms

In the United States, there are several federal, regional and state policies that encourage the utilization of renewable energy sources. According to Menz and Vachon (2006), the pace of renewable energy development has been influenced by regulatory changes, particularly those that restructured of the electricity industry in the 1980's and 1990's. Key federal laws that facilitated this restructuring were the 1978 Public Utility Regulatory Policies Act (PURPA) which required utilities to purchase electricity produced by non-utility entities, and the Energy Policy Act of 1992 (EPACT) which required utilities to open their transmission lines to all producers and generators of electricity, including renewable sources (Menz & Vachon, 2006).

During the last ten years there has been a large amount of research relating to renewable energy policy development and into the factors that lead to climate change policy adoption. The main policy instrument utilized in the energy generation industry in the United States is the Renewable Portfolio Standard or RPS. A typical RPS requires energy producers to provide a gradually increasing percentage of their overall generating or electricity sales from qualifying renewable sources by a certain date (Menz et al., 2006). In many cases the fulfillment of this obligation by electricity generators within the market can be alternatively be facilitated by the use of some kind of tradable renewable energy credits or certificates (Rowlands, 2010, p. 23). The first RPS, according to Lyon and Yin (2010), was established in 1983, when the state of Iowa passed the Alternate Energy Production law requiring its two investor-owned utilities to contract for a combined total of 105 megawatts (MW) of generation from renewable energy resources. The majority of U.S. states adopted RPS standards on or soon after 2000. According to Carley (2009), it was hoped that this trend in state energy policymaking would encourage those who fear the ramifications of global warming and the over-reliance on foreign fossil fuels (p. 3072).

As a direct result of these renewable portfolio standards, several state public utilities commissions have established programs to allow energy providers to buy and sell portfolio energy credits (PEC's) or renewable energy credits (REC's) in order to meet portfolio requirements. One PEC or REC generally represents a single kilowatt-hour (kWh) of generated electricity. Under this standard, the state's principle energy provider must use eligible renewable energy resources to supply a minimum percentage of the total electricity they sell to customers.

In the time since the proposal, adoption and implementation of renewable portfolio standards, a notable amount of solar, wind and geothermal renewable generation capacity has been deployed in the United States. According to U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy (2010), excluding hydropower, renewable electricity installed capacity has now reached about 53 gigawatts (GW) in the United States. In addition, the installed renewable energy capacity in the U.S. has more than tripled between 2000 and 2009.

At present, the U.S. federal government has no national RPS in place. With no federal portfolio standard currently in place, the U.S. states via RPS development and adherence have clearly taken the lead in the development of climate changes policy. Rabe (2004) attributes this situation to the fact that policy entrepreneurs have taken advantage of the failure of the federal government to design or enact an emissions reduction policy, the informal nature of state level policymaking and the absence of opposing interest groups, and because the states perceive it in their own economic self interest to do so (p. 27). In addition, Rabe points out that it is likely for the foreseeable future that American climate policy will build on the respective strengths of both federal and state governments and possibly evolve into a multilevel climate governance system (Rabe, 2008, p. 125).

Present research has indicated that climate change policies at the state level appear to have been successful in increasing the total amount of renewable energy generation infrastructure in the United States. According to Rowlands (2010), the main advantage of renewable portfolio standards is that they virtually assure the development of predetermined quantities of renewable electricity, and by virtue of their reliance on market mechanisms, encourage cost reductions among competing producers and generators (p. 185). The limitations of an RPS approach are mainly price uncertainty in that the financial impacts borne by ratepayers and taxpayers can only be discovered after the introduction and implementation of the policy (p. 185). For the foreseeable future, state level renewable portfolio standards appear to be the primary policy driving the planning, development and deployment of renewable energy generation infrastructure in the United States.

2.54 Geo-Spatial Techniques

Spatial and proximity dependence is best summed up by Tobler's first law of geography which states "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970, p. 199). The concept of spatial diffusion can be traced back to the work of Hägerstrand (1952) who studied the spatial diffusion of the acceptance of subsidies by farmers in Sweden and found that the transfer of knowledge required repeated interaction and was more likely to occur in conditions of close geographic proximity and drew attention to the importance the quality of interpersonal communication. In his studies of the diffusion of innovations, Hägerstrand (1967) developed a three stage sequence of change. The first stage described by the author is local concentrations of initial acceptances or initial agglomerations (p. 133). This first stage was followed by a second which consisted of the radial dissemination outward from initial agglomerations and was accompanied by a rise of secondary agglomerations, while original centers of innovation continued to condense, and during the third stage, a saturation occurred and growth ceased (p. 134). Hägerstrand (1952) next presented three basic assumptions for spatial diffusion. The first was that from the beginning the entire population was informed about the innovation, second, that acceptances occurred independently of one another is a random precedence order, and third, that the course of the growth curve was not considered (p. 141). The author divided potential barriers to diffusion into i) unevenly distributed willingness or opportunity to accept the innovation, ii) an uneven distribution of information regarding the innovation, and iii) some combination of these two afore-mentioned factors (p. 148). In this particular study the uneven distribution of willing adopters could come in the form of state public utility commissions with differing budget levels, RE potential capacity and attitudes towards renewable resources because of differing ideological viewpoints stemming from each state's dominant political party. An uneven distribution of information could take the form of state legislatures and public utility commissions that utilize different means of communication among themselves or with their constituents, (e.g. TV, radio, Internet, etc.).

Hägerstrand (1967) identified two predominant features in the spatial diffusion of innovations processes. First, he described the "neighborhood or proximity effect", where innovation acceptances tend to cluster in a manner related to their location with respect to one another. In this study neighborhood or proximity effects might occur in U.S. states or regions who have similar renewable energy potential capacities, (e.g. solar in the U.S. desert Southwest and wind in the U.S. Midwestern regions). Second, Hägerstrand drew attention to the role of information, in particular, private information in the form of face-to-face conversations as a crucial driving force behind innovation diffusion (p. 164). In this study the forms of private information could be communication between state policymakers, public utility commission staff and utility executives.

In the last ten years spatial econometric models and geo-spatial analyses have been utilized in an increasing number of fields in the social sciences and a better understanding of diffusion processes has been gained as a result. Much of this research has determined that competition is a key factor in spatial diffusion processes. In his study of the spatial diffusion of state government policies and their related implementation organizations, Jenson (2004) found that degrees of spatial diffusion varied greatly and that policies with an institutional basis showed an absence of spatial diffusion while competition-based polices did indeed diffuse spatially (p. 109). In their research, Berry & Baybeck (2005) employed a spatial approach to test for interstate competition. They utilized geographic information systems (GIS) tools and found that in the case of lottery adoptions, diffusion was primarily due to competition.

According to Anselin (2001), the increased attention to the testing for spatial interaction can be attributed mainly to the growing interest within theoretical economics in models that account for interactions between economic agents and other heterogeneous agents in the system, (p. 310). Alternatively stated "in many cases the outcomes or incentives for action of individual actors do not depend solely on the attributes of the individual, but the structure of the system, their position within it and their interactions with other individuals" (Ward & Gleditsch, 2008, p. 1). In this study a global autocorrelation analysis (Moran's I) will be utilized and a local autocorrelation analysis will also be utilized to check for cluster centers that are contributing to the global geospatial outcome. The above-mentioned geographically-weighted regression analysis techniques will serve to augment the more common multivariate regression (OLS) statistical analysis approaches.

2.6 Summary and Research Design Model

This section summarizes the literature reviewed and will describe the main research model and approach that will be taken in this study. Figure 1 provides an overall illustration of how each individual theory and case-related empirical studies from major literature themes contributed to the selection of predictive factors and ultimately the set of independent variables to test for their ability to predict RPS target levels. First, regulation theory and studies of the effect of regulation on policy initiatives were examined to derive a set of regulatory factors to test. Second, the theory of infrastructure-led economic development and contemporary studies of infrastructure's role as a barrier to renewable energy development and deployment efforts were reviewed and multiple infrastructural factors were derived from known barriers. Third, policy innovation theory's internal determinants and regional diffusion models were examined along with studies of the adoption of climate change policy. Geographic, economic, and political ideological factors representing state internal determinants were then selected from known predictors of RPS and climate change policy adoptions. Finally, policy innovation theory's regional diffusion model and research studies of climate change policy diffusion were reviewed to develop factors that could be utilized as independent variables for the diffusion analyses performed. Independent variables for the nearest neighbor and geo-spatial diffusion analyses were developed using these factors to best reflect the degree of inter-state competition and emulation. Tables 1 through 4 provide a summary of literature reviewed and the contributions and key findings of each.

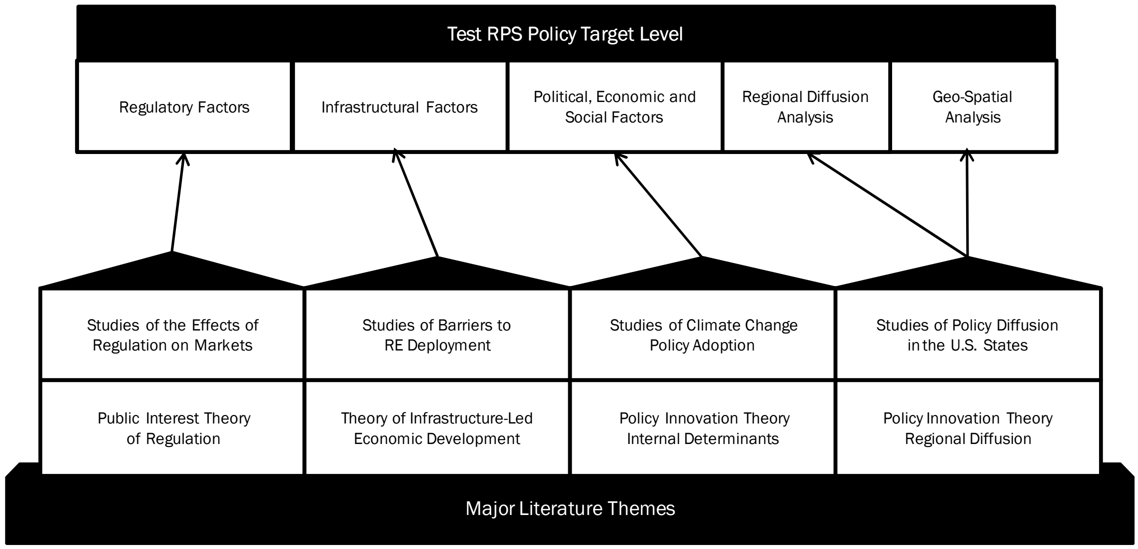


Figure 1. Research Design Model

To date only a small number of empirical studies have examined the predictors of state RPS target levels and there are several research gaps and controversies. First, a study has not yet been conducted that tested the effect of state governmental regulation on measures of RPS target levels. Second, a study has not been conducted to determine the predictive ability of infrastructure on measures of RPS target levels. Third, no policy innovation-themed studies have been conducted that compared the predictive ability of state internal determinants and regional diffusion on measures of RPS target level. Fourth, no study has been conducted of RPS target levels that utilized geospatial global and local autocorrelation techniques. Finally, only Carley & Miller (2012) have conducted a study that tested the predictive ability of political ideology on different measures of RPS target level.

These research gaps or controversies provide a basis for the following research questions outlined below. First, does state regulation affect the RPS target levels set by policymakers? Second, does infrastructure matter for predicting RPS target levels? Third, do measures of political ideology predict RPS target levels? Fourth, is regional diffusion or internal determinants the driver of state RPS target levels? Finally, are there geo-spatial patterns of RPS target levels in states? The sections that follow will link each of these research questions to individual hypotheses and to an accompanying proposed hypothesis test.

Contemporary research has indicated that RPS adoptions have been influenced by political ideology, political institutions and regulatory change. Bacot and Dawes (1997) in their examination of state environmental efforts found that state population was a key factor that influenced a state's environmental initiatives. Another study by Menz & Vachon (2006) indicated that the pace of renewable energy development had been influenced by regulatory changes. Finally, Carley (2009) found that political institutions are significantly related to renewable energy deployment efforts. With the combined known effect of population, political institutions and public regulation on state RE initiatives and development efforts, it could be argued that governmental and regulatory organizational factors matter in predicting RPS target levels. With regard to population, it is projected that policymakers in more populous states with higher numbers of public utility commission staff would set their RPS target levels higher. This effect would likely be strongest in very densely populated states with higher pollution externalities as policymakers could reduce the impact of such market failures more effectively if greater numbers of regulatory staff and policymakers were available to develop more aggressive renewable portfolio standards. In regard to institutions, it is projected that states with a higher number of regulated electricity providing organizational entities would set their RPS target levels higher because their electric system grid would be more diversified and capable of accommodating new generation sources with greater ease. Finally, given public interest theory's assertion that regulation is supplied to protect the public from the effects of market failures, (Joskow & Knoll, 1981, p. 3), it would be logical to assume that the magnitude of electricity market regulation provided at the state level would have some influence on the design of environmentally beneficial renewable portfolio standards, particularly the stringencies of their target levels. At present there have been no studies undertaken that have explored the effect that state regulation has on RPS target levels. This study will test measures of the magnitude of state regulation of public and private electricity providers to determine their effect on RPS target levels and will endeavor to answer the first research question that asks if state regulation affects the RPS target levels set by policymakers. The hypotheses for this research question are presented below.

Hypothesis 1.

States with larger public utility regulatory commission staffing levels will set higher RPS target levels.

Ho: β State PUC Staff = 0

Ha: β State PUC Staff > 0

Previous studies in the area of infrastructure-led economic development have indicated that investment in infrastructure had a positive effect on economic output and growth. In addition, more recent studies have revealed a number of infrastructural barriers to renewable energy infrastructure deployment efforts particularly available electrical transmission lines and a state's natural endowment of renewable energy generation capacity potential. Research conducted by Aschauer (1989), Munnell (1992) and Roller & Waverman (2001) discovered that investment in infrastructure had a positive effect on economic output and growth. In addition, more recent studies have revealed a number of infrastructural barriers to renewable energy (RE) infrastructure deployment efforts. Bohn and Lant (2009) found that the primary determinants of wind energy development were human geographic factors of population distribution and transmission line accessibility (p. 87). Studies by Davis & Davis (2009), Hoppock & Patino-Echeverri (2010) and Alagappan, Orans & Woo (2011) have all drawn attention to the importance of transmission line infrastructure to the development of renewable energy resources. Menz and Vachon, (2006) found that wind generation deployment levels were dependent upon the state's natural endowment of wind capacity potential. It would be expected that policymakers in states with higher amounts of existing transmission network infrastructure, known to be conducive to RE deployment, might set their RPS target levels higher. It would also be expected that policymakers in states that have higher net generation capacities and subsequently a more robust and diversified system, could accommodate new generation sources more easily and therefore would support more stringent RPS targets. Finally it would be assumed that states with higher potential capacities for renewable energy generation sources would set higher RPS targets. What is not currently know is the effect that these infrastructural factors have on the RPS target levels set by state policymakers. Utilizing known infrastructural barriers to RE market penetration, this study will determine if the target levels of renewable portfolio standards, a proposed driver to stimulate RE technological development and economic growth, have been influenced by the amount of available electricity transmission infrastructure. In addition this study will test the effect that a state's natural endowment of RE potential capacity has on RPS target levels. In performing these analyses, this study will answer the second research question of whether infrastructure matters for predicting RPS target levels. The hypothesis for this research question is indicated below.

Hypothesis 2.

Infrastructure does matter. States with higher transmission line densities will set higher RPS target levels.

Ho: β T-Line Density = 0

Ha: β T-Line Density > 0

Researchers have found that state RPS adoptions were motivated by governmental ideology and political party dominancy. Studies by Matisoff (2008), Lyon & Yin (2010) and Huang et al (2007) have indicated that state political ideology and political party dominancy influence renewable energy policy adoption and that a strong Democratic party presence and/or liberal attitudes have a positive effect on climate change policy adoption. In their examination of renewable portfolio standards, Carley & Miller (2012) found that standards of differing stringencies are motivated by systematically different factors including government level ideology. It is therefore expected that states that are more Democratic than Republican will favor a more stringent RPS target level goal. In the study of RPS target levels, little is currently known regarding the abilities of measures of state citizen and governmental level ideology to predict RPS target levels. Using measures of state citizen and state government ideology, this study will endeavor to answer the third research question of whether measures of political ideology can predict RPS target level. The hypothesis for this research question is indicated below.

Hypothesis 3.

States that are ideologically more liberal (citizen and governmental level ideology) will set higher RPS target levels.

Ho: β Political Ideology Index = 0

Ha: β Political Ideology Index > 0

Contemporary studies in the arena of policy innovation that have examined the abilities of state internal determinants and regional diffusion to predict RPS adoptions have had mixed results. Some researchers have also found that the role played by state internal determinants was stronger while others have acknowledged the presence of a regional diffusion effect. Chandler (2009) in his study of state adoptions of sustainable energy portfolio standards found that the role played by regional diffusion was significant especially among similar states (geographically and isomorphs) (p. 3280). In their study of the predictors of state climate change policy innovation, Wiener and Koontz (2010) found that the role played by internal determinants was most applicable but also acknowledged that some evidence of regional diffusion was evident. It would be expected that state policymakers would set their RPS target levels higher if a higher fraction of their nearest neighbor states have set higher targets and it would also be expected that states would set higher RPS target levels if a higher fraction of neighboring states have deployed the same or higher amount of renewable energy capacity on their state grid system. It is possible however that states might set their RPS target levels lower than their neighbors if the policy environment is not a truly competitive one, but one driven more by economic factors. In such a scenario, state policymakers might take a "wait and see" approach and observe the targets set by their immediate neighbor states, set their RPS target levels lower and elect to purchase renewable energy credits from neighboring states and forgo the costs of RE infrastructure and/or the costs of integrating RE generation sources into their grid system. What is presently not known is whether state internal determinants or diffusion effects have the ability to predict RPS target levels set by state policymakers. This study will test the predictive ability of economic, geographic and regulatory state internal determinants and will also test for diffusion effects using the RPS target levels and RE capacity installed in nearest-neighbor states. In performing the above-mentioned analyses, this study will answer the research question of whether regional diffusion or internal determinants are the dominant driver of state RPS target levels. The hypothesis for this research question is indicated below.

Hypothesis 4.

> Regional diffusion matters. States will enact an RPS with higher target levels if their neighboring states have the same or higher stringent target levels or install the same or more renewable generation capacity.

Ho: No diffusion effect by nearest neighbor states

Ha: Nearest neighbor states diffusion effect exists

Some of the research describing the role played by regional diffusion in predicting RPS adoptions has determined that the diffusional effect was especially significant among similar states (geographically and isomorphs). The majority of studies that have explored the effect of diffusion on RPS adoption and innovation have utilized some form of nearest-neighbor regional diffusion model, but none have utilized a geo-spatial approach. In this study two forms of geospatial analysis will be utilized: a global autocorrelation analysis (Moran's I) utilizing spatial lag and error models and a test for local indicators of spatial autocorrelation (LISA) to check for cluster centers that are contributing to the global geospatial outcome. The use of these two geospatial analysis approaches will contribute to the answer of the final research question which queries if there are geo-spatial patterns of RPS target levels in states? The hypothesis for this research question is indicated below.

Hypothesis 5.

Geo-spatial effects exit in the form of regional cluster centers. States will enact RPS policies with similar target levels as their closest neighboring states.

Ho: No local patterns of a geo-spatial diffusion effect exists

Ha: Local patterns of a geo-spatial diffusion effect exists

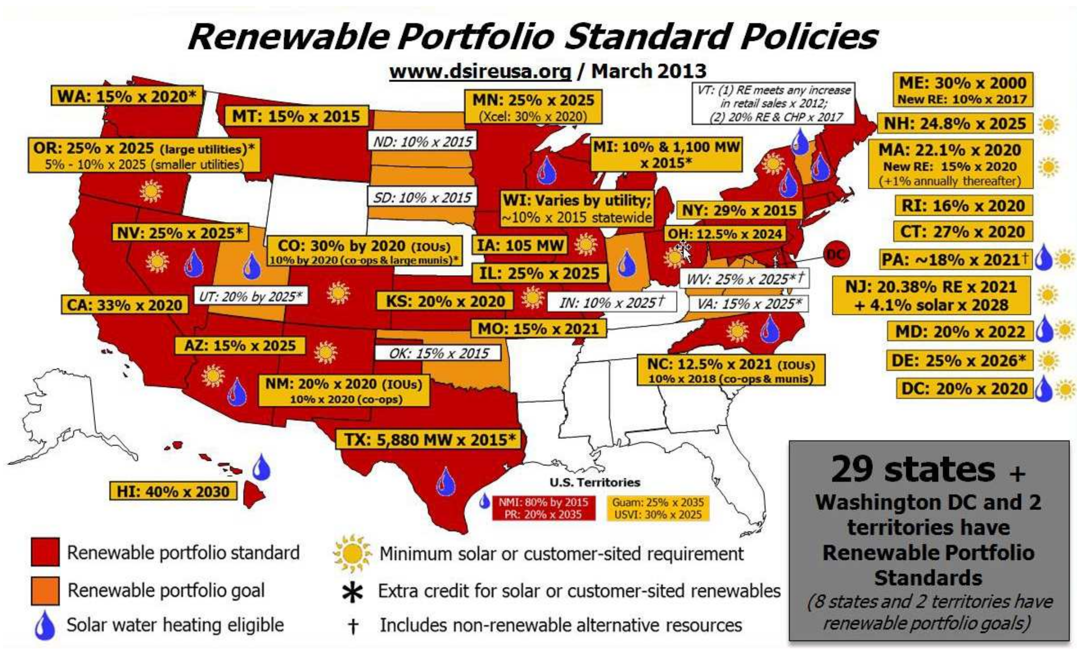
CHAPTER 3: METHODOLOGY

This chapter provides details on current renewable portfolio standards, their target goals and the design and development of the dependent variables representing measures of RPS target level strength. The first section focuses on the primary unit of analysis; U.S. states with an RPS in effect and describes policy origins, the state of renewable portfolio standards and their current target levels. A second section introduces the dependent variable: RPS target level and describes some of the previous methods researchers have employed to measure it and the methods that were employed in this study to provide meaningful, distinct measures of RPS target level. Independent variables that were utilized in this study are described in the third section in terms of how they were chosen and developed to represent measures of the degree of state regulation, infrastructural barriers, citizen and governmental ideology, state internal determinants and regional diffusion. The fourth section describes data sources utilized for this study which included multiple governmental, institutional and private sources. A fifth and a final section introduces and describes the statistical models that were utilized in this study and traces their development in terms of the key factors identified in the empirical literature, existent research gaps and controversies and describes how they were utilized to test the hypotheses. This final section was divided into two parts: the first describing the multivariate regression model and a second describing geospatial autocorrelation models.

3.1 Primary Unit of Analysis

The primary unit of analysis for this study was all U.S. States that had an RPS in effect or a specified target RE goal. At the time of analysis, data from the 2013 Database of State Incentives for Renewables and Efficiency (DSIRE) indicated that a total of 29 states had an RPS and 8 states had an established RE goal. The resultant total of 37 states were further analyzed and it was decided the states of Texas and Iowa from the data set because their RPS target levels were measured in total MW of RE capacity and not as a percentage RE goal. In addition, Texas and Iowa were among the very earliest states to enact an RPS, have met their established RPS targets and to date have not revised their standards to reflect future dates and target percentage goals. In addition, the state of Maine was removed from the data set because it proved to be an outlier in terms of its high percentage of existing RE capacity and correspondingly low RPS target goal which had been easily exceeded long before its intended target date. It should be noted that a number of U.S. southern states did not have an RPS enacted or RE goal. These states included Kentucky, Tennessee, Arkansas, Louisiana, Alabama, Mississippi, Georgia, Florida and South Carolina. This noticeably large geographic gap in RPS and RE initiatives may be partially due to the existence of the federally-owned Tennessee Valley Authority (TVA) Corporation which provides power to Kentucky, Tennessee, Alabama, Mississippi, Georgia, North Carolina and Virginia. Finally, the state of Hawaii was not included in the regional diffusion analyses because it did not border any other U.S. state and therefore would not render a diffusion effect on other states.

A map of U.S. states and RPS targets is provided in Figure 2. A summary of state renewable portfolio standards and their associated enactment dates and originating legislative action is provided in Table 5 and RPS target levels and target dates are summarized in Table 6. In addition, eight U.S. states and two U.S. Territories have set goals of having a certain percentage of renewable energy generation capacity by a specified date and are summarized in Table 7. Figure 3 provides a color-coded U.S. State map indicating the number of years each state's RPS has been in effect.



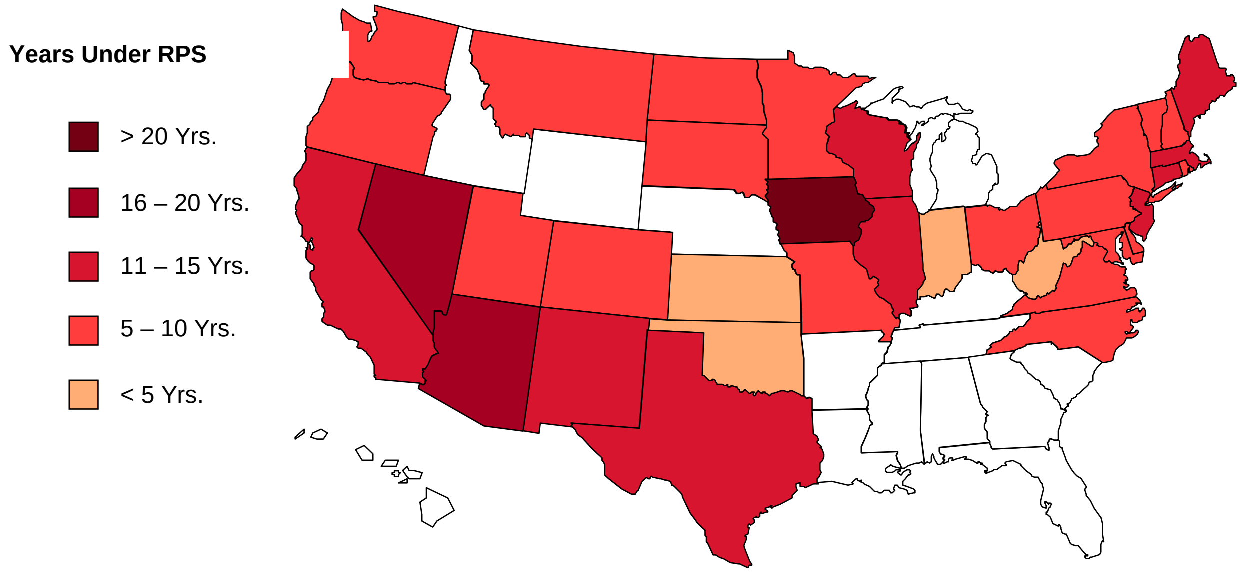
Source: Database of State Incentives for Renewables & Efficiency, (DSIRE)
http://www.dsireusa.org

Figure 2. U.S. State Renewable Portfolio Standards.

Table 5 *U.S. State RPS Goals and Legislative Origins*

State	Policy Enacted	State Legislative Action
Arizona	1996	ACC Ruling
California	2002	CA Public Utilities Code § 399.11 et seq.
Colorado	2004	CRS 40-2-124
Connecticut	1998	CT. Gen. Stat. § 16-245a et seq.
Delaware	2005	S.B. 74
District of Columbia	2005	DC. Code § 34-1431 et seq.
Hawaii	2001	HRS § 269-91 et seq.
Illinois	2001	20 ILCS 688/
Iowa	1983	IA Code § 476.41 et seq.
Kansas	2009	KS Statute 66-1256
Maine	1999	M.R.S. 35-A § 3210
Maryland	2004	MD. PUC Code § 7-701 et seq.
Massachusetts	2002	M.G.L. ch. 25A, § 11F
Michigan	2008	MCL § 460.1001 et seq.
Minnesota	2007	MN. Stat. § 216B.1691
Missouri	2007	S.B. 54
Montana	2005	MCA 69-3-2001 et seq.
Nevada	1997	NRS 704.7801 et seq.
New Hampshire	2007	NH. Statutes, Chapter 362-F
New Jersey	1999	NJ. Stat. § 48:3-49 et seq.
New Mexico	2002	NM PRC
New York	2004	NY PSC Order, Case 03-E-0188
North Carolina	2007	S.B. 3
Ohio	2008	S.B. 221
Oregon	2007	S.B. 838
Pennsylvania	2004	S.B. 1030
Rhode Island	2004	RI. Gen. Laws § 39-26-4
Texas	1999	TX Utilities Code § 39.904
Washington	2006	Initiative 937
Wisconsin	1999	Act 204
Indiana	2011	S.B. 251
North Dakota	2007	H.B. 1506
Oklahoma	2010	H.B. 3028
South Dakota	2008	H.B. 1123
Utah	2008	S.B. 202
Vermont	2005	Title 30 V.S.A. § 8004
Virginia	2007	VA. Code § 56-585.2
West Virginia	2009	WV. Code §24-2F-1 et seq.

Source: Database of State Incentives for Renewables & Efficiency, (DSIRE)



Derived from data from the Database of State Incentives for Renewables & Efficiency (DSIRE) http://www.dsireusa.org

Figure 3. U.S. State Renewable Portfolio Standards and Goals by Policy Duration

Table 6

U.S. States with Renewable Portfolio Standards

State	RPS Start Year	RPS Target	RPS Mandate	RPS Target Year
Arizona	2006	15%		2025
California	2004	33%		2020
Colorado	2007	30%		2020
Connecticut	2006	27%		2020
Delaware	2008	25%		2026
D. of C.	2007	20%		2020
Hawaii	2010	40%		2030
Illinois	2008	25%		2025
Iowa	1983		105MW	2000
Kansas	2011	20%		2020
Maine	2000	10%		2017
Maryland	2006	20%		2022
Massachusetts	2004	22.1%		2020
Michigan	2012	10%	1100MW	2015
Minnesota	2010	25%		2025
Missouri	2011	15%		2021
Montana	2008	15%		2015
Nevada	2005	25%		2025
New Hampshire	2008	23.8%		2025
New Jersey	2005	20.38%		2021
New Mexico	2006	20%		2020
New York	2003	29%		2015
North Carolina	2010	12.5%		2021
Ohio	2009	25%		2025
Oregon	2011	25%		2025
Pennsylvania	2007	18%		2021
Rhode Island	2007	16%		2020
Texas	2006		5880MW	2015
Washington	2012	15%		2020
Wisconsin	2006	10%		2015

Source: Database of State Incentives for Renewables & Efficiency (DSIRE) http://www.dsireusa.org

Table 7

U.S. States with Renewable Energy Goals

State	Goal	Year
Indiana	10%	2025
North Dakota	10%	2015
Oklahoma	15%	2015
South Dakota	10%	2015
Utah	20%	2025
Vermont	20%	2017
Virginia	15%	2025
West Virginia	25%	2025

Source: Database of State Incentives for Renewables & Efficiency (DSIRE) http://www.dsireusa.org

3.2 Dependent Variables

A multi-state database of renewable portfolio standards and their design characteristics and metrics was developed for this study. Three dependent variables were calculated using this data to represent distinct measures of each state's RPS target level. The first method of representing target level designated as "DV1" utilized a ratio proposed by Yin and Powers (2010) that included factors representing RPS target, total retail electricity sales and existing renewable energy capacity and is considered to be representative of target level of ambition or effort. The second method designated as "DV2" utilized Carley & Miller's (2012) measure of target percentage per year metric which included RPS target, policy duration and RPS coverage parameters. This provided a measurement of target percentage per year that included policy coverage factors. The third method of representing RPS target level designated as "DV3" was a more concise measurement of target percentage per year comprised only of RPS target goals and policy duration. This third measure was intended to reflect the absolute target level originally intended by policymakers. All three dependent variables were constructed using data from the Database of State Incentives for Renewables & Efficiency (DSIRE) from which of a total of 353 state RPS year/target observations were drawn.

3.21 Operationalizing RPS Target Level

The dependent variables utilized in this study were intended to represent three distinct measurements RPS target level stringency. The majority of state renewable portfolio standards define a target percentage goal of RE generation and a graduated series of target levels corresponding to a series of future milestone dates. Previous researchers have quantified RPS stringency in differing ways. In their study of renewable portfolio standards in 16 U.S. States, Yin and Powers (2010) measured policy stringency as an 'Incremental Requirement' variable which factored industry size, policy coverage and the amount of pre-existing RE generation prior to policy enactment into the measurement. According to Yin and Powers (2010), this method of measuring policy stringency accounted for policy heterogeneity in terms of coverage exemptions (e.g. exemptions for some load serving entities) and existing capacity (e.g. allowing existing generation infrastructure to fulfill the RPS requirement). (p. 1142). Their equation for RPS stringency was as follows:

$$\text{INCREMENTAL SHARE}_{it} = \frac{\text{GOAL}_{it} \times \text{COVERAGE}_{it} \times \text{SALES}_{it} - \text{EXISTING}_{it}}{\text{SALES}_{it}}$$

In Yin and Powers (2010) equation, GOAL_{it} was the RPS nominal requirement or percentage target level in a given state *i* during time span *t*, COVERAGE_{it} was the fraction of electricity sales in state *i* covered by the RPS during time span *t*, SALES_{it} was the total retail electricity sales in state *i* during time span *t*, and EXISTING_{it} was the renewable capacity that if generated in the future could satisfy the state RPS requirement during time span *t*. (Yin & Powers, 2010, p. 1142). Their approach ultimately produced a ratio that reflected the mandated increase in renewable generation in terms of the percentage of all generation (Yin & Powers, 2010, p. 1142). Yin and Powers (2010) felt that their measurement technique was a strong indicator of the magnitude of the incentive provided by an RPS because it accounted for several key RPS design features that impact RPS strength and could better differentiate between aggressive policies with weak incentives and seemingly moderate policies that are actually quite ambitious (p. 1149). The authors ultimately found that the presence of an RPS had a significant and positive effect on in-state renewable energy development.

An alternative method of measuring policy target level stringency was employed by Carley & Miller (2012) who examined renewable portfolio standards in 32 U.S. States and measured stringency as the rate of change in RE generation target level per time required by the RPS adjusted by the share of a state's electrical load covered by the RPS. The authors calculated RPS 'Stringency' as a target level percentage change per unit year which was obtained by subtracting the starting year mandated percent target level from the ending year percent target level and dividing this by the total duration of policy target levels, (RPS target goal end date minus RPS target goal start date), according to the following formula:

$$\text{STRINGENCY} = \frac{\text{Mandated Goal}_{final} - \text{Mandated Goal}_{start}}{\text{Year}_{final} - \text{Year}_{start}} * \text{RPS\_Coverage}$$

In their equation Mandated Goal $_{final}$ was the mandated RPS percentage target level at the policy final year, and Mandated Goal $_{start}$ was the mandated RPS percentage target level at the policy start year. In addition, Year $_{start}$ and Year $_{final}$ were the respective start and final years for RPS set targets and RPS_Coverage was the percentage of the state's electrical load actually covered by the RPS regulation. Their formula ultimately produced a measurement of policy target level strength expressed in percentage goal change per unit time. Using this approach, Carley & Miller (2012) ultimately found that policies of different stringencies are motivated by systematically different underlying factors.

In this study RPS target level strength or stringency was measured using three methods. The first method utilized was a modified version of Yin & Powers (2010) approach that takes into account existing RE capacity and hence provided a stringency measure that was representative of the level of effort necessary to reach an RPS target. According to Carley & Miller (2012), the approach used by Yin and Powers that calculated RE capacity in each policy year, introduced questions of reliability because it produced a target level stringency measure that differed from year to year while the underlying policy remained the same (p. 739). For this reason Yin & Powers' formula was modified to account for existing RE capacity in a manner that captures policy mandated target level change and policy duration along with the RPS coverage factor. This modified 'Incremental Share' measurement utilized the following formula:

$$DV1\_LVL\_OF\_EFF_{it} = \frac{\text{Mandated Goal }\%_{FINAL\ it} - \text{Existing RE }\%}{\text{Year}_{FINAL\ it} - \text{Year}_{START}} * \text{RPS\_Coverage}$$

Mandated Goal $_{FINAL\ it}$ = RPS final percentage target goal (*state i, time t*)

RPS_Coverage = Percentage of state's electrical load covered by RPS

EXISTING RE % = Percentage of existing RE capacity at start year

Year $_{FINAL\ it}$ = Final year of RPS set goal (*state i, time t*)

Year $_{START}$ = First year of RPS set goal

This modified incremental share measurement of policy target level strength is intended to be representative of the level of effort or ambition required to reach the RPS target and is referred to as dependent variable "DV1".

In the calculation of the percentage amount of existing RE it is important to consider data origins and unit factors as several issues can emerge in the construction of variables measuring electric energy generated or share of energy. Shirmali et al (2012) point out that in previous econometric studies of RE supporting policies the construct of variables measuring energy supply can differ in multiple ways. First, energy supply can be measured in terms of either capacity (watts) or in terms of actual generation (watt-hours). Second, energy supply data can be drawn from U.S. Energy Information Administration (EIA) state level data or from the EIA's annual generator survey. The authors feel that the previous study by Yin and Powers that utilized a generator-level dataset from the EIA suffered from jumps in data due to changes in classification introduced in the late 1990's (p. 17). Third, the authors assert that that RE can be quantified in either absolute values or in terms of a percentage of total electricity (p. 6). With these factors in mind it is important to choose energy supply data sources that are accurate and representative of real energy produced and drawn from similar sources so that they are consistent with one another. In this study energy supply data was expressed in terms of actual capacity (watts), and was derived from the EIA's state level dataset and will be quantified in absolute values. The percentage of existing RE capacity at the start year was calculated by dividing the RE capacity by the total state capacity in watts.

The second proposed measurement of RPS target level strength was the stringency measurement developed by Carley & Miller (2012). The formula for this measurement of RPS target level strength is shown below:

$$DV2\_COV_{it} = \frac{\text{Mandated Goal \%}_{FINAL\ it} - \text{Mandated Goal \%}_{START}}{\text{Year}_{FINAL\ it} - \text{Year}_{START}} * \text{RPS\_Coverage}$$

Mandated Goal $_{FINAL\ it}$ = RPS final percentage target goal (*state i, time t*)

Mandated Goal $_{START}$ = RPS starting percentage target goal

RPS_Coverage = Percentage of state's electrical load covered by RPS

Year $_{FINAL\ it}$ = Final year of RPS set goal (*state i, time t*)

Year $_{START}$ = First year of RPS set goal

This measurement of RPS target level stringency was a measurement of policy target level strength given the quota of state generation covered by the policy that was expressed in terms of percentage target level change per unit time. This measurement was meant to represent RPS target level strength in terms of the standard's fraction of coverage of the total capacity of electricity provided by regulated energy providers. This dependent variable is henceforth referred to as "DV2".

The third method that was utilized to measure RPS target level strength was one that was similar to Carley and Miller's approach but eliminated the coverage factor. The formula for this measurement of absolute RPS target level strength is shown below:

$$\text{DV3\_TARGET\_ABSOLUTE}_{it} = \frac{\text{Mandated Goal \%}_{\text{FINAL } it} - \text{Mandated Goal \%}_{\text{START}}}{\text{Year}_{\text{FINAL } it} - \text{Year}_{\text{START}}}$$

Mandated Goal $_{\text{FINAL } it}$ = RPS final percentage target goal (*state i, time t*)

Mandated Goal $_{\text{START}}$ = RPS starting percentage target goal

Year $_{\text{FINAL } it}$ = Final year of RPS set goal (*state i, time t*)

Year $_{\text{START}}$ = First year of RPS set goal

This measurement of RPS target level stringency was absolute measurement of policy target level strength that was expressed in terms of percentage target level change per unit time. This measurement was intended to be one that reflects the quantitative target level originally intended by state policymakers at the time of policy design, development and inception in terms of a target percentage goal and target year. This dependent variable is referred to as "DV3" in this study.

The three RPS target level strength indices described above provided distinct measures of the strength of each state's RPS that reflected level of effort or a more actual measure of the RE capacity required to meet the RPS target goal, a measure of RPS target strength by policy coverage and an absolute measure of RPS target level strength in terms of a target percentage goal and target year. Table 8 provides a current summary of U.S. states and the relative policy target level indices of their RPS or state RE goal. In addition, Figures 4, 5 and 6. below depict maps showing the relative target level indices of renewable portfolio standards by U.S. State. Bar charts are also provided in figures 7, 8 and 9 that illustrate RPS target level indices by U.S. state ordered by target level.

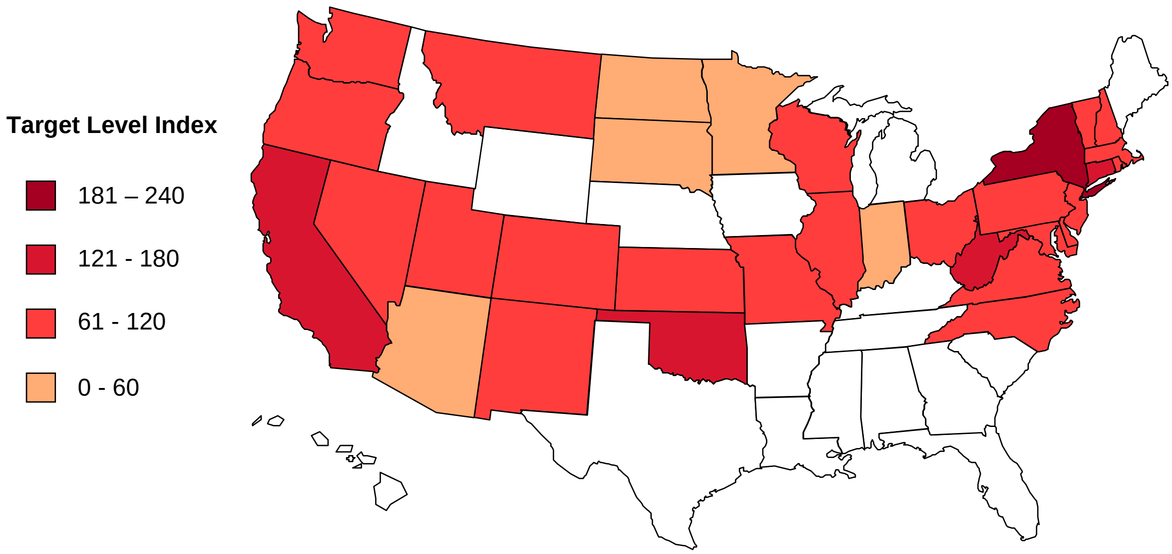
Table 8

State RPS Target Level Indices

U.S. State	RPS Target Index Level of Effort Yin & Powers (2010)	RPS Target Level Index* With Coverage Carley & Miller (2012)	RPS Target Level Index* No Coverage or Initial RE Absolute Target Level
AZ	46.07	42.41	72.37
CA	146.66	116.61	118.75
CO	95.74	121.92	207.69
CT	165.74	146.77	157.14
DC	153.85	123.08	123.08
DE	96.99	89.44	127.78
HI	138.01	150.00	150.00
IL	111.85	114.71	143.75
IN	35.43	-	-
KS	108.04	90.56	111.11
MA	100.57	106.74	124.12
MD	110.82	96.32	103.13
MI	276.02	173.33	173.33
MN	39.04	31.87	66.67
MO	99.32	91.00	130.00
MT	93.43	92.00	142.86
NC	95.93	77.27	77.27
ND	28.51	-	-
NH	104.62	103.98	105.89
NJ	118.20	105.24	107.06
NM	63.14	72.54	107.14
NV	100.89	83.79	95.00
NY	215.45	67.76	80.00
OH	71.81	72.36	81.67
OK	152.25	-	-
OR	87.31	106.57	142.86
PA	111.73	85.49	87.86
RI	111.93	99.30	100.00
SD	54.06	-	-
UT	112.95	-	-
VA	69.10	-	-
VT	99.03	-	-
WA	114.32	127.05	150.00
WI	88.30	71.56	71.56
WV	143.64	-	-

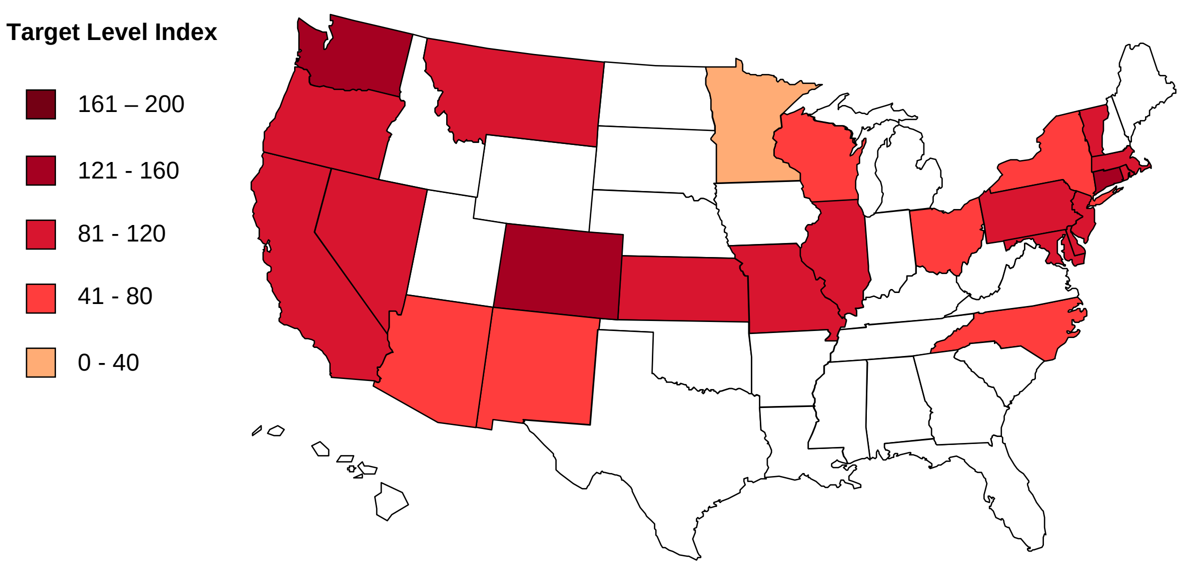
Derived from raw data from DSIRE
Database of State Incentives for Renewables & Efficiency
http://www.dsireusa.org

* Note: States with RE Goals not Included



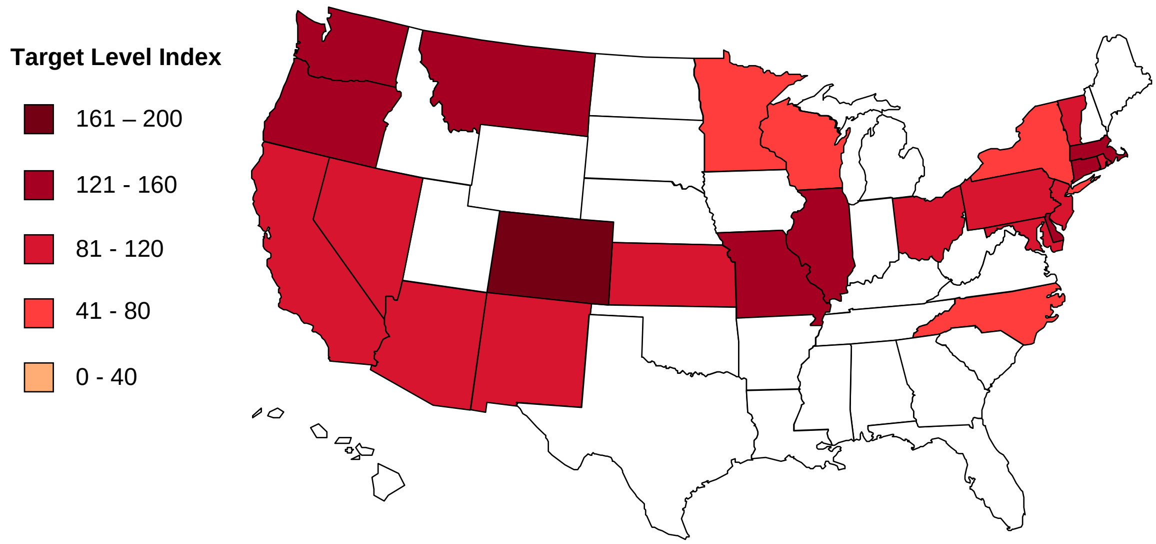
Derived from data from the Database of State Incentives for Renewables & Efficiency (DSIRE)
http://www.dsireusa.org

Figure 4. U.S. State RPS Target Level Index Map - DV1



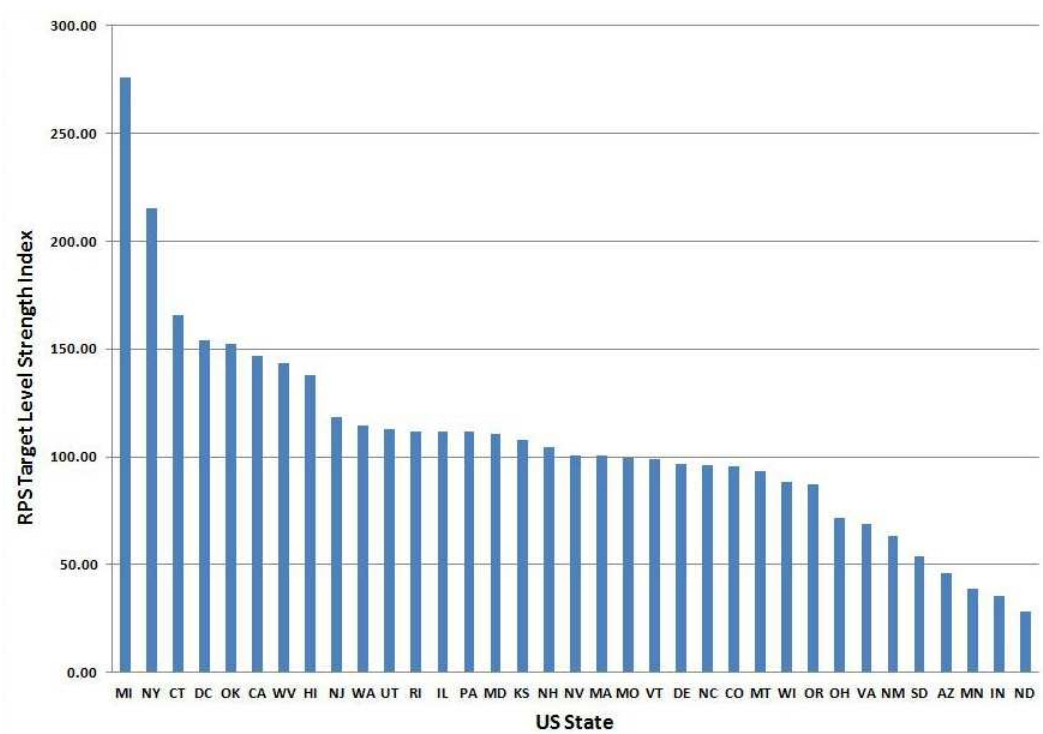
Derived from data from the Database of State Incentives for Renewables & Efficiency (DSIRE)
http://www.dsireusa.org

Figure 5. U.S. State RPS Target Level Index Map - DV2



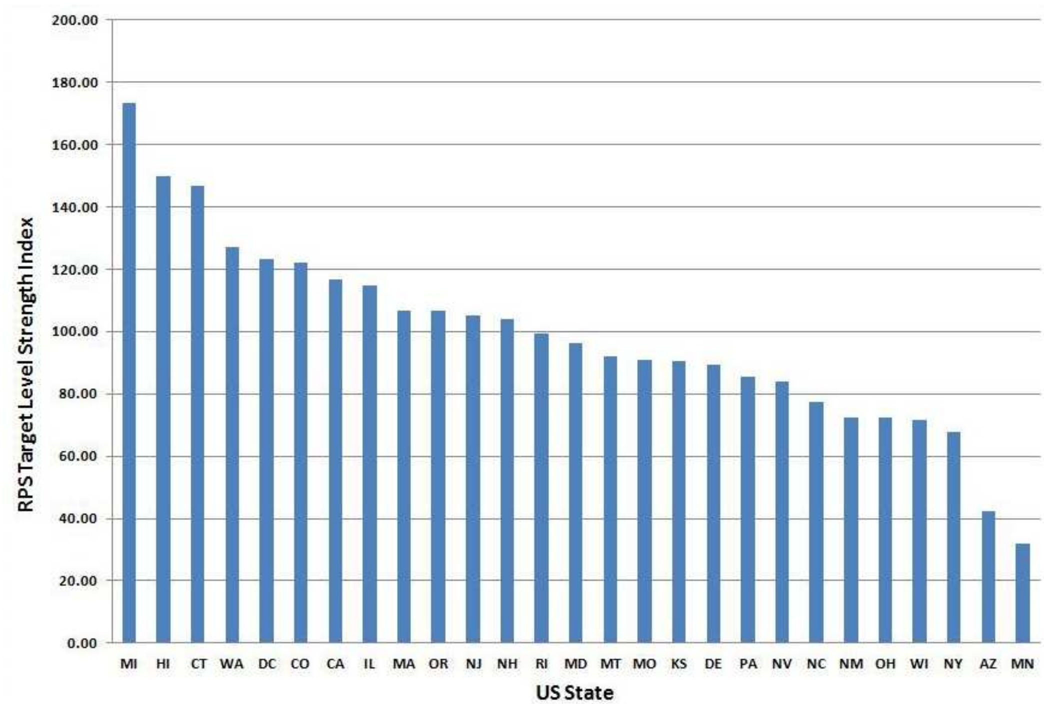
Derived from data from the Database of State Incentives for Renewables & Efficiency (DSIRE) http://www.dsireusa.org

Figure 6. U.S. State RPS Target Level Index Map - DV3



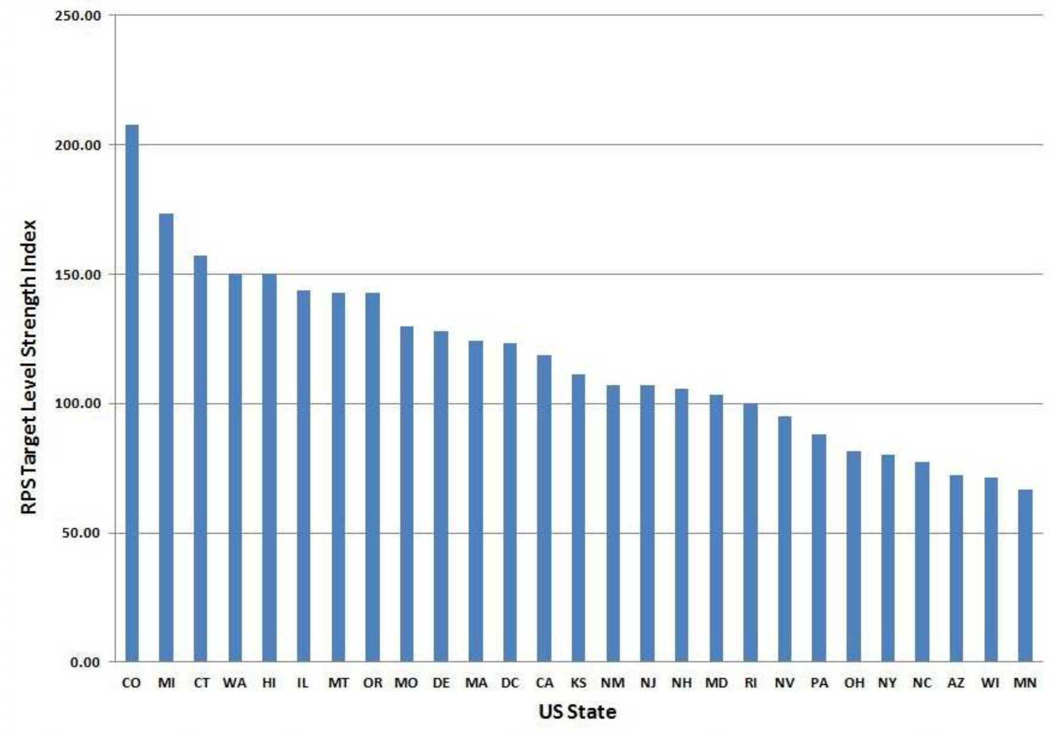
Derived from data from the Database of State Incentives for Renewables & Efficiency (DSIRE) http://www.dsireusa.org

Figure 7. U.S. State RPS Target Levels - DV1



Derived from data from the Database of State Incentives for Renewables & Efficiency (DSIRE) http://www.dsireusa.org

Figure 8. U.S. State RPS Target Levels - DV2



Derived from data from the Database of State Incentives for Renewables & Efficiency (DSIRE)
http://www.dsireusa.org

Figure 9. U.S. State RPS Target Levels - DV3

3.3 Independent Variables

This section describes the independent variables that were utilized in this study. Independent variables were chosen and developed to represent measures of the degree of state regulation, infrastructural barriers, citizen and governmental ideology and state internal determinants. In some cases variables were modified to control for state size, population and total electrical system capacity. A separate set of independent variables were constructed for the tests for regional diffusion and geospatial diffusion analyses that measured the degree of inter-state competition. The following sections describes the assumptions, development and construction of each of the independent variables groupings.

Independent variables representing state regulatory factors or the magnitude of state governmental regulation included the total number of public utility commission staff in each state and the total number of regulated state electricity providers. It was thought that these metrics would best represent the degree of regulation of electricity providers since all public electric utilities, cooperatives and investor-owned electric utilities are regulated by the state commission. Two additional independent variables were developed from existing variables to control for the size of a state's electric system. State regulatory staff per Megawatt (MW) and the number of electricity providers per Megawatt were developed by dividing total state commission staff and the number of state regulated energy providers by the total Megawatts of system capacity in each state. These two variable provided improved measures of state utility regulation which were independent of the size of the electric system. The independent variable selected to represent state regulation in the final model was state regulatory staff per Megawatt .

The analysis of the effect of state political ideology on RPS target levels utilized one independent variable representing citizen ideology and two variables representing state government ideology measures originally conceived and developed by Berry et al. (1998). According to Berry et al. (1998), these measures were constructed using the roll call voting scores of state congressional delegations, the outcomes of congressional elections, the partisan division of state legislatures, the political party of the state governor and multiple assumptions regarding voters, interest groups and state political elites (p. 327). According to Berry et al. (1998), the first ideology variable representing citizen ideology was developed by using the ideological positions of members of congress based on interest group ratings (p. 330). The interest group ratings that were used were those reported annually by Congressional Quarterly and included scores from Americans for Democratic Action (ADA) and the AFL-CIO Committee on Political Education (COPE). This variable measured citizen ideology in each district by utilizing ideological scores for congressional incumbents, estimated scores for challengers to incumbents and election results to reflect ideological division in the electorate (p. 331). These ideological scores were then used to create an un-weighted average measure of citizen ideology for each state. To measure government ideology, Berry et al. (1998) utilized ideology scores for the state governor and the major party delegations in each house of the state legislature utilizing the same ADA/COPE interest group scores (p. 332). Berry et al. (2010) developed a second government ideology measure which utilized Poole's (1998) common space coordinates derived from a comprehensive list of roll call votes on congress (p. 120). The authors differentiated between these measures of governmental ideology that utilized interest group scores and congressional roll call voting records by designating them as the "ADA/COPE" and "Nominate" government ideology measures. In order to control for the temporal effects in this study, the values utilized for each the three political ideology variables were averaged to coincide with a 2005-2010 timeframe. The independent variable ultimately selected to represent state political ideology in the final model was the ADA/COPE government ideology index.

The independent variables representing infrastructure were chosen to represent the barriers known to inhibit renewable energy development and deployment efforts. These variables included the state's available high voltage transmission line infrastructure and its total net electricity generation capacity. The variables representing state high voltage transmission line circuit miles covered two transmission voltage ranges: 132kV and above and 22kV and above. Two additional transmission line infrastructure variables were developed to control for state geographic size. These variables were representative of state transmission line density in circuit miles per square mile and were developed using known state area information by dividing the total circuit miles of transmission lines by state area. In addition, state net total electricity generation capacity in Megawatts and state peak summer capacity in Megawatt-Hours factors were utilized to represent total state electric system capacity. The independent variable chosen to represent infrastructure in the final model was the state 132kV transmission line density.

Independent variables representing state internal determinants utilized the aforementioned regulatory, infrastructural and political ideological variables in addition to a set of geographic and economic factors. The geographic factors included state population, state geographic area in square miles and state population density (persons per square mile). In addition to these factors, a fourth variable was included to represent each state's natural endowment of renewable energy in the form of net renewable energy resource potential capacity for each state in Megawatts. Economic factors utilized as internal determinants included state average personal income, state current dollar gross domestic product (GDP) and the state average price of electricity in cents per kilowatt-hour (kWh). The two independent variables were ultimately selected to represent state internal determinants in the final model were RE potential capacity and the state average electricity price.

Independent variables for the diffusion analyses were measures of the degree of inter-state competition and included the fraction of bordering states of each sample state with the same or higher RPS target level and the fraction of bordering states of each sample state with the same or higher amount of renewable energy capacity deployed on their electric system grid. These two factors provided an indication of the presence of policy diffusion in the form of interstate competition and/or emulation. These independent variable were developed for each distinct dependent variable measures of RPS target level. These variables were also developed for the two levels of state interaction: nearest neighbors (NN) and nearest neighbors of nearest neighbors (NNNN), a measure intended to measure regional diffusion. Table 9 illustrates the diffusion models structure in terms of each subject state and their accompanying state that they share a border with. Second level state "Neighbors of Neighbors" are summarized in Table 10.

Table 9

Diffusion Model Structure: U.S. States and Bordering States

U.S. State	No. of Border States	Immediate Bordering States
AZ	5	UT,CO,NM,CA,NV
CA	4	OR,NV,AZ
CO	7	WY,NE,KS,OK,NM,AZ,UT
CT	3	MA,RI,NY
DC	2	MD,VA
DE	3	PA,NJ,MD
IL	5	WI,IN,KY,MO,IA
IN	4	MI,OH,KY,IL
KS	4	NE,MO,OK,CO
MA	5	NH,RI,CT,NY,VT
MD	5	PA,DE,DC,VA,WV
MI	3	OH,IN,WI
MN	4	WI,IA,SD,ND
MO	8	IA,IL,KY,TN,AR,OK,KS,NE
MT	4	ND,SD,WY,ID
NC	4	VA,SC,GA,TN
ND	3	MN,SD,MT
NH	3	ME,MA,VT
NJ	3	NY,DE,PA
NM	5	CO,OK,TX,AZ,UT
NV	5	ID,UT,AZ,CA,OR
NY	5	VT,MA,CT,NJ,PA
OH	5	PA,WV,KY,IN,MI
OK	6	KS,MO,AR,TX,NM,CO
OR	4	WA,ID,NV,CA
PA	6	NY,NJ,DE,MD,WV,OH
RI	2	MA,CT
SD	6	ND,MN,IA,NE,WY,MT
UT	6	ID,WY,CO,NM,AZ,NV
VA	6	MD,DC,NC,TN,KY,WV
VT	3	NH,MA,NY
WA	3	ID,OR
WI	4	MI,IL,IA,MN
WV	5	PA,MD,VA,KY,OH

Table 10

Diffusion Model Structure: U.S. States and First and Second Level Bordering States

U.S. State	No. of States	First and Second Level Bordering States
AZ	12	UT,CO,NM,CA,NV,ID,WY,NE,KS,OK,TX,OR
CA	8	OR,NV,AZ,WA,ID,UT,CO,NM
CO	18	WY,NE,KS,OK,NM,AZ,UT,MT,ND,SD,ID,IA,MO,AR,TX,AZ,CA,NV
CT	7	MA,RI,NY,NH,VT,NJ,PA
DC	8	MD,VA,PA,DE,NC,TN,KY,WV
DE	8	PA,NJ,MD,NY,OH,DC,VA,WV
IL	16	WI,IN,KY,MO,IA,MI,MN,OH,WV,VA,TN,AR,OK,KS,NE,SD
IN	11	MI,OH,KY,IL,WI,PA,WV,VA,TN,MO,IA
KS	15	NE,MO,OK,CO,SD,IA,WY,IL,KY,TN,AR,TX,NM,AZ,UT
MA	8	NH,RI,CT,NY,VT,ME,NJ,PA
MD	11	PA,DE,DC,VA,WV,NY,NJ,OH,NC,TN,KY
MI	9	OH,IN,WI,PA,WV,KY,IL,IA,MN
MN	7	WI,IA,SD,ND,MI,IL,IA,
MO	25	IA,IL,KY,TN,AR,OK,KS,NE,MN,WI,SD,IN,OH,WV,VA,NC,GA,AL,MS,LA,TX,NM,CO,NE,WY
MT	12	ND,SD,WY,ID,MN,IA,NE,CO,UT,WA,OR,NV
NC	13	VA,SC,GA,TN,MD,DC,KY,WV,FL,AL,MS,AR,MO
ND	8	MN,SD,MT,WI,IA,NE,WY,ID
NH	6	ME,MA,VT,RI,CT,NY
NJ	9	NY,DE,PA,VT,MA,CT,MD,WV,OH
NM	14	CO,OK,TX,AZ,WY,NE,KS,UT,MO,AR,LA,CA,NV,ID
NV	10	ID,UT,AZ,CA,OR,WA,WY,MT,CO,NM
NY	11	VT,MA,CT,NJ,PA,NH,RI,DE,MD,WV,OH
OH	14	PA,WV,KY,IN,MI,NY,NJ,DE,MD,VA,IL,TN,MO,WI
OK	16	KS,MO,AR,TX,NM,CO,NE,IA,IL,KY,TN,MS,LA,WY,AZ,UT
OR	8	WA,ID,NV,CA,UT,WY,MT,AZ
PA	14	NY,NJ,DE,MD,WV,OH,VT,MA,CT,DC,VA,KY,IN,MI
RI	5	MA,CT,NH,NY,VT
SD	13	ND,MN,IA,NE,WY,MT,WI,IL,MO,KS,CO,UT,ID
UT	15	ID,WY,CO,NM,AZ,NV,WA,OR,MT,SD,NE,KS,OK,TX,CA
VA	17	MD,DC,NC,TN,KY,WV,PA,DE,SC,GA,AL,MS,AR,MO,IL,IN,OH
VT	8	NH,MA,NY,ME,RI,CT,NJ,PA
WA	7	ID,OR,NV,UT,WY,MT,CA
WI	11	MI,IL,IA,MN,OH,IN,KY,MO,NE,SD,ND
WV	15	PA,MD,VA,KY,OH,NY,NJ,DE,DC,NC,TN,IL,IN,MO,MI

3.4 Data Sources

For this study data was drawn from a variety of sources which included federal governmental agencies, private agencies and academic institutions. For the development of the dependent variables, current state renewable portfolio standard data was obtained from the Database of State Incentives for Renewables & Efficiency (DSIRE) which is currently operated by the North Carolina Solar Center at North Carolina State University. The DSIRE database included data for every U.S. state with an RPS in effect or an RE target goal and covered the time span from 2000-2030. The data consisted of the following metrics for each state RPS: fraction of load covered, start year, end year, start year target percentage, end year target percentage and a series of yearly fractional RPS target percentages.

To construct the dataset for this study a total of 353 state RPS year/target observations were utilized which covered the time span of 2003-2030 and included 35 U.S. states. In the case of states with no RPS, but with an RE goal the starting and ending RE target percentages were used. This raw data was next utilized to construct the dependent variable target index observations that were representative of the dependent variables DV1, DV2 and DV3 described earlier in this chapter. Since this study examined state renewable portfolio standards with different developmental timelines, efforts were made to control for temporal effects. In cases where independent variable data was not available for individual state RPS year/target observations, values were either projected for or existing data was averaged over the appropriate time span.

Data for independent variables representing geographic, economic, regulatory, infrastructural and political factors were drawn from multiple governmental and private sources. State geographical data was obtained from the U.S. census bureau and consisted of state populations and state areas in square miles. A subsequent geographic factor of state population density (persons/square mile) was calculated using these two figures. State renewable potential capacity data was obtained from the National Renewable Energy Laboratory (NREL) the U.S. Department of Energy's primary national laboratory for renewable energy and energy efficiency research and development. The economic data, namely state current dollar and real gross domestic product (GDP) and state personal income was obtained from regional data reports produced by the Bureau of Economic Analysis (BEA) which is part of the U.S. Department of Commerce. Current average price of electricity (cents/kWh) for each state was obtained from the Energy Information Administration (EIA). State regulatory commission data which included the staffing levels of each state public utility regulatory commission and the number of regulated electric utilities in each state were obtained from the National Association or Regulatory Utility Commissioners (NARUC) data, a national association representing U.S. State Public Service Commissioners. This regulatory commission data was augmented with two additional variables which accounted controlled for state size by dividing staff level and regulated electric utilities totals by each state's population. Electric system infrastructural data, namely each state's total circuit miles of transmission lines by voltage was obtained from the Edison Electric Institute (EEI) annual yearbooks and state net power generation output (MWh) and net summer capacity (MW) was be obtained from the Energy Information Administration (EIA) which is the information repository for the U.S. Department of Energy (DOE). Two additional infrastructural variables representing transmission line density (circuit miles/square mile) were developed utilizing this data and state geographical area data. Finally, the three variables representing State political ideology were represented by one state citizen ideology and two government ideology measures conceived and developed by Berry et al. (1998) and subsequently refined by Berry et al. (2010). The state citizen and government ideology data was obtained from Richard C. Fording, one of the original authors, who has maintained a dataset of updated measures of citizen and government state ideology data from 1960-2010 and has made it available to the public domain. A summary of independent variables and their data sources are listed by group in Table 11 below. The descriptive statistics for each of the independent variables used in this study are provided in Table 12.

Table 11

Independent Variables by Group and Data Sources

Variable Group	Variable	Description, (Units), (Data Source)
Geographical	GEO-POP	State Population, (Persons), (U.S. Census 2010)
	GEO_AREA	State Area, (Sq.Mi), (U.S. Census 2010)
	GEO_POPDENS	State Population Density, (Persons/Sq.Mi)
	GEO_REPOTCAP	State RE Potential Capacity, (MW), (NREL)
Economic	ECO_PRSINC	State Avg. Personal Income 2005-2010, ($), (BEA)
	ECO_CD_GDP	State Avg. Current Dollar GDP 2005-2010, ($), (BEA)
	ECO_RL_GDP	State Avg. Real GDP 2005-2010, ($), (BEA)
	ECO_AREP	State Avg. Price of Electricity, (cents/kWh), (EIA)
Regulatory	REG_STAFF	State Total Public Utility Commission Staff, (NARUC)
	REG_PRVRS	Number of State Regulated Energy Providers, (NARUC)
	REG_STAFF_MW	State Total Public Utility Commission Staff, (Staff/MW)
	REG_PRVR_MW	State Regulated Energy Providers, (Providers/MW)
	REG_YRS_RPS	Years State RPS has been in Effect, (Yrs.), (DSIRE)
Infrastructure	INFRA_SUMCAP	State Electric System Net Summer Capacity, (MW), (EIA)
	INFRA_NETGEN	State Electric System Net Generation, (MWh), (EIA)
	INFRA_TL_132	State Circuit Mi. of HV Trans. Lines >132kV, (Mi.), (EEI)
	INFRA_TL_22	State Circuit Mi. of HV Trans. Lines >22kV, (Mi.), (EEI)
	INFRA_132DENS	State HV Trans. Line >132kV Density, (Mi./Sq.Mi.)
	INFRA_22DENS	State HV Trans. Line >22kV Density, (Mi./Sq.Mi.)
Ideological	IDEOL _CITI	Citizen Ideology Measure, (R.C. Fording Data)
	IDEOL_GOVT_ADA	Gov't Ideology - ADA Measure, (R.C. Fording Dataset)
	IDEOL_GOVT_NOM	Gov't Ideology - NOM Measure, (R.C. Fording Dataset)
Diffusion	DIFF_HITGT_DV1	Border States with ≥ Target Level
	DIFF_HITGT_DV2	Border States with ≥ Target Level
	DIFF_HITGT_DV3	Border States with ≥ Target Level
	DIFF_TGT_REG_DV1	Regional (Bordering Border) States with ≥ Target Level
	DIFF_TGT_REG_DV2	Regional (Bordering Border) States with ≥ Target Level
	DIFF_TGT_REG_DV3	Regional (Bordering Border) States with ≥ Target Level
	DIFF_HITGT_RE_POT	Immediate Border States with ≥ RE Capacity
	DIFF_TGT_REG_POT	Regional (Bordering Border) States with ≥ RE Capacity

Table 12

Variables and Descriptive Statistics

Variable Name	Description	Mean	Std Dev.	Min	Max
Dependent Variables					
DV1 Level of Effort	RPS Target Level (Level of Effort)	107.45	48.71	28.51	276.02
DV2 Target Goal Level	RPS Target Level (Coverage)	98.51	31.04	31.87	173.33
DV3 Target Goal Level	RPS Target Level (Absolute)	116.96	34.29	66.67	207.69
Independent Variables					
GEO_POP	State Population (Persons)	6158896	6926742	601723	3.73e+07
GEO_AREA	State Area (Sq. Mi)	55486.96	42971.15	61	155779.2
GEO_POPDENS	Population Density (Persons/Sq. Mi)	517.54	1653.14	6.8	9864.31
GEO_RE_POTCAP	State RE Potential Capacity (MW)	6445903	5754630	773	1.92e+07
ECO_PRSINC	State Avg. Personal Income ($)	268527	316762.8	26294	1674899
ECO_CD_GDP	State Avg. Current Dollar GDP ($)	292548	351927	24451	1877857
ECO_RL_GDP	State Avg. Real Dollar GDP ($)	272146	326131.9	23140	1731848
ECO_AREP	State Avg. Elec. Price (Cents/ kWh)	10.71	3.8705	6.66	25.12
REG_STAFF	Pub. Utility Commission Staff (Persons)	194.6	201.4609	10	940
REG_PRVRS	Number of Regulated Energy Providers	67.31	45.10822	5	179
REG_STAFF_MW	PUC Staff per Megawatt Capacity	0.0000125	0.0000571	3.55e-07	0.0003402
REG_PRVRS_MW	Providers per Megawatt Capacity	3.97e-06	0.000015	1.24e-07	0.0000901
REG_YRS_RPS	Years State has had RPS in effect	9.34	3.77	3	18
INFR_SUMCAP	System Summer Peak Capacity (MW)	18211.97	14971.29	790	67328
INFR_NETGEN	Net Total Generation Capacity (MWh)	7.18e+07	5.91e+07	199858	2.30e+08
INFR_TL_22	Circuit Miles of Trans. Lines >22kV	12511.57	9978.232	10	48313
INFR_TL_132	Circuit Miles of Trans. Lines >132kV	6064.91	5154.406	51	25887
INFR_22DENS	Transmission Lines >22kV per Sq. Mi	0.4085	0.4999	0.0676	2.9304
INFR_132DENS	Transmission Lines >132kV per Sq. Mi	0.2619	0.6567	0.0281	3.9344
IDEOL _CITI	Citizen Ideology Measure	59.97	13.90	25.31	87.27
IDEOL_GOVT_ADA	Government Ideology - ADA Measure	63.30	24.03	10.38	93.61
IDEOL_GOVT_NOM	Government Ideology - NOM Measure	57.21	19.27	13.11	82.44
Diffusion Variables					
DIFF_HI_TGT_DV1	Border States with ≥ Target Level	0.4505	0.4034	0	1
DIFF_HI_TGT_DV2	Border States with ≥ Target Level	0.4461	0.4192	0	1
DIFF_HI_TGT_DV3	Border States with ≥ Target Level	0.4045	0.4083	0	1
DIFF_HI_TGT_RE_POT	Border States with ≥ RE Capacity	0.5962	0.3481	0	1
DIFF_TGT_REG_DV1	Regional States with ≥ Target Level	0.5114	0.3340	0	1
DIFF_TGT_REG_DV2	Regional States with ≥ Target Level	0.4901	0.3547	0	1
DIFF_TGT_REG_DV3	Regional States with ≥ Target Level	0.4969	0.3521	0	1
DIFF_TGT_REG_POT	Regional States with ≥ RE Capacity	0.5110	0.3066	0	1

353 Observations

3.5 Statistical Models

3.51 Multivariate Regression (Ordinary Least Squares)

In this study the statistical models were created based on factors identified in the empirical literature and the research gaps or controversies that were found. The statistical model accounted for state level fixed effects and time level effects in a manner similar to that developed and utilized by Shrimali et al (2012). The general regression equation for the overall empirical statistical model was as follows:

$$Y = \alpha + \beta_{GEO} X_{GEO} + \beta_{ECO} X_{ECO} + \beta_{REG} X_{REG} + \beta_{INFRA} X_{INFRA} + \beta_{IDEO} X_{IDEO} + \beta_{DIFF} X_{DIFF} + S + T + \varepsilon$$

This equation describes the relationship between the dependent variable Y, which consisted of measures of RPS target level index (target/year) and six groupings of independent variable matrices. The intercept term is denoted by α and each regression coefficient and matrix of independent variables groups are denoted by β and X respectively. The six groupings if independent variable matrices and their formulaic suffix designations are: geographic (GEO), economic (ECO), regulatory (REG), infrastructural (INFRA) political ideological (IDEOL) and diffusional (DIFF). It should be noted that the geographic and economic independent variable also serve as state internal determinant measures. State level and time level effects are controlled for using S and T and ε is the error term. The independent variables developed and utilized for the nearest-neighbor regional diffusion model measuring the fraction of all neighboring states with the same or higher RPS target level (HI_TGT) and the fraction of all neighboring states with the same or higher percentage of RE capacity installed on their electricity grid (HI_RE_CAP). Diffusion variables were constructed to provide measures of two types of state interaction: one that measured immediate neighbor effects and one that included the nearest neighbors of immediate neighbors thus providing a farther-reaching measurement of regional effects.

Previous studies that investigated RPS target levels conducted by Carley & Miller (2012) and Yin & Powers (2010) utilized regression models created from DSIRE data, however since the data projects individual RPS target/year values to 2030, accompanying independent variable values must be either estimated or somehow projected for regression models. In order to mitigate potential errors in measurement that could affect the overall validity, two regression models were constructed: one with the full set of 353 target/year observations and a smaller model using 35 state observations and the overall target level indices that measured target level strength for the full duration of the RPS. An ordinary least squares (OLS) multivariate regression method was used with the larger model and multiple small sample linear regression strategies were investigated for smaller model. According to Elliott and Woodward (2007), the potential outliers associated with a small sample sizes can cause departures from normality which can jeopardize the validity of statistical tests (p. 57). Hinkle, Wiersma & Jurs (2003) claim that a small sample size can also result in increases in standard errors and an overall decrease in the power of statistical tests (p. 309). Fortunately, several statistical software packages include tools that can compensate for and correct the issues associated with small sample datasets. The STATA statistical package application offered a "Robust" standard error type option in its linear regression analyses that substitutes a robust variance matrix calculation for the conventional (OLS) calculation. According to StataCorp (2013), the robust approach uses a degree of freedom correction of n/(n-k) times the error variance to improve small sample estimates. In this study the OLS multivariate linear regression method was utilized for the both large and small models and the smaller model tests were augmented with a robust regression method. These results were then compared with the global and local geospatial approaches which are described next.

3.52 Geospatial Autocorrelation (Global and Local Tests)

The Geo-Spatial analysis portion of this study was performed in two steps: first a global geo-spatial regression analysis (Moran's I) was performed for all independent variables with RPS target level dependent variables and second, local tests of spatial autocorrelation were performed on the dependent variables and key significant independent variables to identify any local patterns of spatial association that are contributing to the global autocorrelation result. The results of the geospatial autocorrelation and multivariate regression (OLS) results were then compared in terms of their overall predictive ability. A summary of the geospatial autocorrelation models and how they were utilized in this study is provided next.

According to Anselin (2001), in standard linear regression models, spatial dependence can be incorporated in two distinct ways: as an additional regressor in the form of a spatially lagged dependent variable or in the error structure (p. 316). The spatial lag model is applicable when the primary focus of interest is in the assessment of the existence and the strength of a spatial interaction which can be interpreted as a substantive spatial dependence in the sense of being directly related to a spatial model or one that incorporates spatial interaction. (Anselin, 2001, p. 316). The general equation for the spatial lag model or mixed regressive, spatial autoregressive model introduced described by Anselin (2001) is expressed as follows:

$$y = \rho Wy + X\beta + \varepsilon$$

In this equation y represents the dependent variable, ρ is the spatial autoregressive coefficient, W is the spatial weight matrix, X is a matrix of dependent variable characteristics and ε is the error term. The primary difference between the spatial model and the ordinary least squares (OLS) regression model is the existence of "Wy" a spatially lagged dependent variable accompanied by a spatial weight matrix "W" and "ρ" its spatial autoregressive coefficient.

The spatial error model is one which attempts to model spatial dependence by utilizing the regression equation's disturbance term or spatial error term "ε". According to Anselin (2001), spatial dependence in the error term is referred to as a nuisance dependence and is appropriate when one wishes to correct for the potentially biasing influence of a spatial autocorrelation due to the use of spatial data (p. 316). Anselin (2001) points out that in the spatial error model with associated non-spherical error term, the structure of spatial dependence is expressed by the off-diagonal elements of an error variance-covariance matrix of the form shown below where θ represents a vector of the coefficients in a spatial autoregressive error process (p. 316).

$$E[\ \varepsilon\ \varepsilon'\ ] = \Omega\ (\theta)$$

In this study the intention was to determine the existence of a spatial effect in the distribution of RPS target levels across geographical U.S. state boundaries and both the spatial lag and error models were utilized.

The specification of the spatial weight matrix W_{ij} was crucial in the development of a spatial model as it dictated the structure and nature of all spatial dependencies. The spatial weight matrix is an N x N matrix that specifies for each location in the system the strength of the effect of the other locations in the system on the value at the former location. Anselin (2001) stressed that spatial weights ultimately depend on the definition of the neighborhood set for each observation which is obtained by selecting for each row location (i) the neighbors as the columns corresponding to nonzero elements W_{ij} in a fixed (non-stochastic) and positive N × N spatial weights matrix (p. 313).

Multiple approaches can be taken in the construction and development of spatial weight matrices depending on how neighbors are defined. Two common varieties are of spatial weight matrices are contiguity-based and distance-based. In contiguity-based spatial weights a neighbor is defined on the basis of polygon shapes sharing a common boundary and in distance-based spatial weights a neighbor is defined based on the distance between the centroids of individual polygon shapes. Contiguity-based spatial weights can be of two varieties depending on how neighbors are defined. In Rook-based contiguity, neighbors are defined using only common boundaries, while in Queen-based contiguity neighbors are defined using all common boundaries and vertices and exhibit a much more densely connected structure with more neighbor-neighbor associations. These two types of contiguity-based spatial weights are illustrated in Figure 10 below. In this study three spatial weight matrices were constructed and utilized: one with queen-based spatial contiguity, a second with rook based spatial contiguity and a third with distance-based contiguity.

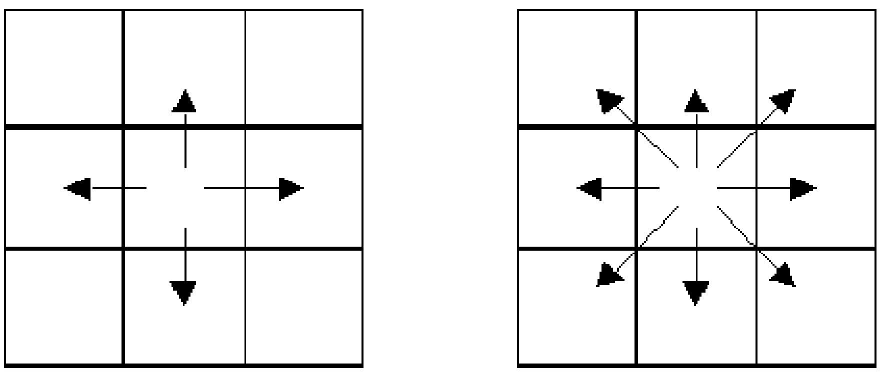


Figure 10. Rook and Queen Based Spatial Contiguity

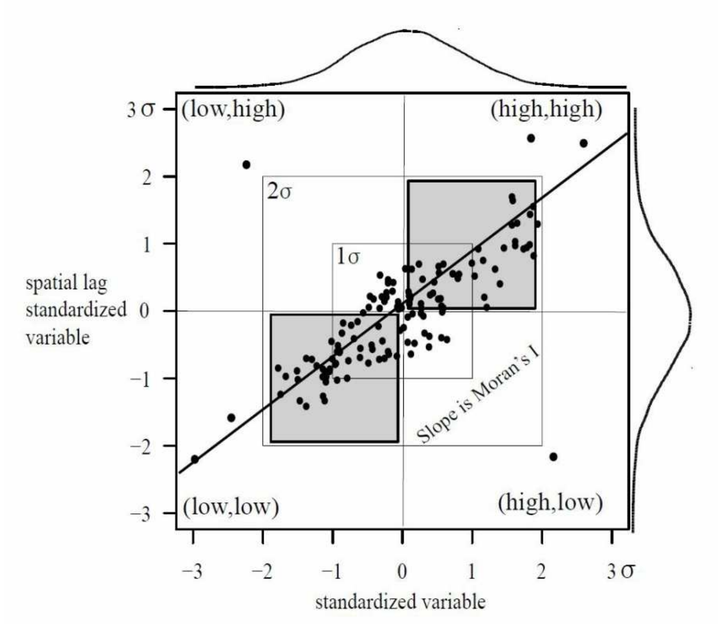
The primary test procedure that was be employed in this study to test for spatial autocorrelation was the Moran's I statistic developed by Moran (1948) and further refined by Cliff and Ord (1973). The equation for the Moran's I statistic in matrix form is shown below.

$$I = (N/S_0) * (e'W * e / e' * e)$$

In this equation I represents the Moran's I statistic, e is a vector representing OLS residuals and S_0 is the standardization factor that corresponds to the sum of the weights for the non-zero cross products ($S_0 = \Sigma i \, \Sigma j \, w_{ij}$). W represents the spatial weights matrix and N is the number of observations. According to Ward and Gleditsch (2008), Moran's I statistic compares the relationship between the deviations from the mean across all neighbors of i row location, adjusted for variation in y and the number of neighbors for each observation (p. 24). Described more succinctly, the Moran's I statistic measures the average correlation of an observation with its neighbors (p. 24). The authors further state that higher values for Moran's I indicate stronger positive clustering of a geographical nature or that values for values for neighboring units are similar to one another (p. 24).

In addition to the use of Moran's I, a global indicator of spatial autocorrelation, this study also utilized a test for local spatial clustering. In order to assess significant local clustering around an individual location, Anselin (1995) developed a general class of "local indicators of spatial association" (LISA). Anselin (1995) defined a local indicator of spatial association (LISA) as any statistic that satisfies two requirements: first each observation provides an indication of the extent of significant spatial clustering of similar values around that observation and second the sum of LISA's for all observations is proportional to a global indicator of spatial association (p. 94). According to Anselin (1995), the LISA indicator effectively allows for the decomposition of global indicators, such as Moran’s I into the contribution of each observation (p. 93). Anselin (1995) states that the LISA statistics serve two primary purposes. First they can be interpreted as indicators of local pockets of non-stationarity or hot spots, and second, they can be used to assess the influence of individual locations on the magnitude of the global statistic and to identify outliers (p. 93).

Spatial association data is generally interpreted using the Moran's I statistic and three visualization tools: Moran's I scatter plots and LISA significance and cluster maps. Figure 11 illustrates a typical Moran's I scatter plot of a variable with its spatial lag. Ward and Gleditsch (2008) describe the components of a typical basic Moran's I scatter plot as follows: the vertical axis represents the spatially lagged variable, the horizontal axis represents observations of the standardized variable, The slope of the regression line through the standardized points is the Moran's I statistic (p. 24). The four quadrants in the Moran's I scatterplot signify the spatial relationship between observations based on their value and mean neighboring values. The upper left quadrant represents observations with low values on the observed variable with neighbors that on average are much higher than the mean of this variable. Consequently the lower right quadrant represents observations with high values on the observed variable with neighbors that on average are much lower than the mean of this variable. Points appearing in the scatterplot in either of these quadrant locations represent the clustering of dissimilar values. Conversely, the upper right quadrant represents observations with high values on the observed variable with neighbors that on average are much higher than the mean of this variable and the lower right quadrant represents observations with low values on the observed variable with neighbors that on average are much lower than the mean of this variable. Points appearing in the scatterplot in either of these quadrant locations are of more interest as they represent the clustering of similar values.



Source: Ward and Gleditsch (2008)

Figure 11. Moran's I Scatterplot.

LISA significance maps depict locations with significant local Moran's statistics differentiated by colors representing significance level p value. LISA cluster maps also depict locations with significant local Moran's statistics, with significant locations differentiated by type of spatial autocorrelation: high-high, low-low, high-low and low-high, corresponding to the four quadrants of a typical Moran's I scatter plot.

The spatial analysis application tool that was utilized for this study was GeoDa version 1.4.6., an open source, cross-platform software program developed by Dr. Luc Anselin from the GeoDa Center for Geospatial Analysis and Computation at Arizona State University. The GeoDa tool was utilized to construct spatial weight matrices using a U.S. State boundary spatial model and differing types of contiguity neighbor definitions. The GeoDa application was also used to perform spatial autocorrelation analyses (Moran's I) using spatial lag and error models on the dependent variables and independent variables. In addition to the autocorrelation analyses, the GeoDa application was also utilized to conduct tests for local indicators of spatial association (LISA) for the dependent variables and significant independent variables.

In order to perform the geospatial analyses, the GeoDa application required a vector-based spatial definition file. GeoDa utilized the Shapefile (.shp), a universal spatial data format which was originally developed by and is currently regulated by the Environmental Systems Research Institute (ESRI). In their technical description of the Shapefile spatial data format, the Environmental Systems Research Institute (1998), defines it as consisting of a main file with an ".shp" filename suffix which describes the overall shape with a list of its vertices and primitive geometric elements, an index file with an ".shx" suffix which contains offset positional values for each geometric element and a dBASE table with a ".dbf" filename suffix which contains the feature attributes for each geometric element (Environmental Systems Research Institute, 1998, p. 2). The main Shapefile contains geometrically-defined spatial primitive data objects in the form of points, polylines and polygons. The U.S. state geographic shape file that was utilized for this study was obtained from and developed by James P. LeSage at Texas State University - San Marcos and was made available as a public domain geographic data file through his Econometrics Toolbox website. This shapefile consisted of 49 polygons which represented the 48 continental U.S. states including the District of Columbia and is shown in Figure 12. In this study the U.S. state shapefile was edited and maintained using ESRI's ArcGIS 10.2.1 application. ArcGIS is a geographic information system tool primarily used for creating and organizing vector-based geographic information files. A summary of the U.S. state shapefile's data elements and their attributes is provided in Table 13.

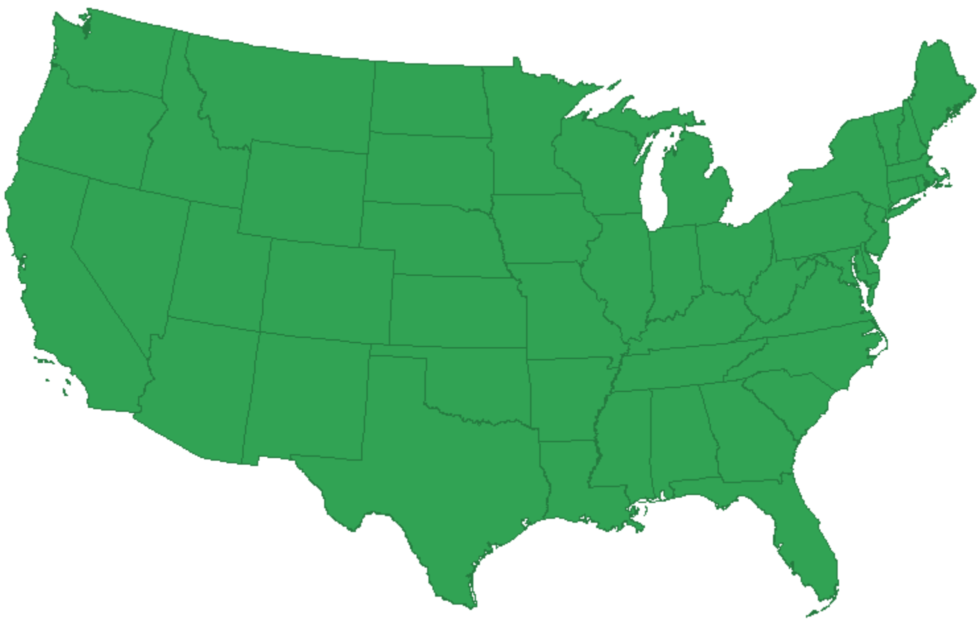
Table 13

ArcGIS Shapefile Data Structure

Spatial Object ID	Spatial Object Type	State	Perimeter (m)	Area (m^2)	X Centroid	Y Centroid
1	Polygon	AL	1916511	133883485154	852704	-487010
2	Polygon	AZ	2386280	295259602137	-1424321	-243221
3	Polygon	AR	2152082	137732412167	322374	-285752
4	Polygon	CA	4147625	410032802351	-2043308	218402
5	Polygon	CO	2099631	269596327804	-817819	208823
6	Polygon	CT	590423	12940489807	1905889	696145
7	Polygon	DE	426193	5322108131	1745388	356971
8	Polygon	DC	63933	177178912	1620184	319763
9	Polygon	FL	3722216	150452778148	1322523	-894281
10	Polygon	GA	2102852	152638248473	1168852	-466340
11	Polygon	ID	2900528	216440701347	-1470663	910625
12	Polygon	IL	2092223	145913218094	574928	305401
13	Polygon	IN	1689983	93704498491	822261	310350
14	Polygon	IA	1838288	145738904087	205779	515060
15	Polygon	KS	2001002	213094653566	-205446	113833
16	Polygon	KY	2134607	104656811113	934491	56528
17	Polygon	LA	3262282	122613637379	383605	-713023
18	Polygon	ME	2475355	84877829791	2068696	1171928
19	Polygon	MD	1971973	27477996410	1639407	337421
20	Polygon	MA	1429536	21321759022	1962969	783870
21	Polygon	MI	4142255	151156068853	842401	810240
22	Polygon	MN	3003499	218555815761	130946	981831
23	Polygon	MS	2472305	123543614035	589642	-513239
24	Polygon	MO	2372496	180537093287	306561	101678
25	Polygon	MT	3117173	380822651796	-1037464	1140167
26	Polygon	NE	2177995	200335380851	-314176	458404
27	Polygon	NV	2368048	286338816821	-1748404	395521
28	Polygon	NH	906914	24033979182	1939254	942185
29	Polygon	NJ	832035	20173628594	1786086	501598
30	Polygon	NM	2391060	314905305854	-920612	-296988
31	Polygon	NY	2512058	127048233429	1650591	787130
32	Polygon	NC	2913207	130393631184	1490345	-87199
33	Polygon	ND	2068742	183106465232	-338763	1118159
34	Polygon	OH	1577927	106994712655	1109490	389651
35	Polygon	OK	2648606	181040973808	-134105	-212999
36	Polygon	OR	2314305	251374564010	-1942960	972344
37	Polygon	PA	1573109	117350846990	1512120	523659
38	Polygon	RI	506953	2868665773	1998380	726233
39	Polygon	SC	1522894	80685042453	1381459	-292348
40	Polygon	SD	2094242	199738479557	-335493	784126
41	Polygon	TN	2087842	109149684482	862234	-140114
42	Polygon	TX	6781470	686994369987	-314382	-667521
43	Polygon	UT	1974667	219878355885	-1332808	312448
44	Polygon	VT	890722	24894203453	1844250	962684
45	Polygon	VA	2564266	105702712263	1497340	138098
46	Polygon	WA	2762624	176769772644	-1838327	1340912
47	Polygon	WV	1965975	62754401108	1320114	234864
48	Polygon	WI	2263202	145340502406	475319	811798
49	Polygon	WY	2028637	253321903396	-934440	671947

Source: LeSage (2014)

The ESRI ArcGIS application was utilized to edit the U.S. state Shapefile's dBASE table to provide the necessary links between each of the polygonal (state) component and their associated dependent and independent variable values. Once the Shapefile's database table had been updated using the ArcGIS tool, it could then be utilized by the GeoDa application for subsequent to development of spatial weight matrices and global and local autocorrelation analyses.

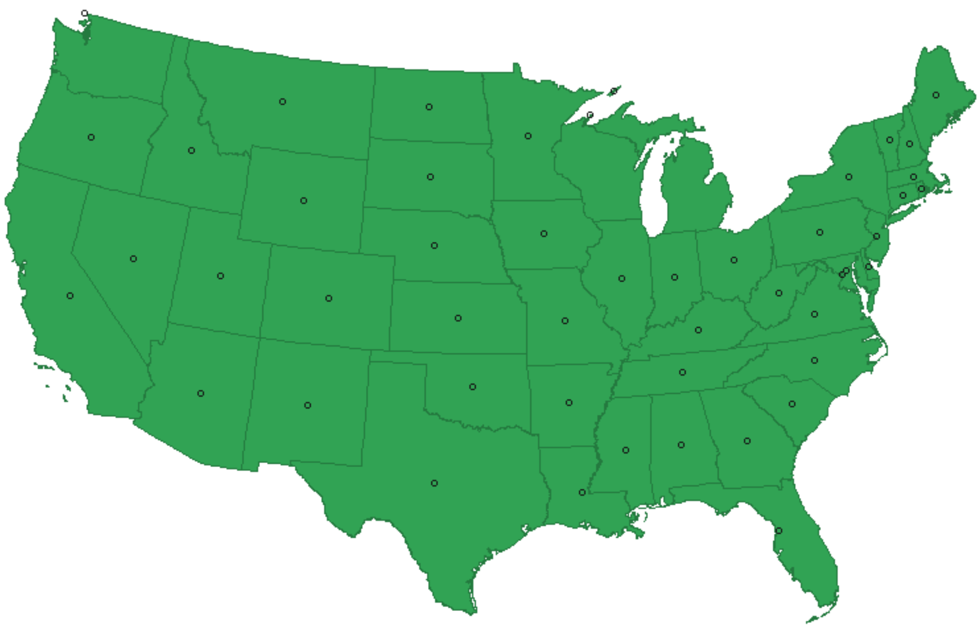


Source: LeSage (2014)

Figure 12. U.S. State Shapefile.

For this study, Rook and Queen contiguity-based weight matrices were constructed as well as a distance-based weight matrix. The Queen and Rook contiguity weight files were created with a contiguity order of one, or first order contiguity. To construct the distance-based spatial weight it was first necessary to utilize the GeoDa application was to compute the centroids of each of the U.S. state shapefile's polygons.

The U.S. state shapefile with its associated polygon centroids is shown in Figure 13. After the polygon centroids had been calculated, a distance-based weight file was created with a standard k-nearest neighbor value of 4 using the U.S. state shapefile's polygon centroid coordinates as the X and Y coordinate variables.



Source: LeSage (2014)

Figure 13. U.S. State Shapefile with Polygon Centroids.

The connectivity histograms for queen, rook based contiguities and the distance based spatial weights for the U.S. state boundary spatial shape model are shown in Figures 12, 13 and 14 respectively. These histograms illustrate the frequency distribution of the number of neighbor associations for the 49 polygon entities in the U.S. state shapefile.

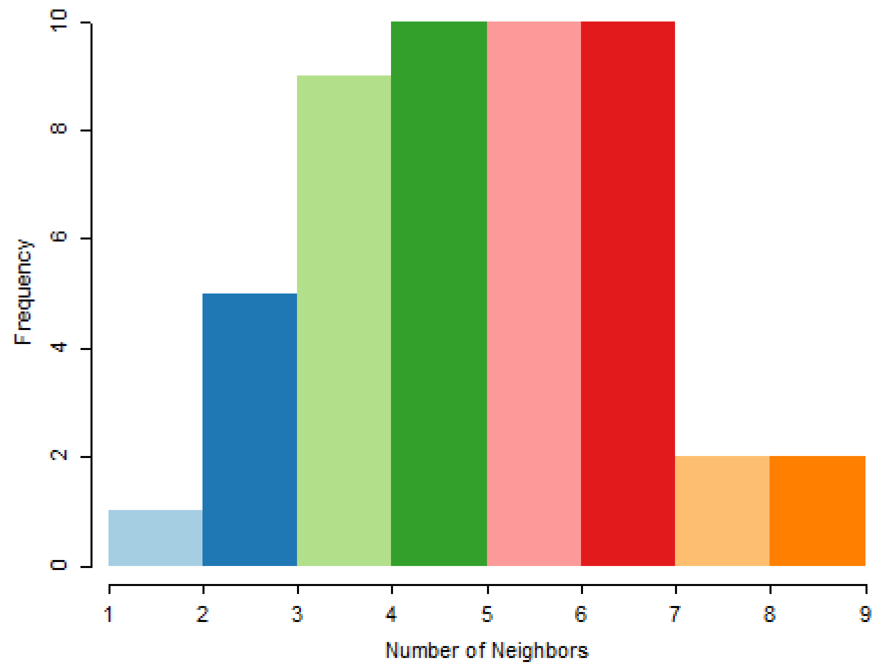


Figure 14. Connectivity Histogram for Queen Weight Matrix (U.S. States)

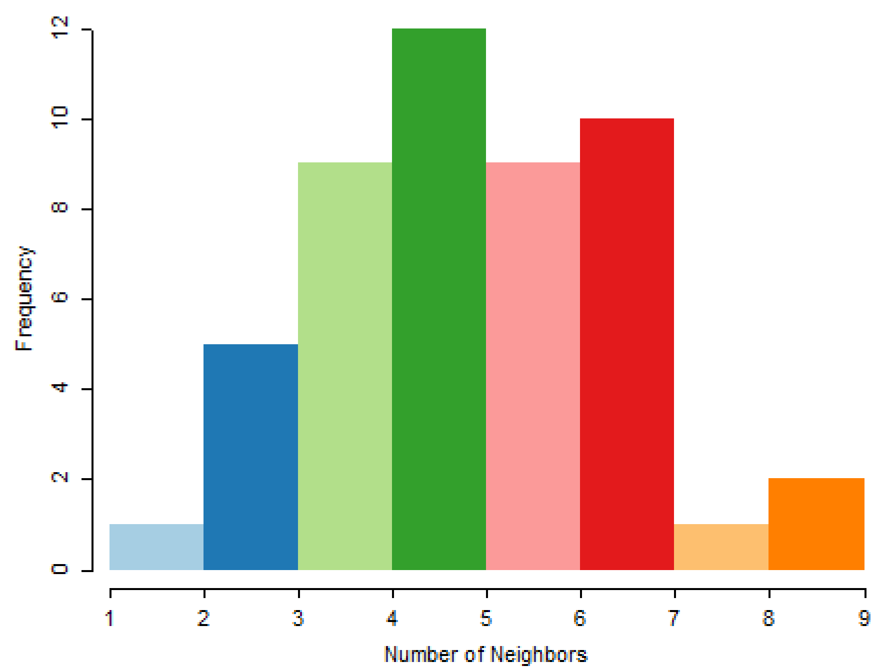


Figure 15. Connectivity Histogram for Rook Weight Matrix (U.S. States)

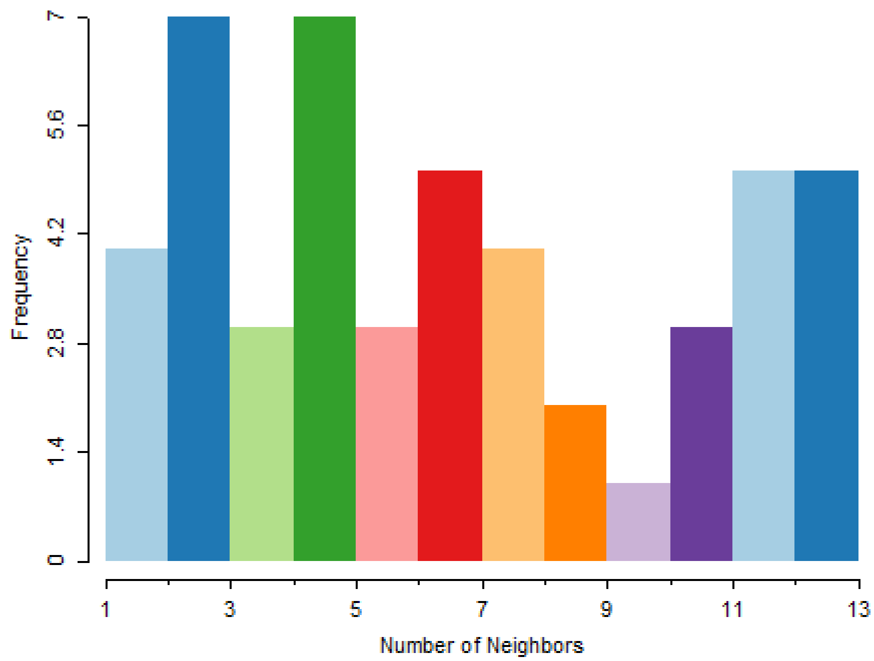


Figure 16. Connectivity Histogram for Distance Weight Matrix (U.S. States)

After the spatial weight matrices had been created, the GeoDa application was utilized to perform spatial regression analyses by estimating spatial lag and spatial error models supported by means of the Maximum Likelihood method. Spatial autocorrelation tests were performed for each of the spatial weights and for each of the spatial lag and error models using the three dependent variable measures of the RPS target level (DV1, DV2 and DV3) and the independent variables. The Moran's I z-value and its level of significance was used as the test for spatial autocorrelation.

Tests for local spatial association were performed using the GeoDa application for all three independent variable representing RPS target level and for the independent variables found to be statistically significant predictors of RPS target level from the multivariate regression (OLS) and global spatial autocorrelation tests. The GeoDa application performs local spatial autocorrelation analyses based on the local indicators of spatial association (LISA) Moran statistics introduced by Anselin (1995). For this study univariate LISA analyses were conducted for all three independent variable (DV1, DV2 and DV3) and bivariate LISA analyses were conducted for the key independent variables and their associated dependent variables. The primary output for the tests for local spatial autocorrelation were the Moran's I scatter plot and LISA significance and cluster maps. The Moran scatter plot was a standard four quadrant plot showing spatial lag or error average neighbor values on the vertical axis and observed values of the standardized variable on the horizontal axis with clusters of homogeneous observations occurring in the upper right (high-high) and lower left (low-low) quadrants, (Ward & Gleditsch, 2008, p. 24). The significance map was a choropleth map that showed spatial polygon locations with a significant local Moran statistic as different color shades corresponding to significance level. The cluster map was a choropleth map that showed spatial polygon locations with a significant local Moran statistic further classified by the type of spatial autocorrelation, particularly emphasizing observations with high-high associations. The results of the local spatial autocorrelation analyses could be easily interpreted as the local Moran scatter plots revealed clusters of homogeneous observations and the significance maps and cluster maps revealed the geographic regions of high spatial autocorrelation. The results of the local tests for spatial autocorrelation are reported in the empirical analysis chapter and are presented in Appendix A in the form of the Moran's I scatter plots and cluster and significance maps.

CHAPTER 4: EMPIRICAL RESULTS

In this chapter empirical results are presented for the preliminary correlation tests, multivariate regression tests (Ordinary Least Squares and robust regression), global geospatial Maximum Likelihood (MLA) spatial lag and error tests and finally tests for Local Indicators of Spatial Association (LISA). These tests were conducted for each of the three dependent variables representing distinct measures of RPS target level strength using the final model of six independent variables representing geographic, regulatory, economic, infrastructure, political ideology and diffusion factors. The preliminary tests for multicollinearity performed on dataset variables are discussed in the first section along. In the second section findings are presented for tests conducted to determine the effect of the state regulation on RPS target levels. The third section presents findings and results for the tests of infrastructure's effect on RPS target levels. Results and findings are presented in the fourth section for the analyses that tested the predictive ability of political ideology on RPS target levels. A fifth section presents the results of the tests that determined to what extent state internal determinants or regional diffusion were predictors of RPS target levels. Finally, the results and findings of the global geospatial regression analyses where both spatial lag and error models were utilized are presented in the sixth section and tests for local spatial autocorrelation are presented in the seventh and final section.

A summary of the results of the Ordinary Least Squares (OLS) multivariate regression and Robust Regression analyses of the dependent variables representing RPS target level with independent variables is shown in Tables 17a and 17b. Ordinary Least

Squares (OLS) multivariate regression and robust regression analyses were run on the regression model and independent variables found to be significant at the 99% level (P>|t| = 0.01), 95% level (P>|t| = 0.05) and the 99.9% level (P>|t| = 0.001) were reported. All relationships were positive unless otherwise indicated by a coefficient with a negative sign. Similar summaries of the global geospatial Maximum Likelihood (MLA) spatial lag and error autocorrelation tests is shown in tables 18 and 19. The STATA Statistics/Data Analysis application Version 13.1 developed by StataCorp was utilized for the preliminary correlation tests and the multivariate OLS and robust regression analyses. The geospatial autocorrelation tests for global and local spatial association were performed using the GeoDa application Version 1.4.6.

4.1 Preliminary Tests for Multicollinearity

A correlation analysis was run on all 21 independent variables as the test for multicollinearity. In cases where independent variable pairs had a Pearson's correlation coefficient above 0.75, one of the variables was removed from the regression model. In cases where a given independent variable had a Pearson's correlation coefficients greater that 0.75 with multiple variables, the variable was also removed from the regression model. According to Elliott and Woodward (2007), highly correlated variable pairs should be addressed as they could cause problems in the interpretation of resultant multiple regression resultant equations (p. 99). In this analysis it was found that several variables especially those representative of state size and magnitude were found to be highly correlated and were subsequently removed from the regression model. Bivariate correlation analyses were then run on the remaining independent variables as a preliminary test correlation with dependent variables and a final set of six independent variables representing each of the variable of the geographic, economic, infrastructural, regulatory, political ideological and diffusion groups were chosen for the final regression model based on their predictive ability for the three dependent variables. The correlation results are shown in Tables 14, 15 and 16 for the six independent variables comprising the final regression model. Since three distinct independent variables were utilized to represent the diffusion of each of the three dependent variables, correlation tests were performed for each one and its accompanying independent variables. None of the independent variables in the final regression model had a Pearson's correlation coefficient greater than 0.6.

Table 14. *Correlation Matrix for Regression Model Independent Variables (DV1)*

VARIABLE	AVG_ELEC _PRICE	RE_POT _CAP	HV_TLINE _132_DN	PUC_STAFF _MW	GOV_IDEOL _ADA	DIFF_RE HI_TGT
AVG_ELEC_PRICE	1.0000					
RE_POT_CAP	-0.5169	1.0000				
HV_TLINE_132_DN	0.2111	-0.3934	1.0000			
PUC_STAFF_MW	0.1994	0.0346	0.1797	1.0000		
GOV_IDEOL_ADA	0.4004	-0.4188	0.2075	0.2957	1.0000	
DIFF_REG_HI_TGT_1	-0.2126	0.0998	0.0016	0.1325	-0.1187	1.0000

Pearson's Correlation Coefficients

Table 15. *Correlation Matrix for Regression Model Independent Variables (DV2)*

VARIABLE	AVG_ELEC _PRICE	RE_POT _CAP	HV_TLINE _132_DN	PUC_STAFF _MW	GOV_IDEOL _ADA	DIFF_RE HI_TGT
AVG_ELEC_PRICE	1.0000					
RE_POT_CAP	-0.5818	1.0000				
HV_TLINE_132_DN	0.2331	-0.4219	1.0000			
PUC_STAFF_MW	0.2107	0.2217	0.2639	1.0000		
GOV_IDEOL_ADA	0.2210	-0.3950	0.2021	0.1589	1.0000	
DIFF_REG_HI_TGT_2	-0.1081	0.2162	-0.1522	0.0452	-0.2513	1.0000

Pearson's Correlation Coefficients

Table 16. *Correlation Matrix for Regression Model Independent Variables (DV3)*

VARIABLE	AVG_ELEC _PRICE	RE_POT _CAP	HV_TLINE _132_DN	PUC_STAFF _MW	GOV_IDEOL _ADA	DIFF_RE HI_TGT
AVG_ELEC_PRICE	1.0000					
RE_POT_CAP	-0.5074	1.0000				
HV_TLINE_132_DN	0.0669	-0.3951	1.0000			
PUC_STAFF_MW	0.2920	0.1883	0.2252	1.0000		
GOV_IDEOL_ADA	0.1417	-0.3881	0.2038	0.1498	1.0000	
DIFF_REG_HI_TGT_3	0.0738	0.0162	-0.0687	-0.0301	0.2107	1.0000

Pearson's Correlation Coefficients

4.2 State Regulation and RPS Target Levels

The variables utilized to test for effect of regulation on RPS target level were the total state public utility commission staff and total commission staff per Megawatt of state system capacity and the total number of electricity providers in the state as well as total providers per Megawatt of state system capacity. Neither the multivariate (OLS) regression analyses nor the geospatial (Moran's I) autocorrelation analyses revealed a significant relationship between these measures of the magnitude of state regulation and the measures of RPS target level. It was hypothesized that regulation would have a positive effect on RPS target level and that more highly regulated states would set higher RPS target levels in an attempt to attract profit-seeking RE providers. According to Buchanan (1980), rent-seeking activity is directly related to the scope and range of governmental activity in the economy (p. 9). In this study it appeared that the magnitude of regulation of state electricity providers was not an effective predictor of RPS target level.

4.3 Infrastructure and RPS Target Levels

The variables utilized to test the effect of existing infrastructure as a predictor of RPS target level included measurements of each state's transmission line total circuit miles and transmission line density measured in circuit miles per square mile and the state's potential capacity of renewable electricity generating resources measured in Megawatts. In the case of state transmission lines it was not found that any of the measures had any influence on the measures of RPS target level. It was expected that since the construction of new transmission lines to remote RE generation sites is prohibitively high, policymakers in states with a higher density of transmission lines would find it to be more economically feasible to tie remotely located renewable energy generation sources to their electricity grid and hence set more stringent RPS goals. This finding indicates that the theory of infrastructure-led development which attributes growth to the presence of a robust network or networked delivery system designed to serve a multitude of users (Agenor, 2006, p. 4), is not exerting an effect on target levels set by state policymakers. This may be due to the fact that policymakers have little knowledge of the electrical system grid due to a lack of infrastructural and systemic information flow between energy providers and policymakers. A positive relationship was however found to exist between state RE potential capacity and RPS target level and was in the hypothesized direction. This result was consistent with the findings of Menz and Vachon, (2006). This relationship was present in both the multivariate (OLS) regression analyses (see Tables 17a and 17b) and the geospatial (Moran's I) autocorrelation analyses (see Tables 18 and 19). These findings would indicate the states with higher renewable energy potential capacities are setting their target level correspondingly higher to account for their greater endowment of RE potential.

4.4 Political Ideology and RPS Target Levels

The tests to measure the influence of political ideology on RPS target levels were conducted using the measures of State government ideology developed by Berry et al. (1998) which utilized ideology scores for the state governor and the major party delegations in each house of the state legislature utilizing ADA/COPE interest group scores (p. 332). It was found that there was a positive relationship between the State government ideology index and RPS target level. This relationship was found to exist in the geospatial (Moran's I) autocorrelation analyses (see Figure 19) for all three measures of RPS target level. This relationship was in the hypothesized direction and was consistent with the findings of previous studies by Carley and Miller (2009) who found that RPS stringency was influenced by government ideology and several other policy innovation studies by Yin and Powers (2010), Matisoff (2008), Lyon and Yin (2010), Huang et al (2007), and Chandler (2009), who all found that RPS adoptions could be predicted by political ideology, particularly in states with a strong Democrat party presence and where state citizen liberalism was dominant. In the multivariate (OLS) regression analyses for dependent variable DV1 when the larger main model was utilized (see Table 17a) a significant relationship of smaller magnitude was detected between DV1 and state government ideology in the opposite hypothesized direction.

4.5 State Internal Determinants and Regional Diffusion

The tests to determine whether state internal determinants or regional diffusion predict RPS target level were conducted using multiple variables representing state geographic, economic and governmental ideology factors and a diffusion-themed variable representing RPS target levels in neighboring states. The state internal determinants of average retail electricity price and government ideology both proved to be predictors of RPS target level in both OLS multivariate regression tests (see Table 17a) and in the geospatial (Moran's I) autocorrelation analyses (see Tables 18 and 19). In the case of electricity price, it is interesting to note that Carley (2009) found average electricity price to be negatively associated with renewable energy deployment and speculated that this occurred because higher electricity prices acted as a deterrent for state utilities to invest in more expensive renewable energy sources (p. 3076). If electricity is considered to be the commodity delivered on an infrastructural network, (transmission lines), a potential explanation for this effect might be that state policymakers see more value in setting RPS target levels high if the resultant economic growth is directly influenced by the price of the delivered commodity. In this market model scenario, the price of the commodity (electricity) would be the key driver and policymakers would make efforts to deliver it to customers as efficiently as possible and hence would set high target levels. It has been speculated that renewable generation infrastructural costs may eventually be driven down by the emergence of economies of scale for key infrastructural RE components (e.g. solar modules, wind turbines, etc.) if states continue to deploy increasingly higher generation capacities to meet their policy goals. Rowlands (2010) and Klare (2008) have both predicted that electricity providers will realize significant cost reductions in renewable generation infrastructure in the future. An explanation of the political ideology internal determinant's role is described in the previous section above. The predictive power of state electricity price and state governmental ideology indicate that some state internal determinants do play a role in predicting RPS target levels.

The regional diffusion analyses performed in this study demonstrated that interstate diffusion was a significant negative driver of RPS target levels as there was a negative diffusional effect present in the opposite hypothesized direction. The predictive power of the regression model which tested the level of effort dependent variable (DV1) was the strongest and yielded consistently higher regression coefficients. This result indicates that states with neighbors with the same or higher RPS target goals have set the targets of their RPS lower which contradicts the results of previous studies of the diffusion of RPS adoptions conducted by Chandler (2009) and Wiener and Koontz (2010). In this study it was hypothesized that States would enact an RPS with higher target levels if their neighboring states had the same or more stringent target levels. Our finding of an opposite effect directly counters the classic notion that diffusion processes occur due to learning, emulation and competition proposed by Berry & Berry (2007).

A possible explanation for this diffusion effect is that the market may not be a truly competitive one in the sense of setting higher target level milestones, but is more competitive in ensuring policy effectiveness. In this scenario, state policymakers would observe the target levels set by their immediate and regional neighbors and set theirs lower so that they are easier to achieve. This strategy would ensure that state policymakers successfully achieve the requirements of their RPS. Another explanation for this effect is that state policymakers might be observing the RPS target levels set by policymakers in adjacent border states and relying on these neighbors to set higher targets and produce higher amounts of RE generation capacity. In such a scenario a state could satisfy their own lower and easier RPS target goal and also purchase renewable energy credits from their neighbor state to further satisfy the requirements of their RPS goal without incurring the capital costs of installing RE generation infrastructure. A second metric utilized to determine the presence of a diffusion effect was the fraction of RE capacity deployed in the state. It was found that the fraction of bordering states with the same or higher percentages of RE generation capacity deployed had no effect on RPS target levels.

Table 17a.

OLS and Robust Regression Summary Table (Main Model)

	DV1 Level of Effort	**DV2 Policy Coverage**	**DV3 Absolute Target Level**
Variable	**OLS Coefficient**	**OLS Coefficient**	**OLS Coefficient**
State Avg. Price of Electricity	13.31*** (2.718)	3.744** (1.271)	4.093** (1.481)
State RE Potential Capacity	-0.00000136 (0.00000159)	0.000000238 (0.000000780)	0.00000222* (0.000000918)
State HV Transmission Line >132kV Density	-42.49 (36.65)	-29.56 (17.57)	-33.40 (20.90)
State Commission Staff by MW Capacity	6534148.7 (4399225.8)	-407016.2 (2179190.0)	-5170209.2 (2547559.6)
State Gov't Ideology Measure - ADA/COPE	-0.941** (0.338)	0.241 (0.174)	-0.344 (0.208)
Fraction of Regional States with ≥ Target Level	-162.1*** (46.78)	-70.65*** (8.394)	-100.4*** (9.985)

Main Model 353 Observations, OLS - Ordinary Least Squares

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 17b.

OLS and Robust Regression Summary Table (Smaller Model)

	DV1 Level of Effort		**DV2 Policy Coverage**		**DV3 Absolute Target Level**	
Variable	**OLS Coeff.**	**ROB Coeff.**	**OLS Coeff.**	**ROB Coeff.**	**OLS Coeff.**	**ROB Coeff.**
State Avg. Price of Electricity	3.052 (2.247)	3.052 (2.024)	1.483 (1.467)	1.483 (0.868)	1.264 (1.325)	1.264 (1.156)
State RE Potential Capacity	-7.62E-07 (1.24E-06)	-7.62E-07 (7.32E-07)	2.05E-07 (9.29E-07)	2.05E-07 (8.48E-07)	2.07E-06* (8.39E-07)	2.07E-06* (9.17E-07)
State HV Transmission Line >132kV Density	-16.93 (38.12)	-16.93 (25.88)	-20.03 (22.86)	-20.03 (15.04)	-26.62 (20.75)	-26.62 (16.69)
State Commission Staff by MW Capacity	400529 (3287324)	400529 (1803067)	-1415400.8 (2618319)	-1415400 (2559866)	-4666200.2 (2351352)	-4666200 (2312843)
State Gov't Ideology Measure - ADA/COPE	0.357 (0.264)	0.357 (0.203)	0.271 (0.206)	0.271 (0.152)	0.148 (0.188)	0.148 (0.123)
Fraction of Regional States with ≥ Target Level	-105.0*** (17.25)	-105.0*** (24.46)	-72.09*** (9.415)	-72.09*** (11.68)	-95.04*** (8.604)	-95.04*** (10.08)

35 Observations, OLS - Ordinary Least Squares, ROB - Robust Regression

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.6 Global Geospatial Regression Analysis Results

Global geospatial results of the analysis of the three dependent variables representing RPS target level are presented in tables 18 and 19. The Moran's I statistic provided an indication of the degree of spatial autocorrelation in a given model. Strong spatial autocorrelation is indicated by a positive and significant Moran's z-value. Both the spatial lag model and spatial error models of maximum likelihood estimation were utilized in the analysis. Each of the three dependent variables representing RPS target level were analyzed with the standard set of independent variables representing geographic, economic, regulatory, infrastructural, diffusion and ideological factors. The U.S. state shape file was utilized and both Queen and Rook contiguity-based weight matrices with an order of contiguity of 1 were utilized for the analysis.

In the geospatial autocorrelation analysis it was found that several of the variables that showed significant relationships with dependent variables in the (OLS) multivariate regression analysis also showed similar relationships with sometimes stronger levels of significance. In both the spatial lag and error MLE models it was found that there was a significant negative relationship between the diffusion variable and all three dependent variable which was again in the opposite hypothesized direction. This relationship was stronger for DV1 dependent variable and the Moran's I values for this relationship ranged from -6.54 to -6.78. It also was found that there was a significant and positive relationship between dependent variables DV1 and DV2 and the state average electricity price. For this relationship, spatial lag and error model Moran's z-values ranged from of 1.98 to 5.93. Similar to the regression analyses a moderately positive relationship was found to exist between dependent variables DV1 and DV3 and state RE potential capacity. The Moran's I values for this relationship ranged from 2.47 to 2.83. Finally, it was discovered that a positive relationship existed between all three dependent variables and the measure of state government ideology. This relationship was similar to that found in the regression analyses and was in the hypothesized direction. The Moran's I values for the relationship ranged from 3.23 to 6.86.

Table 18

Global Geospatial Autocorrelation Summary Table - Queen-Based Contiguity

	DV1 Level of Effort		**DV2 Policy Coverage**		**DV3 Absolute Target Level**	
Variable	**SLM Coeff.**	**SEM Coeff.**	**SLM Coeff.**	**SEM Coeff.**	**SLM Coeff.**	**SEM Coeff.**
State Avg. Price of Electricity	8.47689*** (1.54056)	8.11564*** (1.367727)	2.418204 (1.238924)	1.984743 (1.043481)	1.487578 (1.517384)	0.7986859 (1.228515)
State RE Potential Capacity	1.98E-06* (8.02E-07)	2.12E-06** (7.49E-07)	1.38E-08 (6.14E-07)	1.76E-07 (5.36E-07)	1.39E-06 (7.41E-07)	1.67E-06** (6.03E-07)
HV Transmission Line >132kV Density	14.97623 (32.03527)	14.19734 (31.96189)	-9.067435 (25.59979)	-9.654415 (24.44033)	-2.500842 (32.33744)	-7.313981 (28.16859)
Commission Staff by MW Capacity	-63012.73 (371098.4)	-48292.07 (370072.3)	377396.5 (295569.9)	388843.6 (283576.6)	341818.2 (373638.2)	402224.9 (330584.8)
State Gov't Ideology Measure - ADA	0.650789** (0.2014163)	0.663468*** (0.1996576)	0.99468*** (0.1601651)	1.01233*** (0.1585492)	1.28597*** (0.2028588)	1.31723*** (0.1958151)
Fraction of Regional States ≥ Target Level	-86.4977*** (13.23303)	-87.66625*** (13.08492)	-0.33688* (0.1590066)	-0.35797* (0.1583226)	-0.559258** (0.2007413)	-0.617669** (0.1966026)

SLM - Spatial Lag Model, SEM - Spatial Error Model

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 19

Global Geospatial Autocorrelation Summary Table - Rook-Based Contiguity

	DV1 Level of Effort		**DV2 Policy Coverage**		**DV3 Absolute Target Level**	
Variable	**SLM Coeff.**	**SEM Coeff.**	**SLM Coeff.**	**SEM Coeff.**	**SLM Coeff.**	**SEM Coeff.**
State Avg. Price of Electricity	8.46866*** (1.533966)	8.18284*** (1.391632)	2.427649* (1.223756)	1.979469 (1.039322)	1.54347 (1.492058)	0.7523756 (1.209064)
State RE Potential Capacity	1.99E-06* (8.01E-07)	2.10E-06** (7.71E-07)	4.88E-09 (6.13E-07)	1.76E-07 (5.35E-07)	1.36E-06 (7.37E-07)	1.66E-06** (5.96E-07)
HV Transmission Line >132kV Density	14.98024 (32.04164)	11.15467 (32.71317)	-9.123707 (25.57376)	-9.637175 (24.39192)	-2.617064 (32.18413)	-7.458336 (27.85122)
Commission Staff by MW Capacity	-63118.48 (371107.3)	-17425.15 (377904.8)	378493.9 (295148.4)	388667.4 (282971.9)	343763.6 (371630.2)	404802.3 (326860.9)
State Gov't Ideology Measure - ADA	0.650355** (0.2011226)	0.661501*** (0.2000966)	0.99698*** (0.1594939)	1.01250*** (0.157824)	1.29088*** (0.2010169)	1.32199*** (0.1926818)
Fraction of Regional States ≥ Target Level	-86.5562*** (13.23646)	-88.13251*** (12.993)	-0.3367264* (0.1587694)	-0.3577785* (0.158276)	-0.557455** (0.1997444)	-0.615844** (0.1956832)

SLM - Spatial Lag Model, SEM - Spatial Error Model

Standard errors in parentheses

* p < 0.05, ** p < 0.01, *** p < 0.001

4.7 Local Indicators of Spatial Association (LISA) Analysis Results

The previous section described the results of global measures of spatial autocorrelation in terms of Moran's I z-values and their associated levels of significance. The results provided in this section represent the results of the local measures of spatial autocorrelation or Local Indicators of Spatial Autocorrelation (LISA). Univariate local Moran's I tests of spatial autocorrelation were performed on the three dependent variables representing different measures of state RPS target level. In addition, bivariate local

Moran's I tests were performed on independent variables and their accompanying dependent variables in cases where the independent variables were found to be significant predictors of RPS target level. The purpose of the local spatial tests was to determine the geographic location of cluster centers or local spatial patterns contributing to the global autocorrelation outcome. Three types of spatial weight matrices were developed for the local analyses: Queen based, rook based and distance based. The geospatial output formats for local tests for autocorrelation typically include Moran's I scatter plots and cluster and significance maps. In a typical Moran's I scatter plot attention should be paid primarily to the upper right (high-high) and lower left (low-low) quadrants of the plot which are indicative of data with positive local spatial autocorrelation or spatial clusters. The upper left (low-high) and lower right (high-low) quadrants of the Moran scatter plot indicate data with negative local spatial autocorrelation and are considered to be spatial outliers. In this particular analysis attention was paid primarily to data with high-high spatial autocorrelations as it was indicative of the states and groups of states with similar RPS target levels or in the case of the bivariate tests the geographic centers of high correlation between dependent and independent variable pairs. The LISA significance maps illustrate spatial locations with the significance of local Moran's I statistic indicated in different colors corresponding to specific ranges of p-value. The corresponding LISA cluster maps illustrate spatial locations color-coded by the type of spatial autocorrelation, (i.e. high-high, low-low, high-low and low-high). In this analysis attention was primarily paid to significant high-high cluster centers because some states proved to have positive low-low autocorrelation results due to the fact that not all U.S. states have a renewable portfolio standard or renewable goal and the GeoDa spatial analysis application could not differentiate between states with very low RPS target levels and state with no RPS in place or RE goal. It should be noted that several of the local tests revealed low-low spatial clusters which included a number of U.S. southern states that did not have an RPS in effect or an RE goal. This gap in state RPS and RE initiatives may be partially due to the existence of the federally-owned Tennessee Valley Authority (TVA) Corporation which provides power to Kentucky, Tennessee, Alabama, Mississippi, Georgia, North Carolina and Virginia.

The results of the local geo-spatial analysis on the dependent variables are provided in Appendix A and include the Moran's I scatter plots and cluster and significance maps. These results indicated that there were localized spatial patterns associated with RPS target levels or that some states have enacted renewable portfolio standards with similar target level strengths as their closest neighboring states. The region that exhibited the highest degree of RPS target level similarity or cluster-centering was a grouping of Northeastern U.S. states which included NY, PA, NJ, MD, DE, CT, VT and MA . Since none of the states in this grouping had particularly high renewable energy potential generation capacities a potential explanation for this effect could be that their RPS target levels are influenced either by a diffusion effect, (i.e. observing and emulating the target levels set by policymakers in their adjacent neighbor states), or by one or more internal determinant factors of the state. The next section will elaborate on the local effects of some of the key significant independent variables that predicted RPS target levels.

The global Moran's I autocorrelation results showed that the dependent variables representing RPS target level could be predicted by state average electricity price, the state's renewable energy potential capacity and state government ideology. In addition, there was a diffusion effect as the diffusion variables representing higher target levels in neighboring states exerted a negative influence on RPS target levels. The significant independent variables were tested individually with their accompanying dependent variable using bivariate local Moran's I tests. The local spatial autocorrelation results for the state average electricity price variable indicated that this effect was observed to be strongest in a large grouping of Northeastern U.S. states which included NY, PA, VT, NH, MA, CT, RI, NJ, DE, DC and MD a result very that was very similar to the Northeastern cluster of states associated with the dependent variable's univariate local Moran's I tests. The bivariate local Moran's I scatter plot, and cluster and significance maps for the average electricity price variable are shown in Figures 17, 18 and 19.

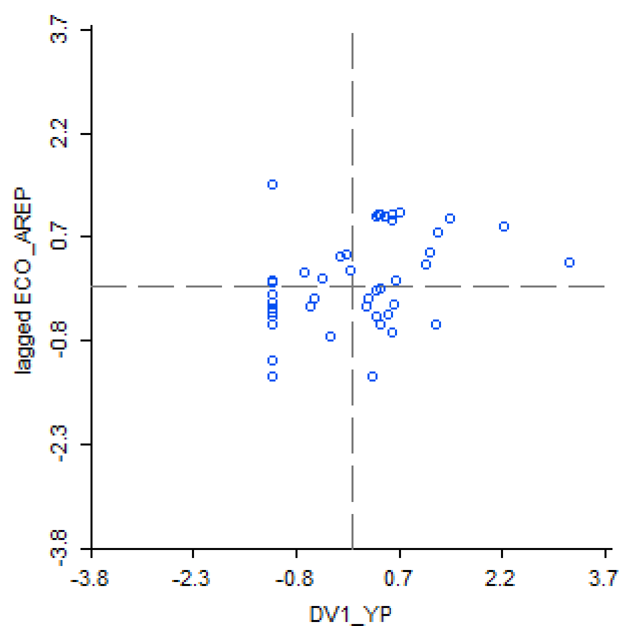


Figure 17. Bivariate Local Moran's I Scatter Plot of DV1 and Average Electricity Price

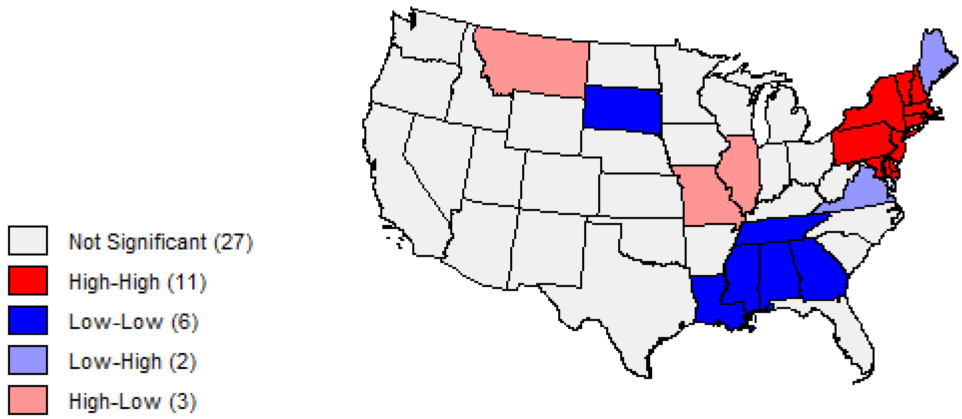


Figure 18. Bivariate Local Moran's I Cluster Map of DV1 and Average Electricity Price

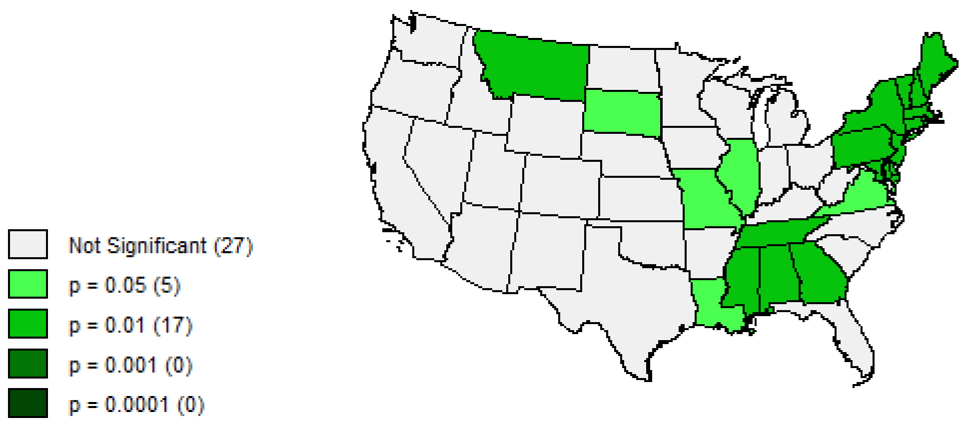


Figure 19. Bivariate Local Moran's I Significance Map of DV1 and Average Electricity Price

The results of the local spatial autocorrelation analyses for the independent variable representing state RE potential capacity variable indicated that this effect was strongest in a pair of Southwestern U.S. state s which included Utah, Colorado and in some tests Arizona and New Mexico. These states have some of the highest potential renewable potential capacities in the United States particularly for solar power. This result indicates that policymakers in some of the U.S. states with the higher RE potential capacities may be factoring these metrics into the derivation of their RPS target levels. The bivariate local Moran's I scatterplot, cluster and significance maps for the RE potential capacity variable are shown in Figures 20, 21 and 22.

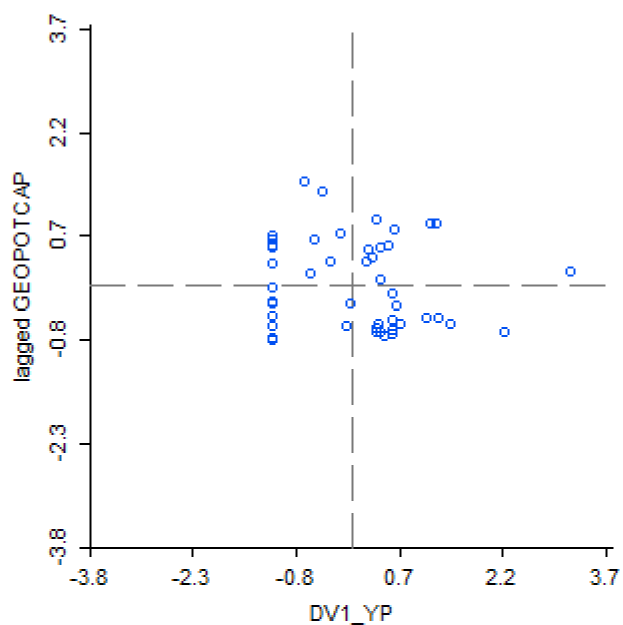


Figure 20. Bivariate Local Moran's I Scatter Plot of DV1 and RE Potential Capacity

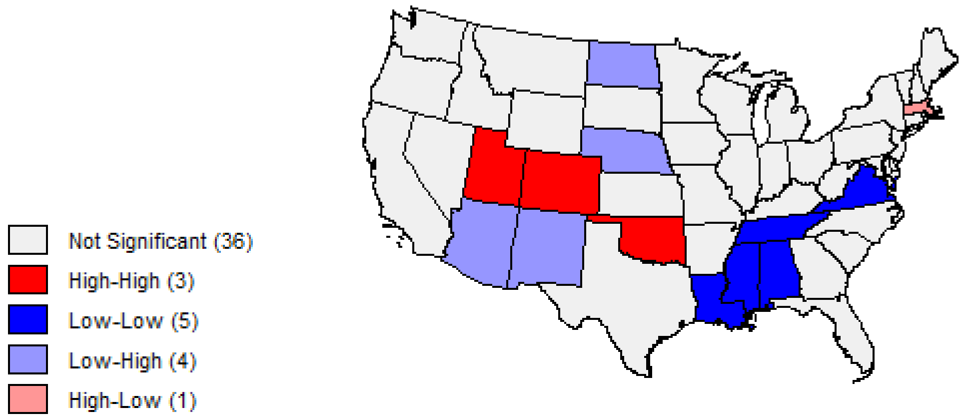


Figure 21. Bivariate Local Moran's I Cluster Map of DV1 and RE Potential Capacity

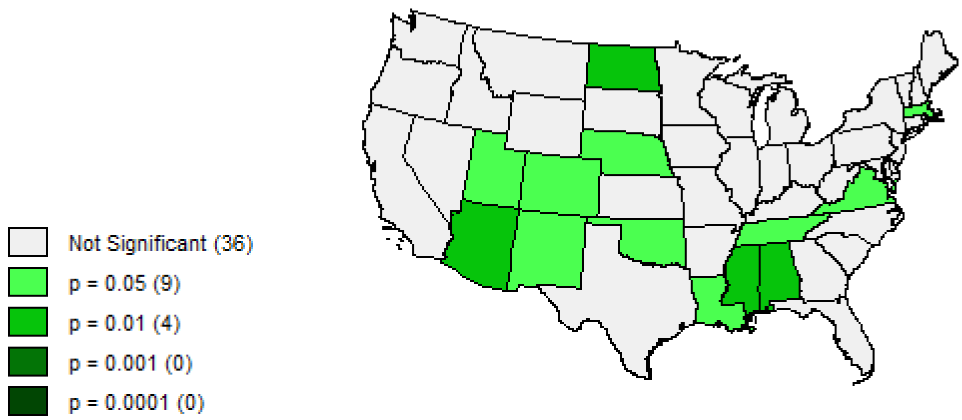


Figure 22. Bivariate Local Moran's I Significance Map of DV1 and RE Potential Capacity

The local spatial autocorrelation results for the state government ideology variable indicated that its effect as a predictor of RPS target level effect was observed to be strongest in a large grouping of Northeastern U.S. states which included NY, PA, NH, MA, CT, RI, NJ, DE, DC and MD. This grouping of states is known to be predominantly Democrat in both measures of citizen and governmental ideology and this result indicates where the effect of government ideology on RPS target levels is strongest. The bivariate local Moran's I scatterplot, cluster and significance maps for the state government ideology variable are shown in Figures 23, 24 and 25.

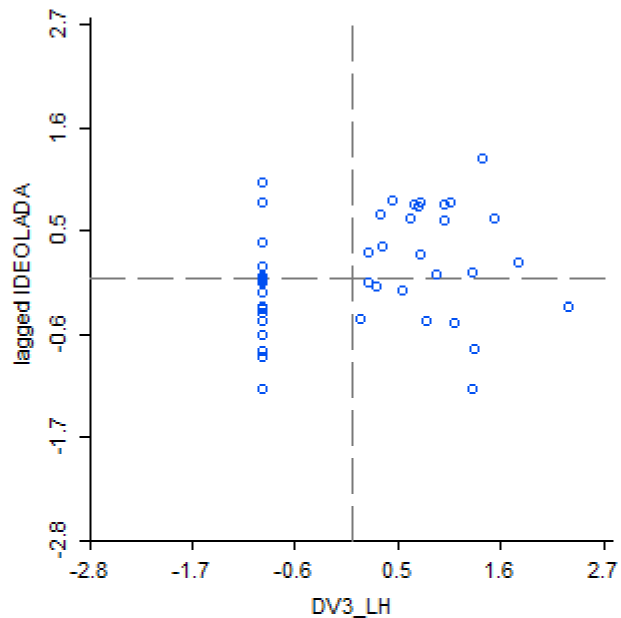


Figure 23. Bivariate Local Moran's I Scatter Plot of DV3 and Government Ideology

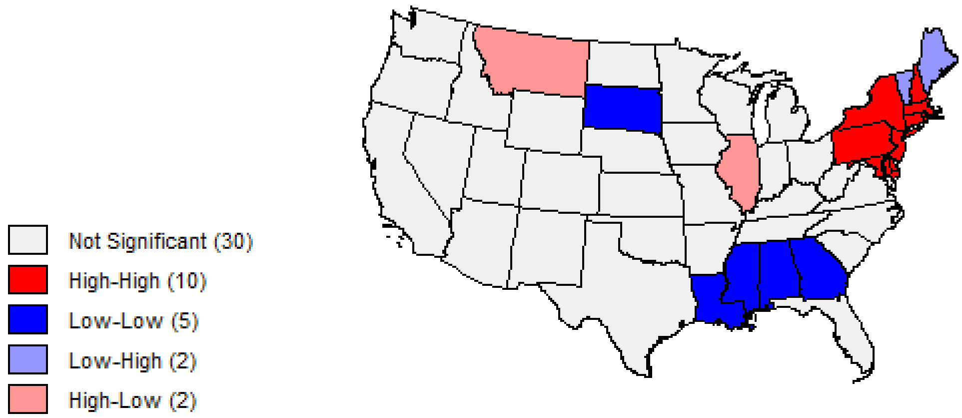


Figure 24. Bivariate Local Moran's I Cluster Map of DV3 and Government Ideology

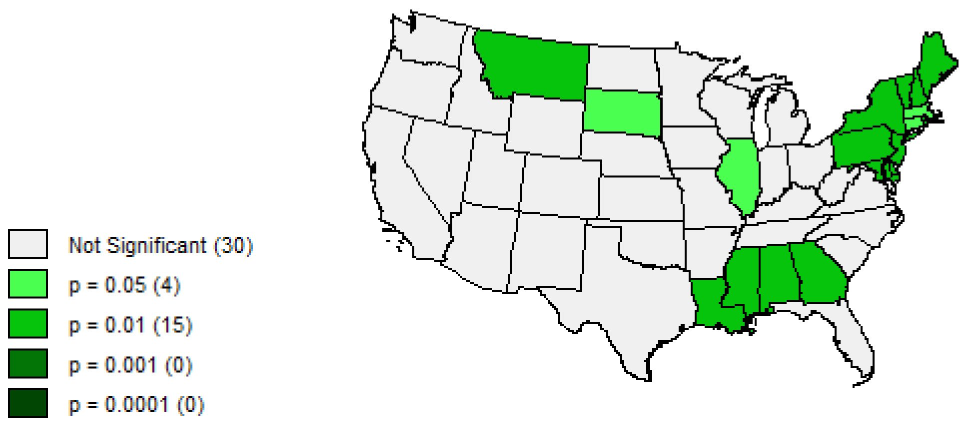


Figure 25. Bivariate Local Moran's I Significance Map of DV3 and Government Ideology

The results of the local spatial autocorrelation analyses for the diffusion independent variable representing the fraction of neighboring states with higher RPS target levels indicated that this effect was observed to be strongest in MI, PA, NJ and DE. This grouping of states represents those that are the most active in setting their RPS target levels lower that their neighboring states. With the exception of Michigan, none of these states have high renewable energy potential capacities, so it is possible that this effect is strongest in states with lower RE potential and subsequently have the least to gain by investing in RE generation infrastructure. The bivariate local Moran's I scatterplot, cluster and significance maps for the regional diffusion variable are shown in Figures 26, 27 and 28.

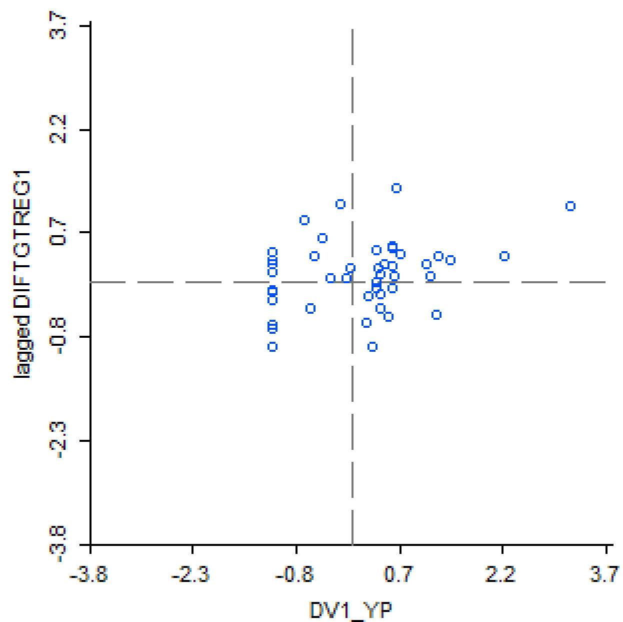


Figure 26. Bivariate Local Moran's I Scatter Plot of DV1 and Diffusion Variable

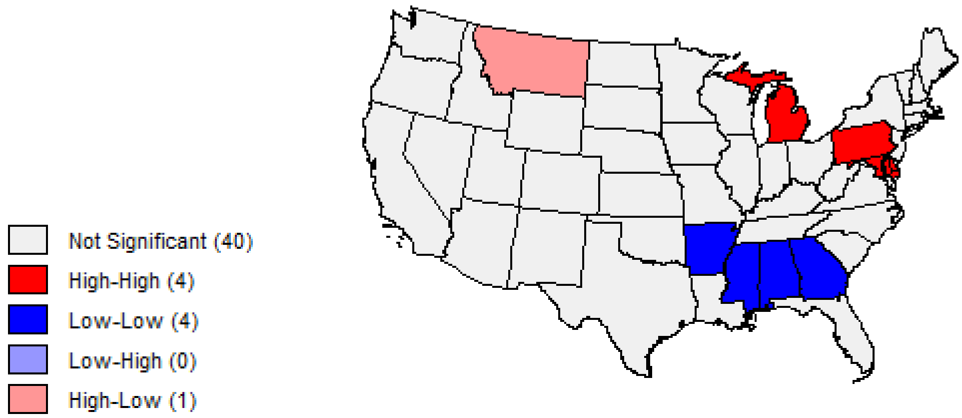


Figure 27. Bivariate Local Moran's I Cluster Map of DV1 and Diffusion Variable

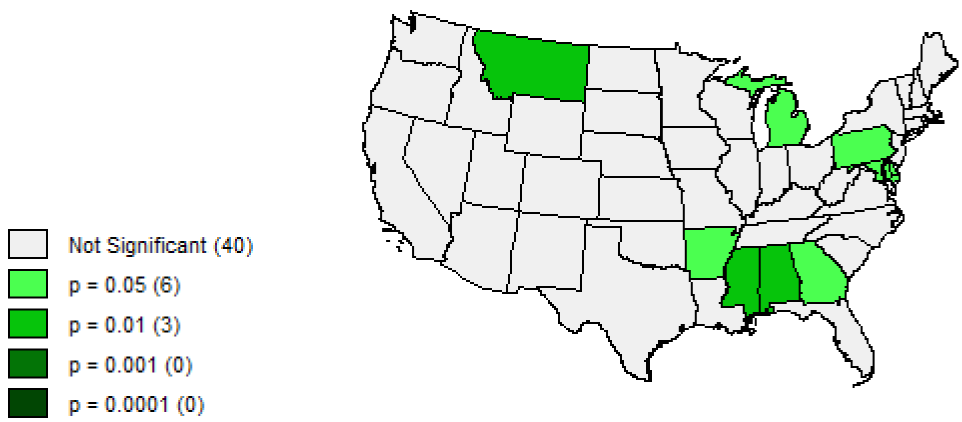


Figure 28. Bivariate Local Moran's I Significance Map of DV1 and Diffusion Variable

Overall, both the global spatial lag and error autocorrelation models exhibited improved predictive ability to determine the influence of individual factors over conventional OLS multivariate regression approaches. The LISA approach proved to be very effective at isolating the localized cluster centers and the geographic patterns that are contributing the most strongly to the global Moran's I geospatial autocorrelation outcome result. In terms of the spatial models, those that utilized weight matrices constructed with distance based contiguities proved to be the more effective at determining significant high-high local clustering. Weight matrices utilizing Queen-based and Rook-based contiguities yielded considerably smaller significant cluster groupings, but not nearly as large and detailed as when a distance-based approach was used.

CHAPTER 5: CONCLUSIONS

The following conclusions chapter is divided into four sections and provides an overall summary of the results of this study and their implications. The first section addresses each of the hypothesis-based research questions and provides a brief recap for each of the answers that this study provided. In the second section a discussion of the lessons-learned during the course of this study is provided. The third section describes the overall contributions that this study makes in terms of its findings and future avenues of further research are discussed in the fourth and final section.

5.1 Summarized Conclusions

In terms of the regulation-based research question, results indicated that regulatory commission size was not a predictor of state RPS target levels. It was hypothesized that states with larger public utility regulatory commission staffing levels per system capacity and hence more highly regulated would set higher target levels. Similarly, transmission line infrastructure did not appear to have any effect on RPS target level for any of the three measures of RPS target level. It was hypothesized that states with higher transmission line densities would set higher RPS target levels. Political ideology, particularly state government ideology did have a positive effect in predicting RPS target levels. This result was consistent with previous studies of the predictors of RPS adoption by; Carley and Miller (2009), Yin and Power (2010), Matisoff (2008), Lyon and Yin (2010), Huang et al (2007), and Chandler (2009). Local geospatial analyses indicated that the effect was predominant in states that were ideologically more liberal in terms of citizen and governmental level ideology. For the policy innovation-related research question querying the role of internal determinants and regional diffusion in predicting RPS target levels, it was found that both factors were capable of predicting RPS target levels with diffusion playing a marginally larger role. Internal determinants that predicated RPS target level included the average electricity price, government ideology and to a lesser extent RE potential capacity. A diffusion effect was found to exist but in the opposite of the hypothesized direction as it was found that policymakers have been setting state RPS target levels lower than their bordering neighbor states. Finally it was found that geo-spatial patterns were present as regional spatial cluster centers were found to exist for the dependent variables representing RPS target level in a grouping of northeastern states. It was also found that geospatial clustering was evident for the independent variables that were significant predictors of RPS target level.

5.2 Lessons Learned

In the course of this study a number of lessons were learned that are worthy of mention for future researchers. First, the predictive power of the regression models was improved when the dependent variable (DV1) which provided a measure of level of effort was utilized. The DV1 dependent variable yielded the highest regression coefficients for the nearest-neighbor diffusion and average electricity price independent variables. In the majority of regression models where dependent variables DV2, which accounted for policy coverage and DV3 which provided an absolute measure of policy target level were utilized the regression coefficients were consistently lower. It appears that measures of RPS target level that include existing RE capacity and are representative of the true level of effort that is necessary to reach targets can add predictive power to regression models. Second, in the nearest-neighbor diffusion analysis portion of the study, it was found that diffusion independent variables developed using only the immediate neighbor states for each state were low in predictive power due the fact that some states had few immediate neighbors and the diffusion variable had too few distinct values. The diffusion variables were improved by including both a given state's immediate neighbor states and the "neighbors of neighbors" in their calculation. The resultant enhanced diffusion variables exhibited improved predictive power and provided a wider and more encompassing measurement of inter-state regional diffusion. Finally, it was found that the global spatial lag and error autocorrelation models had more predictive power than the traditional OLS multivariate regression and robust regression estimations. Their improved predictive ability could be due to the fact that these approaches accounted for spatial dependence effects by factoring geospatial weight matrices into the regression model which accounted for the geographic and spatial nature of the primary units of analysis. It is hoped that geospatial tools will find more use in the social sciences, especially in studies where the presence of diffusion effects are purported to exist.

The use of U.S. a state border physical shapefile for geospatial autocorrelation analysis presented some interesting geometric accuracy and data validity issues particularly in cases where state geographic borders were defined by rivers. Several Eastern U.S. state borders are defined by the natural flow patterns of rivers that meander and change with time. This is especially true for multiple states in the U.S. southeast regions and noticeably apparent in the alluvial valley of the lower Mississippi River which stretches from the Southern tip of Illinois to Southern Louisiana. This phenomenon was apparent with the borders of several eastern U.S. states including Arkansas, Mississippi, Louisiana and Oklahoma and border-defining rivers including the Mississippi, Ohio and Red Rivers. In some cases the differences in the border length distance magnitudes between a plotted river-defined border and a simple straight line drawn between the geographic start and end points pairs was as great as 2-3 times. Since the intent of the geospatial analysis was to measure geospatial and diffusion effects and inter-state border interactions, this issue may result in errors. In future studies, it might worth considering modifying the U.S. state border shapefile using a vector based editing tool (e.g. ArcGIS), and replacing some longer portions of state river-defined borders with a line segments or polyline entities that could provide a truer representation of the "political" length of interstate borders.

5.3 Implications for Future Policy

The primary contribution that this study makes is its finding that renewable portfolio standard target levels are being driven by a multiple factors of which only a few are essential to creating effective policy outcomes. The results of this research indicate that RPS target levels have been primarily influenced by an inter-state diffusion effect, the cost of electricity, state government ideology and to a lesser extent the state's actual renewable energy potential capacity. Patton & Sawicki (1993) and Weimer and Vining

(1989) both emphasized the importance of policy goals and objectives, hence stringency, as a major critical component of policy problem analysis. In the case of state renewable portfolio standards, whose primary purpose was to stimulate RE economic development, the setting of realistic and meaningful policy targets is crucial. In order to maximize policy effectiveness, the selection of target levels should have been determined by multiple state internal factors including the potential capacities of RE sources for the state and the availability of a robust infrastructural network for the delivery of electricity from known locations of maximum potential RE yield. This knowledge would ensure that policy targets are set realistically to reflect a state's natural endowment of RE potential and the ability to deliver it efficiently to customers. This approach would also reveal the inadequacies in the power delivery network that could be remedied in order to achieve the state's ultimate renewable energy potential generation capacity.

State electricity providers have extensive knowledge of existing infrastructural electricity transmission system networks and their limitations. State potential RE capacities are also known and available from the National Renewable Energy Laboratory (NREL). It is speculated that policymakers in their determination of RPS quantitative targets and goals may not have such knowledge readily available to them due to either communication issues or existing asymmetries of information between energy providers and state regulatory staff. Better communication between state policymakers who set RPS targets, public utility commission staff who regulate providers, and utility personnel who understand the systemic limitations of the grid is imperative. The importance of setting realistic and attainable RPS targets with accurate systemic information is crucial if the overall goal is to maximize their effectiveness. The current lack of a national renewable portfolio standard will likely mean that future deployment levels of RE infrastructure in the U.S. will continue to be driven by policies at the state level which further underscores the importance of developing effective state policies to mitigate the effects of climate change.

5.4 Future Directions for Research

This study found that RPS target levels could be predicted by a state's average electricity price. Unfortunately electricity price was a variable chosen to be representative of state internal determinants and the nature and direction of its effect on the dependent variables was not hypothesized. One could hypothesize however that wealthier, more affluent states set higher RPS target levels because the state can afford the infrastructural costs and known reduced generation efficiencies associated with RE generation sources. Potential future studies in this area could explore the predictive power of measures of state affluence on RPS target levels. Since the price of electricity is known to influence RPS target levels, future studies could also explore the complex financial relationships in electricity markets that exist between public state utility regulating commissions, energy providing utilities and private sector renewable energy producers/entrepreneurs.

The results of this study indicated that the amount of state regulation had no effect on RPS target levels. It would be worthwhile to further study the effect of deregulation on electricity markets especially now that current regulatory actions have opened these market to RE suppliers. Future researchers could determine if current regulatory changes have created economic rents for private sector RE supply firms, or as Buchanan (1980) posited "opportunities for profit-seeking entrepreneurs that might not have existed in a previously ordered market structure" (p. 5). A study of the Independent Power Producers (IPP's) that have entered the electricity generation market in recent years and of the factors contributing to their success or failure would be very worthwhile.

Another potential avenue for research lies in determining the overall effectiveness of state renewable portfolio standards now that several of them have been in effect for a number of years. At present, several states have installed varying amounts of RE generation capacity on their grid systems and it would also be worthwhile to utilize deployed system RE capacity data in determining the effectiveness of policy for states that have an RPS in effect, states that have no RPS and states that have an established RE capacity goal. The findings of the diffusion portion of this study indicated that the market may not be truly competitive and that states may be relying on their neighbors to set higher targets and have hence have developed creative workarounds to ensure their success in achieving the target goals and objectives of their respective renewable portfolio standards. Future studies could explore the origin and dynamics of this “race to the bottom” effect possibly by exploring the role played by the trading of renewable energy credits between states or by looking for evidence that some states are deferring the capital expense of renewable energy generation infrastructure to their neighboring and inter-regional states.

Finally, future research efforts could be conducted towards the development of a software tool for policymakers to aid them in setting optimal RPS target levels that could potentially lead to more effective policies. In determining RPS target levels such a tool could incorporate internal factors unique to each state including: economic feasibility, political feasibility, state RE potential capacity, the presence of an infrastructural transmission network, land use and terrain and multiple other factors. This study determined that with the exception of RE potential capacity, few of these factors were taken into consideration in the development of RPS target levels by state policymakers. Ideally, the development of such an analytical tool could enable policymakers to make better and more informed RE policy decisions and create more realistic RPS target levels that are uniquely applicable to their state.

APPENDIX A

UNIVARIATE LOCAL SPATIAL AUTOCORRELATION FIGURES

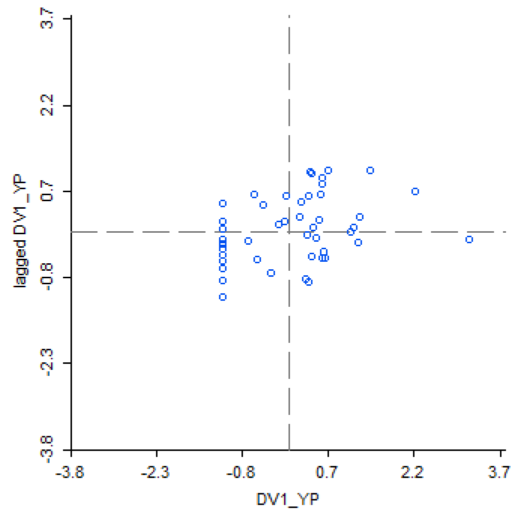


Figure 29. Moran Scatter Plot of DV1 (Level of Effort), Queen Contiguity

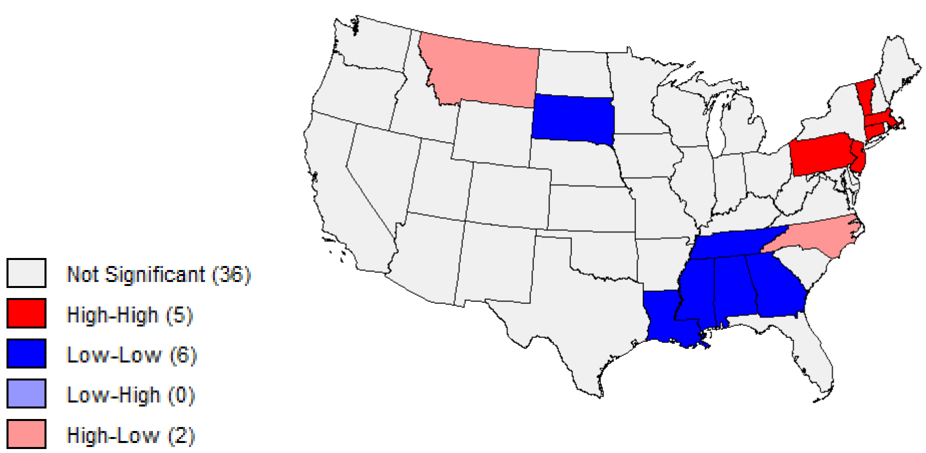


Figure 30. LISA Cluster Map of DV1 (Level of Effort), Queen Contiguity

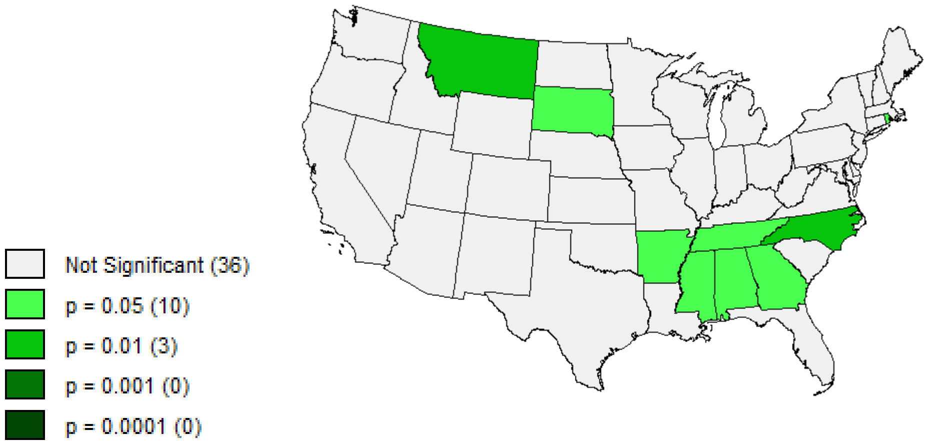


Figure 31. LISA Significance Map of DV1 (Level of Effort), Queen Contiguity

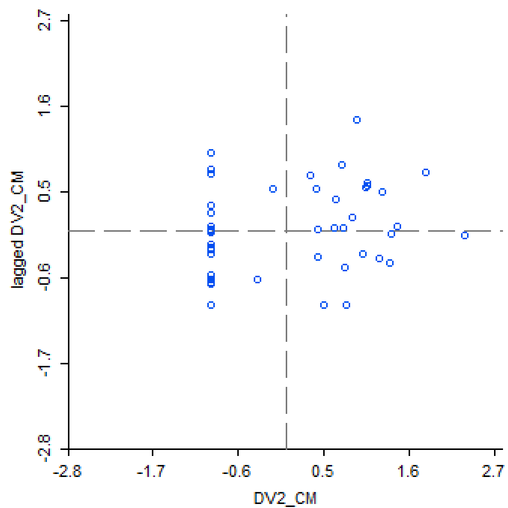


Figure 32. Moran Scatter Plot of DV2 (Policy Coverage), Queen Contiguity

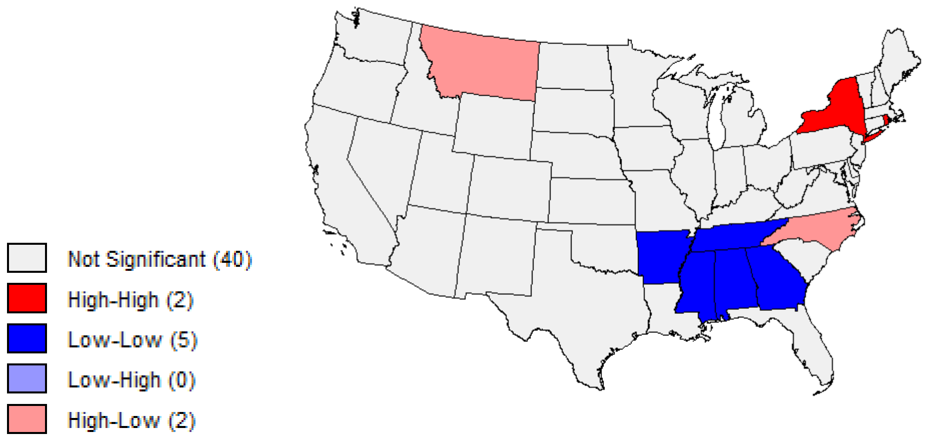


Figure 33. LISA Cluster Map of DV2 (Policy Coverage), Queen Contiguity

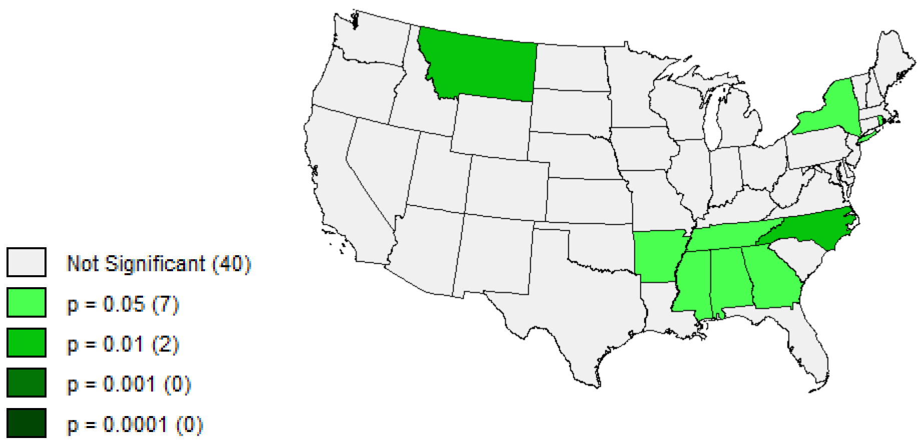


Figure 34. LISA Significance Map of DV2 (Policy Coverage), Queen Contiguity

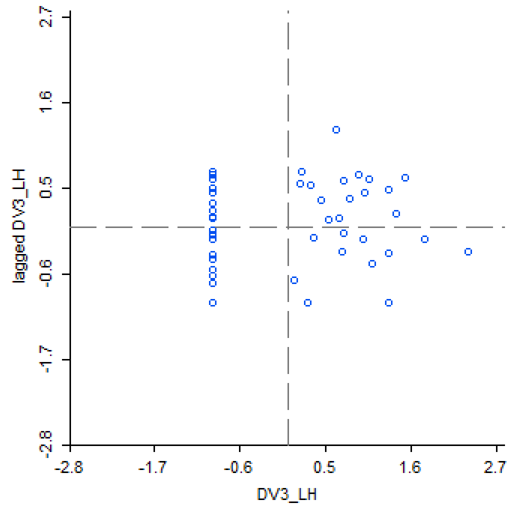


Figure 35. Moran Scatter Plot of DV3 (Absolute Target), Queen Contiguity

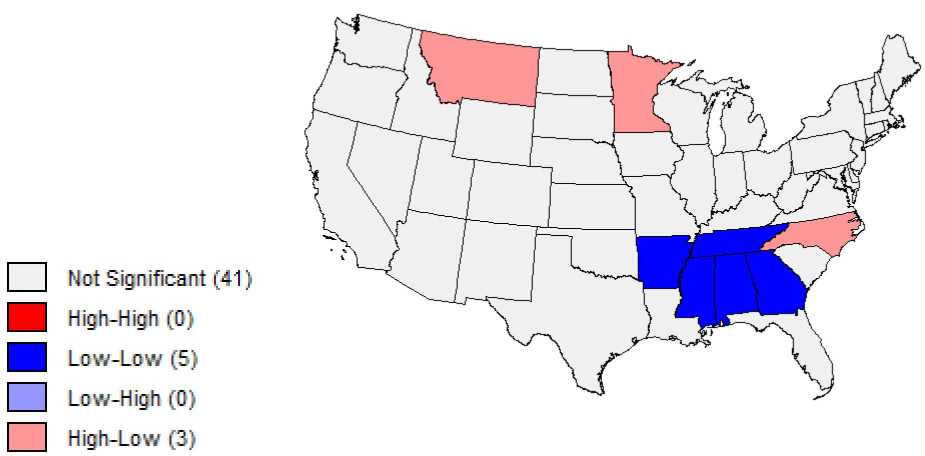


Figure 36. LISA Cluster Map of DV3 (Absolute Target), Queen Contiguity

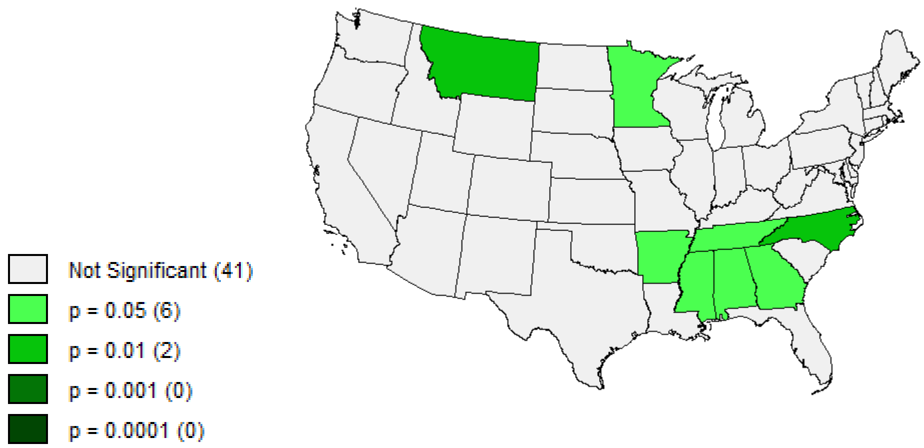


Figure 37. LISA Significance Map of DV3 (Absolute Target), Queen Contiguity

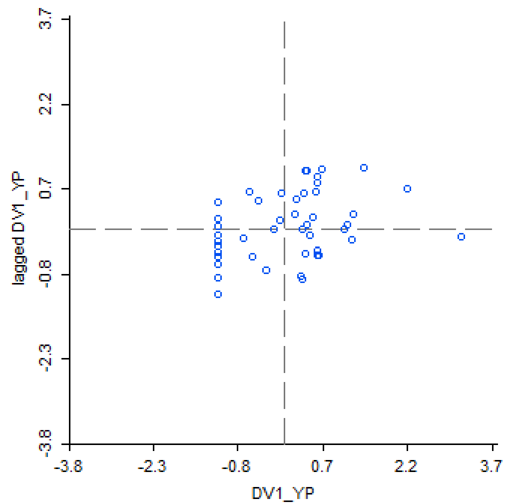


Figure 38. Moran Scatter Plot of DV1 (Level of Effort), Rook Contiguity

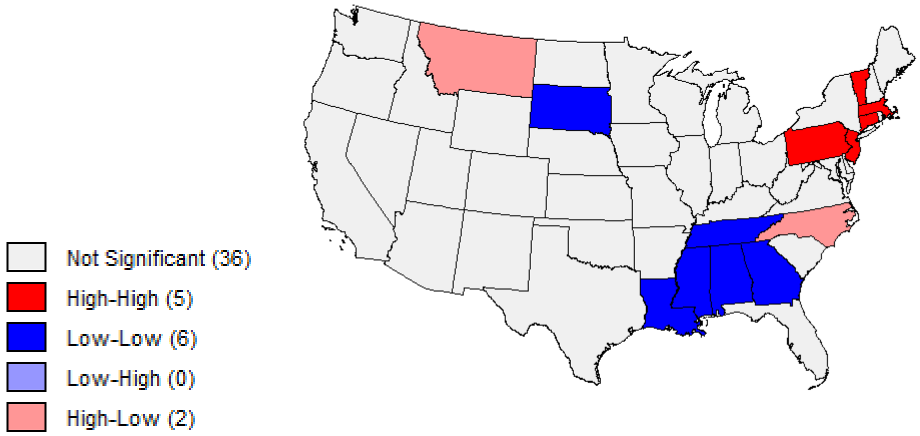


Figure 39. LISA Cluster Map of DV1 (Level of Effort), Rook Contiguity

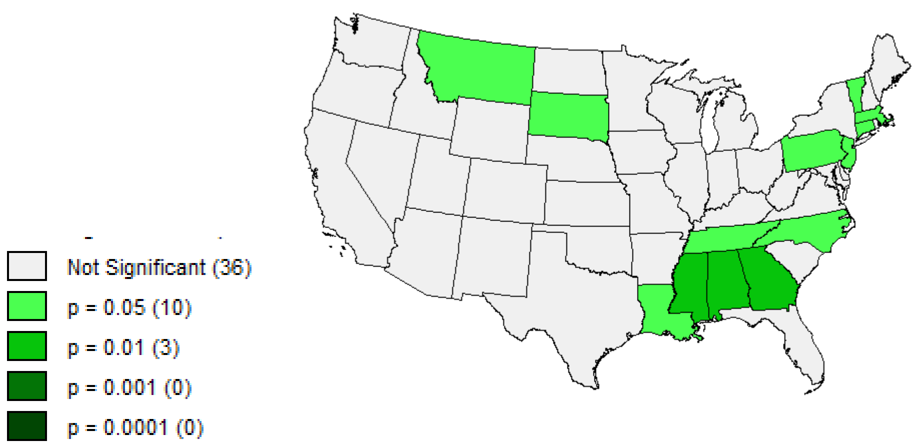


Figure 40. LISA Significance Map of DV1 (Level of Effort), Rook Contiguity

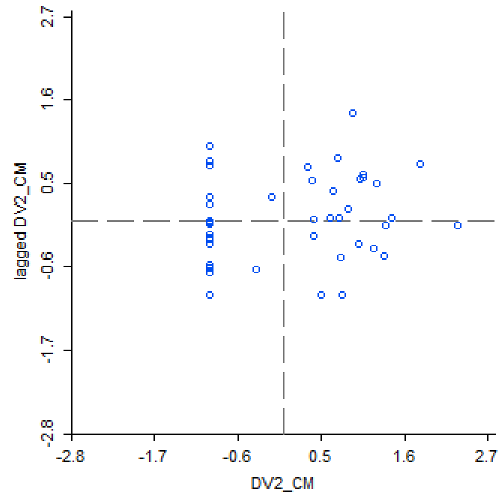


Figure 41. Moran Scatter Plot of DV2 (Policy Coverage), Rook Contiguity

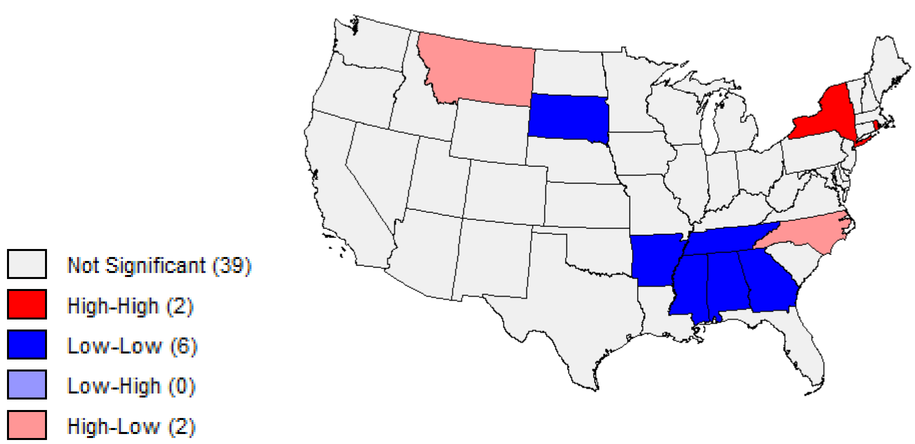


Figure 42. LISA Cluster Map of DV2 (Policy Coverage), Rook Contiguity

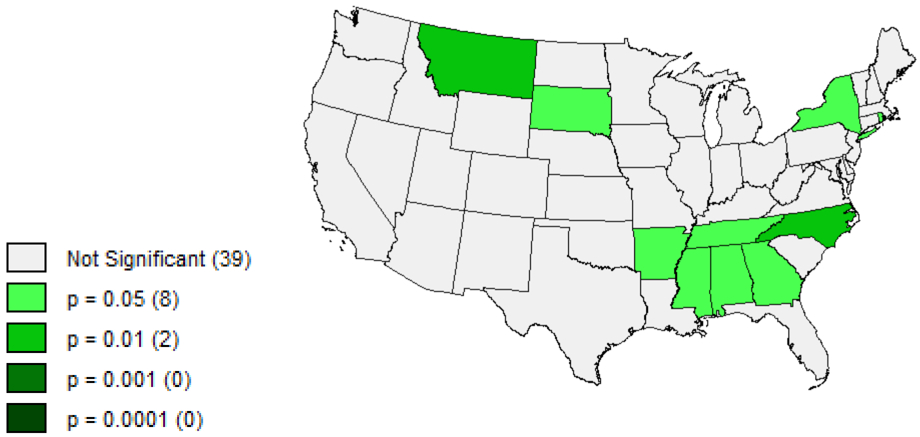


Figure 43. LISA Significance Map of DV2 (Policy Coverage), Rook Contiguity

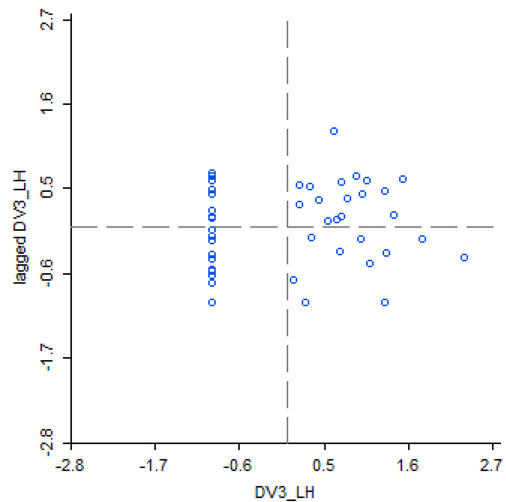


Figure 44. Moran Scatter Plot of DV3 (Absolute Target), Rook Contiguity

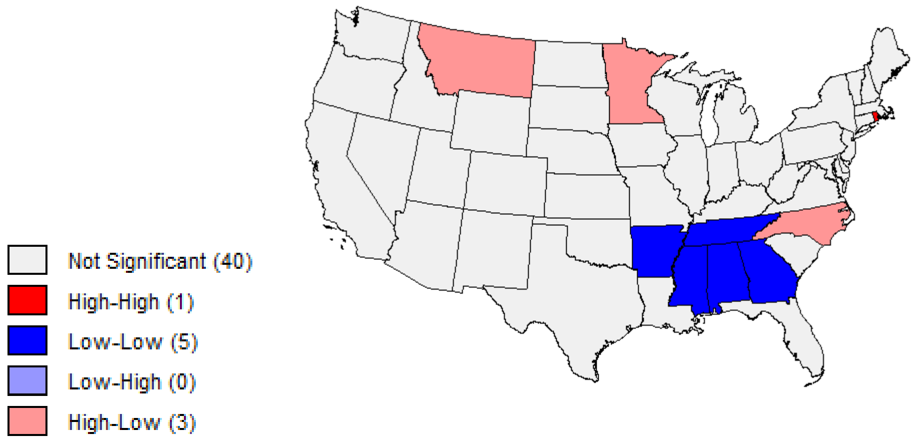


Figure 45. LISA Cluster Map of DV3 (Absolute Target), Rook Contiguity

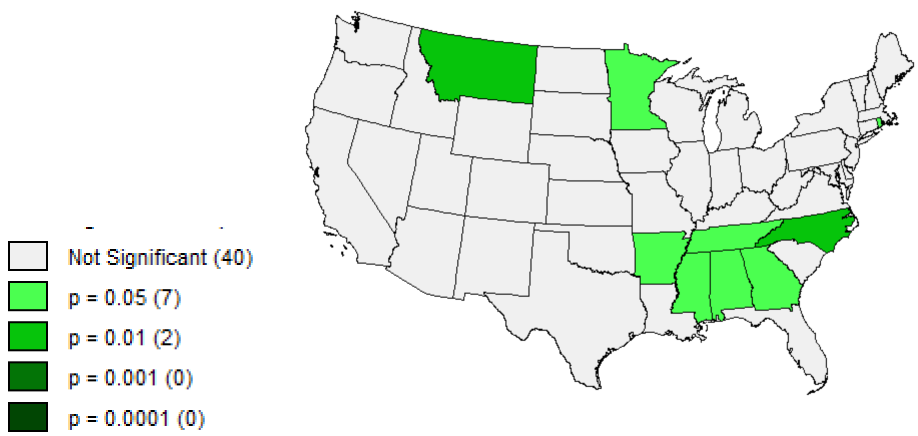


Figure 46. LISA Significance Map of DV3 (Absolute Target), Rook Contiguity

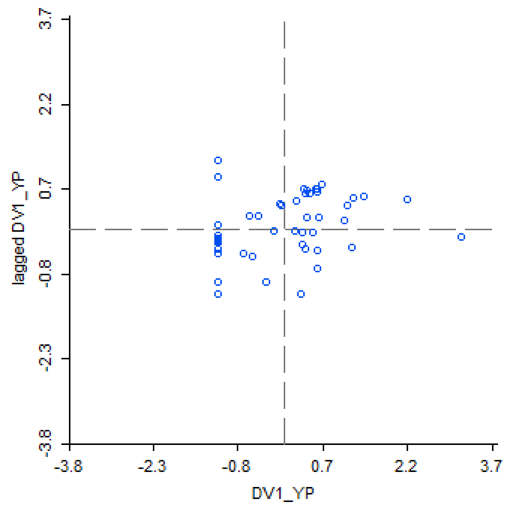


Figure 47. Moran Scatter Plot of DV1 (Level of Effort), Distance Contiguity

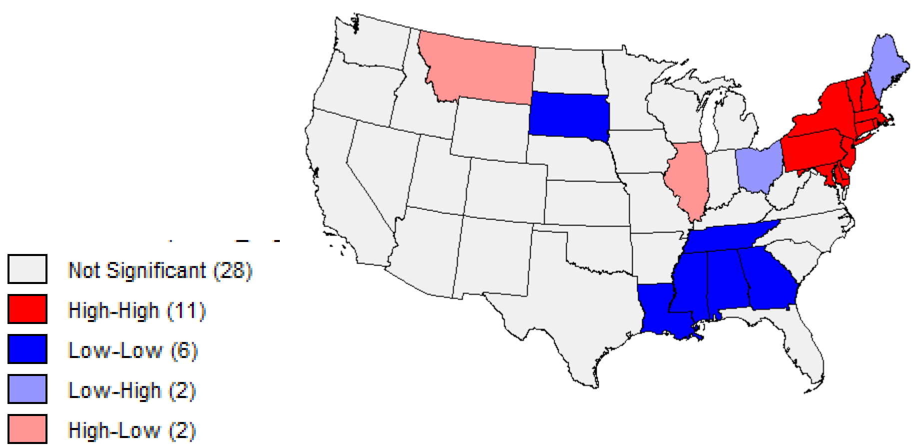


Figure 48. LISA Cluster Map of DV1 (Level of Effort), Distance Contiguity

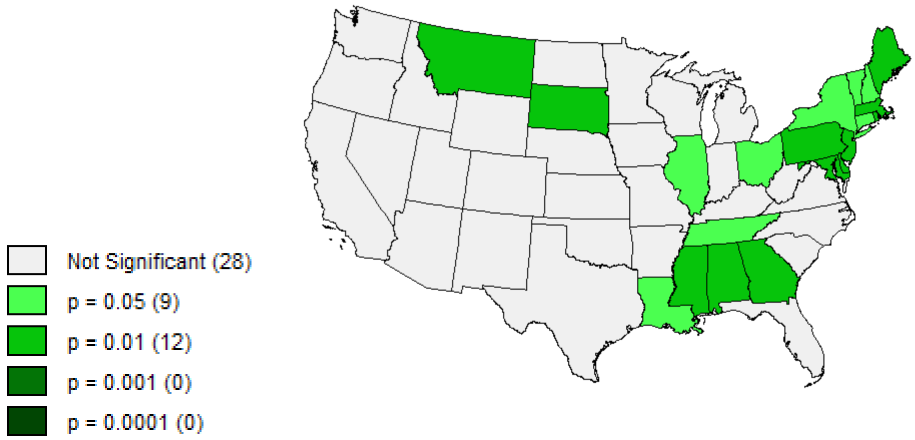


Figure 49. LISA Significance Map of DV1 (Level of Effort), Distance Contiguity

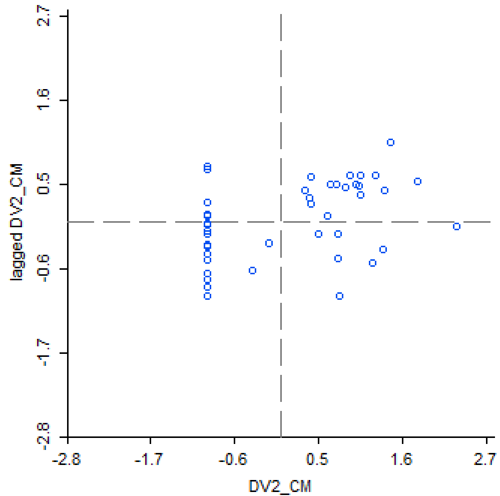


Figure 50. Moran Scatter Plot of DV2 (Policy Coverage), Distance Contiguity

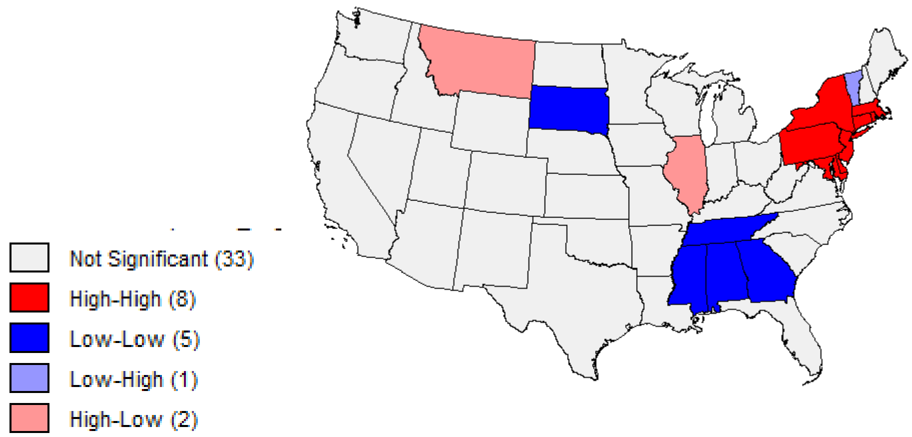


Figure 51. LISA Cluster Map of DV2 (Policy Coverage), Distance Contiguity

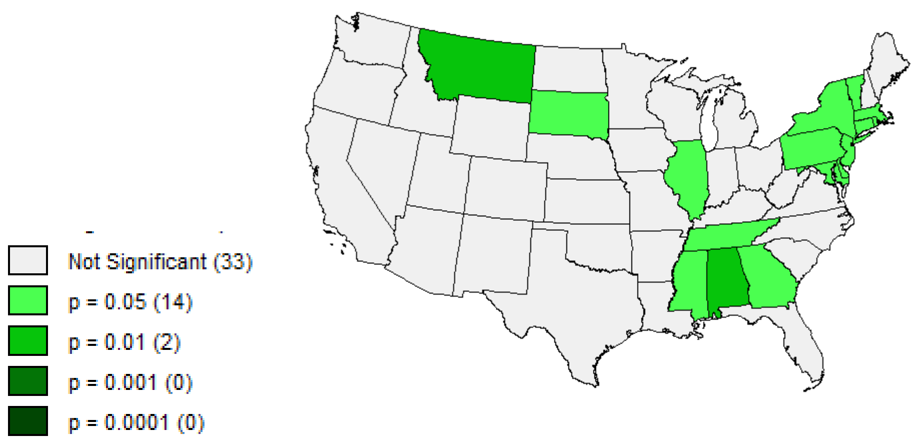


Figure 52. LISA Significance Map of DV2 (Policy Coverage), Distance Contiguity

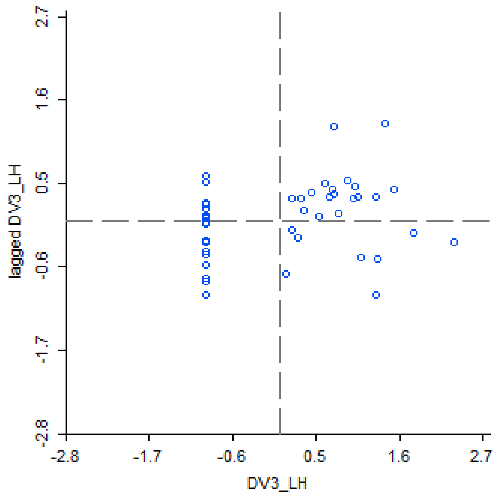


Figure 53. Moran Scatter Plot of DV3 (Absolute Target), Distance Contiguity

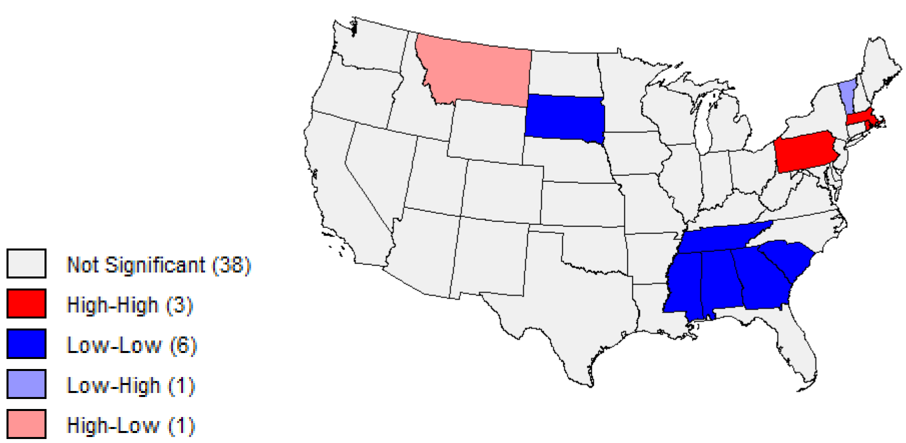


Figure 54. LISA Cluster Map of DV3 (Absolute Target), Distance Contiguity

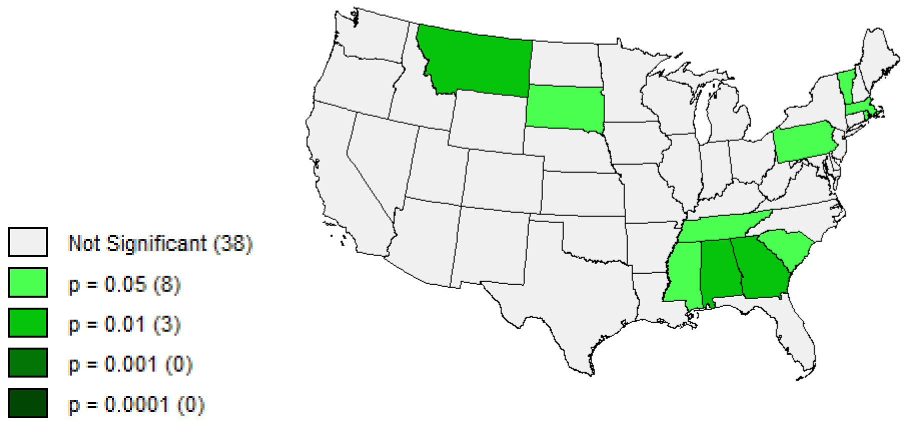


Figure 55. LISA Significance Map of DV3 (Absolute Target), Distance Contiguity

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