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Renewable Energy Adoption and Natural Disasters in the United States

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Abstract

This research investigates the hypothesis that states within the United States which have experienced a greater number of major natural disasters are more likely to adopt renewable energy systems. Research in adoption and diffusion, adaptive management, community resilience and natural hazards provides a theoretical understanding for this hypothesis. These fields support the idea that direct experiences can shape how individuals perceive risk(Dominicis, et al., 2014), adapt to change (Mase, et al., 2016), view pro-environmental political policies (van der Linden, 2015), and influence behavior (Rudman et al., 2013). The research also suggests experiences with natural disasters could lead to higher rates of renewable energy adoption as an adaptive mechanism that improves energy security, community resilience and mitigates long-term natural disaster risk (Park, et al., 2013). Physical realities also connect renewable energy adoption and disaster experience wherein the destruction of existing infrastructure provides the opportunity to improve community resilience by shifting energy sourcing to decentralized and renewable technologies. In addition to the social and physical realities that accompany natural disaster events, individuals and communities participating within an adaptive cycle may act in ways that mitigate future losses. The results of global and spatial regression analysis support the hypothesis that major natural disaster events appear to be an important factor that works within a complex society-energy system to increase the adoption of renewable energy.

Keywords: *renewable energy, natural disasters, energy resilience, energy adoption*

1. Introduction

The adoption of technologies and diffusion of innovations has been one focus of geographic and planning research for decades (Zahran, et al., 2008). Renewable energy system technology is one area of adoption studies that has investigated demographic, economic, government, and other characteristics of the early adopters of renewable energy systems. The current research tests demographic characteristics, energy costs and non-renewable energy variables, government policy and the total number of presidentially declared natural disasters.

Weather related disruptions to electricity grids have been increasing and are likely to continue to do so as the impacts of climate change. These impacts are being experienced and are represented by the graph from the Energy Information Administration (2013). A simple conceptual overview of the processes connecting natural disaster to renewable energy adoption is seen below and incorporates one simplified understanding of why states that have higher numbers of major natural disasters also have higher renewable energy generating capacity. The adoption of distributed renewable energy systems is one of many choices that can improve individual and community energy resilience as well as energy security. When these renewable energy systems are adopted, they can benefit adopters during other natural disasters while also mitigating long-term risk by decreasing carbon pollution. The decentralized nature of renewable energy systems is one quality that builds an energy system that is more resistant to disruption and better able to recover after a disaster event. It is within this framework that the current study provides evidence that major natural disaster events are a driver of renewable energy adoption.

2. Method, Results, and Discussion

2.1. Method

This research used publicly available data, hierarchical multiple regression analysis, and a geographic information systems (GIS) statistical and spatial analysis to test the hypothesis. Data used were from all 50 states and the District of Columbia. Independent variables were regressed on the dependent variable of renewable energy electricity summer capacity. The independent variables were entered in 4 steps with demographic variables, electricity costs and non-renewable generation capacity, government support in terms of renewable energy portfolios, and total number of disasters in that order. These same data were used in the GIS analysis. A table further describing these can be found in section 3.

2.2. Results

The results of the regression analyses support the hypothesis that states with a higher frequency of natural disasters have higher renewable energy capacity. The inclusion of the natural disasters variable into the regression model predicting renewable energy capacity significantly improves the accounted variance, improving the R^2 from a .304 to .719. The significant predictors of renewable energy capacity were fossil fuels capacity and total natural disasers. The significant relationships represented an increasing renewable energy capacity as the number of ntural disasters increased while fossil fuel capacity decreased. The regression analyses can be found in section 3.

2.3. Discussion

The analyses of these data provide robust support for the hypothesis that renewable energy capacity increased within states that have a higher frequency of natural disasters. These analyses also add the interesting finding that fossil fuel energy capacity decreases as the number of natural disasters increase. This finding may document the beginnings of an energy transition. In a society-energy system that has increasing pressure from weather-related disruptions to the electric grid and increasing influence of social pressure to shift energy sources, it is possible that states are one place that this phenomenon can be observed. The adoption of renewable energy will provide substantive advantages to communities that will continue to suffer from increasing climate disruptions. Documenting the shift from the perspective of a complex system adapting to those changes may help support actions taken at various levels to foster the deployment of renewable energy systems.

3. Tables, figures, equations, and lists

3.1. Tables

Table 1: Sources and variables used in analyses of entire United States.

Variable	Variable Coding Name	Source	Date Covered	Date Retrieved
Renewable Electricity Summer Capacity by State	NetRE15	Energy Information Agency	2015	2017
Total Number of Natural Disasters from 1953-2015	TotDisasters15	Federal Emergency Management Agency	1953-2015	2017
Fossil Fuel Electricity Summer Capacity by State	NetFossilFuels15	Energy Information Agency	2015	2017
Percent of Population with a Bachelor's Degree or higher	BachelorMore15	United States Census	2015	2017
Nuclear Electricity Summer Capacity by State	NetNuclear15	Energy Information Agency	2015	2017

Average Cost of Electricity by State	AvCost15	Energy Information Administration	2015	2017
Median Age of Population by State	MedianAge15	United States Census	2015	2017
Renewable Portfolio Standard	RPS15	National Renewable Energy Laboratory	2015	2017

Table 2: Hierarchical regression analysis predicting renewable energy production.

Predictor	B	Standard Error	b	T	*p*	R^2
Model 1						
PopDensity15	-2.972	2.007	-.280	-1.481	.145	
BachelorHigher15	172.742	165.602	.193	1.043	.302	
MedianAge15	-499.923	311.339	-.231	-1.606	.115	
						.077
Model 2						
PopDensity15	-3.450	1.867	-.325	-1.848	.071	
BachelorHigher15	342.236	175.688	.383	1.948	.058	
MedianAge15	-279.501	301.457	-.129	-.927	.359	
AvCost15	-220.259	250.325	-.137	-.880	.384	
NetNuclear15	-.338	.328	-.160	-1.031	.308	
NetFossilFuel15	.175	.054	.505	3.225	.002	
						.280
Model 3						
PopDensity15	-2.965	1.897	-.279	-1.563	.125	
BachelorHigher15	239.585	193.483	.268	1.238	.222	
MedianAge15	-354.344	305.774	-.164	-1.159	.253	
AvCost15	-201.242	249.334	-.125	-.807	.424	
NetNuclear15	-.312	.327	-.148	-.955	.345	
NetFossilFuel15	.170	.054	.491	3.149	.003	
RPS15	2288.320	1855.780	.181	1.233	.224	
						.304
Model 4						
PopDensity15	-.638	1.255	-.060	-.508	.614	
BachelorHigher15	134.153	125.110	.150	1.072	.290	
MedianAge15	-78.849	199.672	-.036	-.395	.695	
AvCost15	-145.622	160.455	-.090	-.908	.369	
NetNuclear15	.561	.238	.265	2.360	.023	
NetFossilFuel15	-.206	.059	-.596	-3.492	.001	
RPS15	723.786	1209.519	.057	.598	.553	
TotDisasters15	116.578	14.802	1.172	7.876	.000	
						.719

N = 51, R^2 = .719

3.2. Figures

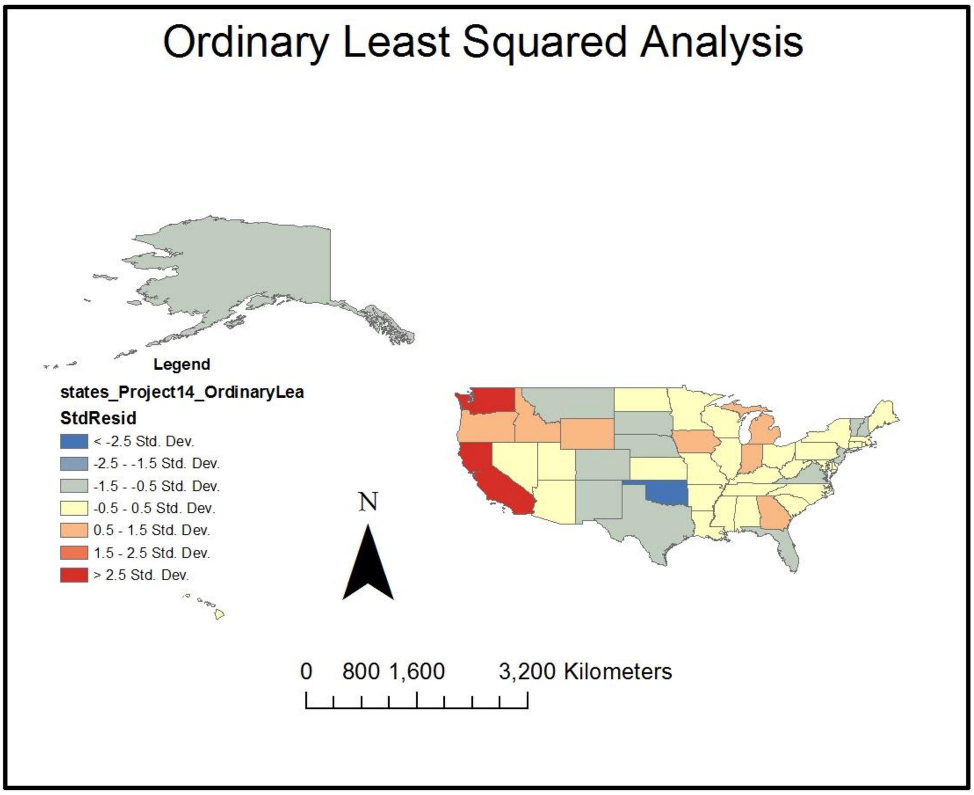

Figure 1: Spatial regression analysis of renewable energy adoption model including natural disasters variable. (R^2 = .72, N = 51)

4. References

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