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UNIVERSITY OF CALIFORNIA,
IRVINE

The Global Rise in Renewable Energy

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Sociology

by

Jolene McCall

Dissertation Committee:
Professor Evan Schofer, Chair
Professor Anne Hironaka
Professor Charles C. Ragin

2018

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DEDICATION

To

Tim and our remarkable children
for your support, patience, and unconditional love

and

my mother, sisters, and brothers
for always believing in me

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ACKNOWLEDGMENTS

Rarely in life are successes achieved alone without the support of many. I am incredibly grateful to the community that has supported me throughout the years and guided me to achieve my goals. Without the support and guidance of scholars, colleagues, family and friends, who have offered their patience, time, insight, and understanding throughout this journey, I would have not made it this far.

I am extremely appreciative of my dissertation committee: Evan Schofer, Ann Hironaka, and Charles Ragin. Not only was the advice and feedback I received leading up to the dissertation instrumental, but the encouragement and reassurance throughout the process was invaluable. I am grateful for Ann challenging me to reach further, providing critical feedback, and offering endless amounts of support. I truly appreciate Charles's expertise and encouragement that helped grow my research skills tremendously and confidence as a scholar. I am thankful for the support and guidance which David Frank and Linda Cohen provided during the dissertation proposal stage and for the enthusiasm they expressed for my project.

I am particularly indebted to my advisor, dissertation chair, and mentor, Evan Schofer. The countless hours Evan took providing me with ample amounts of support, feedback, advice, and encouragement were vital to my success. As I navigated both graduate school and motherhood, Evan's support and guidance pushed me to become a better scholar while also offering skills and reinforcement for maintaining a balance between family and work. While working endlessly with me to improve my research skills, writing, and theoretical understandings, Evan's compassion and encouragement created the foundation I needed to accomplish each goal along the way.

At UC Irvine, I have been incredibly fortunate to have had the opportunity to work closely with a number of professors and get to know many others very well. I am especially grateful for Cecelia Lynch, whose passion, knowledge, experience, and support will continue to inspire me while also challenging me to reach further. I am appreciative of the mentorship of Estela Zarate who provided me many research opportunities which were imperative for developing my research skills. Catherine Bolzendahl was a key figure in my journey into sociology and I am forever grateful for the support and guidance she provided and for introducing me to a broad range of sociological theory and perspectives. I wish to thank David Smith for his critical feedback and always taking time to provide input on my projects. I am thankful for the abundance of support and encouragement from Julia Lerch, who gave me confidence in presenting my research. David Meyer's continuous guidance and support were a significant part of my success and I am grateful for all of the time he took to offer teaching, research, and life advice. Finally, I wish to thank Nurudeen Alao for many wonderful quarters that I served as a teaching assistant in his classes.

The support that John Sommerhauser provides students in the School of Social Sciences daily is insurmountable. John is patience, knowledgeable, and compassionate and his help navigating the program was critical to my success. I am very appreciative of the depth of knowledge and support he provided me as I approached every juncture in the program. I also wish to thank Patricia Frazier, Matt Arias, and Ekua Arhin for all of their help, hard work, and kindness.

I'd like to thank my colleagues at UC Irvine, especially, Megan Brooker, Kathryn Hoban, Julie Kim, Anna Penner, Brian Wiley, Kelly Ward, Aaron Tester, Christopher Gibson, and John McCollum. I relied deeply on the strength and unconditional support of my colleagues and I am incredibly grateful to each and every one of them.

Throughout my time at UC Irvine and during my work on this project, I was supported by those both within academia as well as outside. I am overwhelmed by the amount of enthusiasm, encouragement, and support from my community who kept me going at moments of doubt and guided me back to a place of confidence. My final thanks is to Timothy VanderBeek who spent countless hours proof-reading all of my work, providing feedback on all of my presentations, talking through all of my ideas, and always believing in my abilities.

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ABSTRACT OF THE DISSERTATION

The Global Rise of Renewable Energy

By

Jolene McCall

Doctor of Philosophy in Sociology

University of California, Irvine, 2018

Professor Evan Schofer, Chair

Global, anthropogenic climate change has resulted in worldwide responses to address the existing and potential impending dangers to society. As a result, the world sits at an historic crossroads as efforts to transform the energy sector globally continue to progress. This research examines the global rise in renewable energy and the complex factors underlying this international phenomenon. The IPCC (2014) identifies renewable energy as a viable alternative to fossil fuels with the potential of mitigating climate change. However, despite a steady increase in renewable energy generated worldwide, there remains immense variation amongst nations in the amount of electricity being generated by renewable sources. In this dissertation I focus on understanding the variation in renewable energy generation as well as renewable energy regulatory frameworks. In three empirical chapters, I examine the relationship between renewable energy generation and regulatory framework and country-level cultural, political, and economic factors. In my dissertation, I examine (1) factors associated with increases in renewable energy production from 1970 through 2012, (2) factors associated with increases in solar energy generation from 2000 through 2016, and (3) the causal configuration of country-level conditions that result in advanced renewable energy regulatory frameworks. I employ

cross-national time series regression analyses as well as a fuzzy set qualitative comparative analysis. Overall, the findings highlight the impact the environmental regime on the global increase in renewable energy generation, including the role of international treaties and non-governmental organizations. Additionally, the results highlight variation among the mass adoption of renewable energy regulatory frameworks, by identifying the causal configuration of country-level conditions that lead to advanced regulatory frameworks for renewable energy. The findings contribute to the growing environmental sociology literature focused on environmental remediation. This dissertation supports previous research demonstrating the role of international treaty ratification and INGOs in the global civil society and in influencing the trend of renewable energy generation. Furthermore, the findings suggest that the implementation of advanced renewable energy regulatory frameworks is the result of a combination of a multiple country-level conditions.

CHAPTER 1

Introduction: Global Transformations in Energy

The world sits at a momentous crossroads as concerted efforts to transform the energy sector globally have risen to the top of international agendas. This complex and vast undertaking to move away from fossil fuel technology and carbon intensive infrastructure toward a path of more sustainable energy generation pervades global discourses and action. Energy is described as the "only universal currency" (Smil, 2017) where the process of transforming resources into energy is a necessary building block of society. As an integral part of human civilization, the demand for energy continues to rise with projections that global energy consumption will increase by 28 percent by 2040 (EIA, 2017). The majority of this upsurge is anticipated to be generated from renewable sources rather than traditional forms of fossil fuels. The development and expansion of energy in society is an integrative phenomenon interlinked with social, economic, and political processes as well as cultural patterns influencing energy generation and consumption. With the rise and popularity of renewable energy across the globe, it is important to consider the complex factors and dynamics underlying this global transformation in the energy sector.

In 1970, less than a quarter of a percent of electricity was generated from renewable sources worldwide. In contrast, in 2017 electricity generated from renewable sources accounted for 8.4 percent of all electricity generated globally (EIA, 2017). While this increase indicates major shifts across the globe, in certain areas this transformation has been much more radical, with some nations now generating more than 50 percent of their total electricity from renewable sources. In July, 2018, Baynes (2018) with the Independent reported that Germany generates enough solar energy in six months to meet the nation's energy needs for an entire year.

Meanwhile, California is aiming to generate 50 percent of its total electricity from renewable sources by 2030; a goal which it is now anticipated to achieve a decade early. Goals to reduce energy generated by fossil fuels have flourished in recent years with certain nations, such as Sweden, actively racing to become the first country that is completely "fossil fuel free." In what has been termed the "clean energy revolution," ambitious goals of increasing renewable energy generation are also highlighted in Central America where nations like Costa Rica are ambitiously investing in renewable energy technologies and where Nicaragua, in 2012, invested the fifth highest percentage of GDP worldwide towards increasing renewable energy (REN21, 2014). In 2018 in South America, Uruguay reached 44 percent of total generation from wind and solar, following concerted efforts by the government over the past decade (Wynn, 2018). In sub-Saharan Africa, Kenya increased its geothermal energy generation from 13 percent in 2010 to 51 percent of total generation in 2015 while also developing what is anticipated to be among the largest wind farms on the continent (World Bank, 2015). Over the past two decades in Southeast Asia energy consumption has doubled. At the same time, projects and developments to increase electricity generated from renewables are well underway in countries such as Vietnam that aims to increase electricity generated by wind and solar from less than 1,000 MW to 18,000 MW by 2030 (USAID, 2017). The increasing interest in renewable energy over that past few decades and the rapid deployment of renewable energy technologies can be observed across the globe to different degrees marking a major sociological transformation that changes the energy sector dramatically within nations.

Renewable energy is defined as being derived from resources that can be replenished in a short period of time and do not diminish (EPA, 2014). Many forms of renewable energy are viewed as being both sustainable and minimally invasive, particularly in comparison to tradition

fossil fuels used for electricity generation. Renewable energy[1] resources span the globe, covering vast geographical areas and include: solar energy, wind energy, geothermal energy, bioenergy and ocean energy. Solar and wind energy are among the most popular renewable energies in recent years. Solar energy, in particular, is largely responsible for the steady growth in renewable energy expansion as it is seen as the most feasible alternative to fossil fuels (IPCC, 2011). The IPCC (2011) defines solar as the most abundant of all energy sources and predicts that the use of solar energy will continue to rise worldwide. Solar energy technologies use a variety of methods to harness energy from solar irradiance to generate electricity. The use of photovoltaics (PV) is the most widespread means of converting solar irradiance into electricity. Alternatively, concentrating solar power (CSP) can be used to produce thermal energy or to meet direct lighting needs. Wind energy is generated by harnessing the kinetic energy of moving air. Predominantly, this is achieved through the use of large wind turbines located both onshore and offshore. Geothermal energy is generated by converting heat from the Earth's interior into electricity. Geothermal energy is generated in a similar fashion to CSP, however in this case rather than using heat from concentrated solar energy, geothermal power plants generate energy using heat which comes directly from the Earth's core where there are geothermal reservoirs. Bioenergy is used to describe a variety of biomass feedstocks, including "forest, agricultural and livestock residues; short-rotation forest plantations; energy crops; the organic component of municipal solid waste; and other organic waste streams" (IPCC, 2011). These organic materials, wastes, and agricultural and municipal processes are used to produce electricity and often vary by region based on the resources available. The category of bioenergy also includes biofuels which are gas, liquid, or solid fuels that are made from plant material and can be used to produce

[1] Renewable energy excludes hydroelectric energy since this is a fixed resource. Additionally, the driving factors and environmental impact of hydroelectric energy are significantly different than those of other renewable energies. Instead the analysis focuses on the emergence of non-hydroelectric renewable energy in recent decades.

electricity. Lastly, ocean energy is a type of renewable energy that relies on harnessing the kinetic, thermal, or chemical energy of seawater to generate electricity. There are a wide range of technologies that rely on ocean energy to generate electricity, including technologies using tidal and ocean currents, as well as those using thermal or salinity gradients. The heterogenous types of technologies for renewable energy continue to advance with new, innovative technologies emerging and entering the market frequently.

Although modern and often ground-breaking technologies continue to be introduced in the renewable energy market, the use of renewable sources for energy production is not a new phenomenon. Despite the current upswing in renewable energy and the visible shift in the energy sector worldwide, the use of renewable sources has been a consistent means of energy generation and consumption throughout human history. In fact, human existence and survival is dependent upon renewable sources for energy, such as solar radiation for heating the earth to create habitable conditions. Other examples range from the basic use of the wind to propel boats and ships to concentrating rays from the sun to create fire. Even more sophisticated methods such as using windmills for generating energy can be traced back 2,500 years to where they were first documented in India. The use of renewable energy has persisted as a viable form of electricity production while continuing to evolve with technological advancements. In consideration of human dependence on energy generation, Smil (2017) points to the progress of human evolution and the social process of controlling greater stores and flows of various forms of energy. While renewable energy has been the primary energy option available during the majority of human history, the increasing demand for energy in society and the practice of controlling greater stores and flows within human civilization created the conditions that allowed for the mass-scale diffusion and global expansion of fossil fuels (Smil, 2017).

Although the use of fossil fuels for energy can be traced back for thousands of years, the mass-scale dependence on fossil fuels is a relatively recent phenomenon in society. Smil (2017) points out two critical advances in human history that led to new ways of converting fossil fuels that contributed to its widespread use: first, the introduction of "prime movers" such as the steam engine and second, the invention of new ways to transform raw fuels, such as creating coke from coal and refining crude oils. Fossil fuels provided an entirely new capacity for work and stimulated the Industrial Revolution in the mid 18th century. Considering Smil's (2017) argument that society strives to control stores and flows of energy while also finding cheaper and more efficient ways of converting forms of energy, electrification spurred geographic exploration and fuel extraction. Fossil fuels provided more reliable and cheaper electricity that impacted and altered every form of industrial activity (Smil, 2017). Renewable energy could not complete with the rise and expansion of fossil fuel energy. With limited infrastructure, solar and wind power became seemingly too expensive as fossil fuel based energy systems were widely developed, further restraining the ability for renewables to compete with the vast infrastructures being implemented across the globe (Sorensen 1991). Following industrialization, modern civilization became dependent upon the extraction of these energy stores and the burning of coal, oil, and natural gas to create unprecedented amounts of energy. While this transformation has led to advances throughout society, such as economic growth, agriculture, transportation, urbanization, communication, and, improved quality of life to name a few, it has also had some significant consequences. The most immediate consequence of burning fossil fuels for energy is the depletion of the finite fossil fuel deposits that take thousands of years to replenish, leading to a variety of environmental concerns. However, surmounting those concerns is climate change due

to anthropogenic emissions of greenhouse gases which are predominantly produced from burning fossil fuels.

Concern about anthropogenic climate change emerged in the late 1980s. In the natural and physical science communities, scientists have developed a complex understanding of the global climate and the effects of global warming, also known as the "greenhouse effect," caused by greenhouse gas emissions. Carbon dioxide makes up the majority of the greenhouse gases that contribute to climate change. Furthermore, the IPCC (2014) identifies human activity related to producing excess carbon emissions as the primary factor driving climate change. This is largely due to the continually increasing social demand for energy in order to meet the basic needs of the population. The burning of fossil fuels, such as coal, oil and natural gas, which dominate energy production to this day, have resulted in the rapid increase of carbon dioxide emissions worldwide. With human activity identified as the primary cause of climate change, the value of sociological approaches and contributions to understanding and addressing climate change become exceedingly important (Dunlap and Brulle, 2015).

Scientists largely agree that human activity has altered earth's natural processes and systems and that reducing reliance on fossil fuels will curtail the effects of climate change. Recognizing the threats on the physical and social worlds, the Intergovernmental Panel on Climate Change (IPCC) was established in 1988 and is responsible for the extensive knowledge base on global climate change, primarily in the natural and physical sciences. The panel is seen as the international authority on climate change that communicates its dangers and offers options for mitigation. The IPCC has identified climate change as one of the most pressing problems of the time which is primarily driven by human action (IPCC, 2014). Through their efforts to inform the global community about the serious threats of climate change, the IPCC (2014) has

identified renewable energy as an alternative energy source that is a possible step towards climate change remediation. However, recognizing that the central drivers of anthropogenic climate change are deeply embedded within the social structures and routines of modern society (Reuswig and Lass, 2010), changes in the way energy is produced are expected to be gradual. Therefore, despite expanding scientific knowledge and increasing evidence of the dangers of climate change, global carbon emissions continue to rise, climate disruption continues to grow, and uncertainty remains in the dedication to and the influence of global efforts to mitigate these environmental impacts.

Considering the relationship between human behavior, society, and the ecosystem, social scientists have long focused on the natural environment. The rise of sociological theories addressing the natural environment began in the late 1960s and early 1970s as predominately Western sociologists began to focus on environmental issues and the relationship between society and the natural environment. This scholarship has continued to expand with competing theories primarily centered on what is driving environmental degradation and whether degradation will continue. This work bridges the gap between the societal impacts and natural systems, drawing attention to human societies' embeddedness within the natural environment (Dunlap and Catton, 1979; Schnaiberg, 1980). A number of macrosociology studies in recent years have aimed to understand a variety of environmental issues, including water pollution, deforestation, and consumption (Shandra, Shor, & London, 2009; Bryant & Bailey, 1997; Jorgenson, 2003; Jorgenson, Dick, & Shandra, 2011). More recently, some researchers within this field have begun to theorize explanations of environmental remediation, including renewable energy (York, 2012; more).

Recent scholarship on the emergence of environmentalism draws attention to the growing environmental awareness across the globe (Meyer& Frank et al., 1997; Schofer & Hironaka, 2006). These scholars point to the emergence of an international environmental regime that consists of international nongovernmental organizations, inter-governmental organizations, environmental treaties, scientific professions, and social movement organizations (Haas, 1992; Meyer & Frank et al. 1997; Schofer & Hironaka, 2006). Amongst this global civil society, cultural models specifying and defining environmentalism are shared and spread worldwide. The global environmental regime began to emerge in the late 19th century which laid the ground work for rise of a new institution following 1972 United Nations Stockholm Conference of the Human Environment (Hironaka, 2014). As a consequence of the environmental regime, nations face pressure on a wide range of environmental issues, which in turn influences national agendas and actions (Meyer & Frank et al., 1997). In relation to nations' responses to the natural environment, scholars argue that the rise in environmentalism has led to an increase in state responsibility for the natural environment resulting in a proliferation of policies, laws, and regulations that aim to address a variety of environmental issues, including renewable energy as a way of mitigating climate change.

My research builds upon recent scholarship on the emergence of international institutions and environmental *remediation* by focusing global changes within the energy sector. Although global responses to climate change have been slow and deemed inadequate, particularly in regards to reducing carbon emissions, renewable energy offers one possible solution where collective action can remedy the situation. The recent rise in renewable energy is an indication of a global transformation in the energy sector; however, there remains extreme variation amongst nations in the amount of electricity being generated by renewable sources. As demonstrated

earlier, some nations have experienced immense increases in renewable energy generation; yet, a large number of nations continue to produce less than 10 percent of their total electricity from renewables. To understand this variation, I focus on examining factors influencing the global rise in renewable energy as well as conditions associated with renewable energy regulatory frameworks.

My dissertation consists of three empirical chapters examining the global rise of renewable energy from a sociological perspective. Chapter two, the first empirical chapter, consists of a cross-national time series regression analysis on the factors associated with increases in renewable energy production from 1970 through 2012 using a fixed effects model. Using this type of analysis, I ask: what factors contribute to increases in energy produced from renewable sources from 1970 through 2012? In this chapter, I test a series of hypotheses I formulate based on existing macrosociological theories, including ecological modernization theory, political economy perspectives, and world society theory. Specifically, I test a series of hypotheses about country-level factors related to modernization, world economy, and global civil society that are associated with increases in electricity produced from renewable sources. The results of this study indicate that ratification of the Kyoto Protocol have a strong impact on renewable energy production, suggesting that treaty ratification is an imperative step towards mitigating the effects of climate change.

In my third dissertation chapter, I look specifically at the proliferation of solar energy around the world. As the most abundant of all energy sources (IPCC, 2011), solar energy is to a large extent responsible for the rapid deployment of renewable energy technologies and steady rise in energy generation from renewable sources in the past few decades. In this chapter, I ask: what factors contribute to increases in solar energy generation from 2000 through 2016. I use a

cross-national time series regression analyses on the increase in solar energy generation from 2000 through 2016 using a fixed effects model. I test variables associated with ecological modernization theory, notions of world economy and foreign direct investment dependence, and assertions of world society theory and the role of international non-governmental organizations in spreading global environmentalism. By disaggregating renewable energy and examining solar specifically, I am able to identify key factors influencing country-level behavior in investing in a specific energy type. The findings suggest the spread of environmentalism through global civil society has had an impact on the way nations generate electricity in the midst of the climate change crisis.

My fourth chapter is a Qualitative Comparative Analysis (QCA) of renewable energy regulatory frameworks. QCA is an innovative method that allows me to analyze the conditions under which nations implement advanced regulatory frameworks for renewable energy. This method, developed by Dr. Charles Ragin (2000), bridges the gap between qualitative and quantitative methods and focuses on complex causal arguments. While quantitative methods often aim to isolate specific variables associated with theories to explain social outcomes or phenomenon, QCA is best suited for identifying the complex causal combination resulting in advanced renewable energy regulatory frameworks. By using this methodology I'm able to ask the question: Under what conditions do countries adopt multi-dimensional renewable energy regulatory frameworks to address changes in the energy sector? I identify the extent to which different configurations of economic, political, social, and cultural conditions have a causal effect on advanced regulatory frameworks for renewable energy. My findings highlight the combination of conditions that lead to this outcome amidst rising regulations and policies around renewable energy.

In the final chapter of my dissertation, I draw conclusions on the determinant of the global rise in renewable energy based on the findings from the three empirical chapters. Focusing on the theoretical contributions from each chapter, I highlight the ways in which my research contributes to the sociological literature on globalization and the environment. As concerns over effective international action to address the growing climate change crisis endure, the need for ongoing research, particularly is sociology, is vital. Specifically, I discuss how my findings contribute to the growing scholarship on environmental remediation and research that addresses how global efforts to address environmental issues are transforming society.

CHAPTER 2

A Cross-National Analysis of Renewable Energy Production, 1970–2012

The topic of global, anthropogenic climate change is widely established in mainstream society as concerns and curiosity about this phenomenon have ceased to be hypothetical and have transitioned into reality. The climate change crisis continues to grow, affecting human health and safety, food production, economics, land and resources, and other dimensions of society. The dramatic disruptions and critical consequences caused by anthropogenic climate change ultimately threaten the future of human society. The Intergovernmental Panel on Climate Change (IPCC), established in 1988, is the international authority on climate change, communicating the dangers of climate change and offering options for mitigation. In an effort to inform the global community about the serious threats of climate change, the IPCC (2013) has identified renewable energy as a possible step toward climate change remediation.

In the contemporary world, all societies demand energy sources to meet the basic needs of the population. Fossil fuels, such as coal, oil, and natural gas, have dominated energy production since the mid-1800s, resulting in a rapid increase of carbon dioxide emissions worldwide. The IPCC (2007, 2013) identifies the growth in carbon dioxide emissions as directly contributing to anthropogenic climate change, making alternative energy sources critical to addressing the climate crisis. However, even as the scientific knowledge around climate change continues to expand, global carbon emissions continue to rise, climate disruption continues to grow, and global efforts to mitigate these impacts remain questionable. Individuals and nations view global efforts to address climate change with much skepticism, as countries not only default on prior commitments to reduce carbon dioxide emissions, but even withdraw from global

agreements, as Canada did in 2011 from the Kyoto Protocol and the United States from the Paris Agreement in 2017.

As concerns over effective international action to address the growing climate change crisis endure, the need for ongoing research is not only warranted, but necessary, particularly in sociology. Dunlap and Brulle (2015) posit that understanding both the sources of climate change, one of the most critical issues of the time, and the potential improvements are fundamentally sociological issues. Focusing on potential improvements, this study approaches climate change through exploring the phenomenon of renewable energy production. While a number of macrosociology studies in recent years have aimed to understand environmental issues such as water pollution, deforestation, and consumption (Bryant & Bailey, 1997; Jorgenson, 2003; Jorgenson, Dick, & Shandra, 2011; Shandra, Shor, & London, 2009), my research builds upon recent scholarship on the emergence of international institutions and focuses on climate change remediation and global changes within the electricity industry. It is important to examine the sociological reasons for the increases in renewable energy production worldwide in order to uncover the impetus behind this change, which has influenced and continues to shape industry and infrastructure globally.

Despite a continual increase in carbon dioxide emissions (IPCC, 2013), recently the world has begun to witness a major shift in the way energy is produced. The rise in popularity of alternative energy has resulted in drastic increases of electricity generated from renewable sources. According to the Energy Information Administration (US EIA, 2014), approximately 5 percent of electricity worldwide was produced from renewable sources in 2012, compared to less than a quarter of a percent in 1970. Several countries have experienced increases far beyond 5 percent, with some nearing 50 percent of their total electricity deriving from renewable sources.

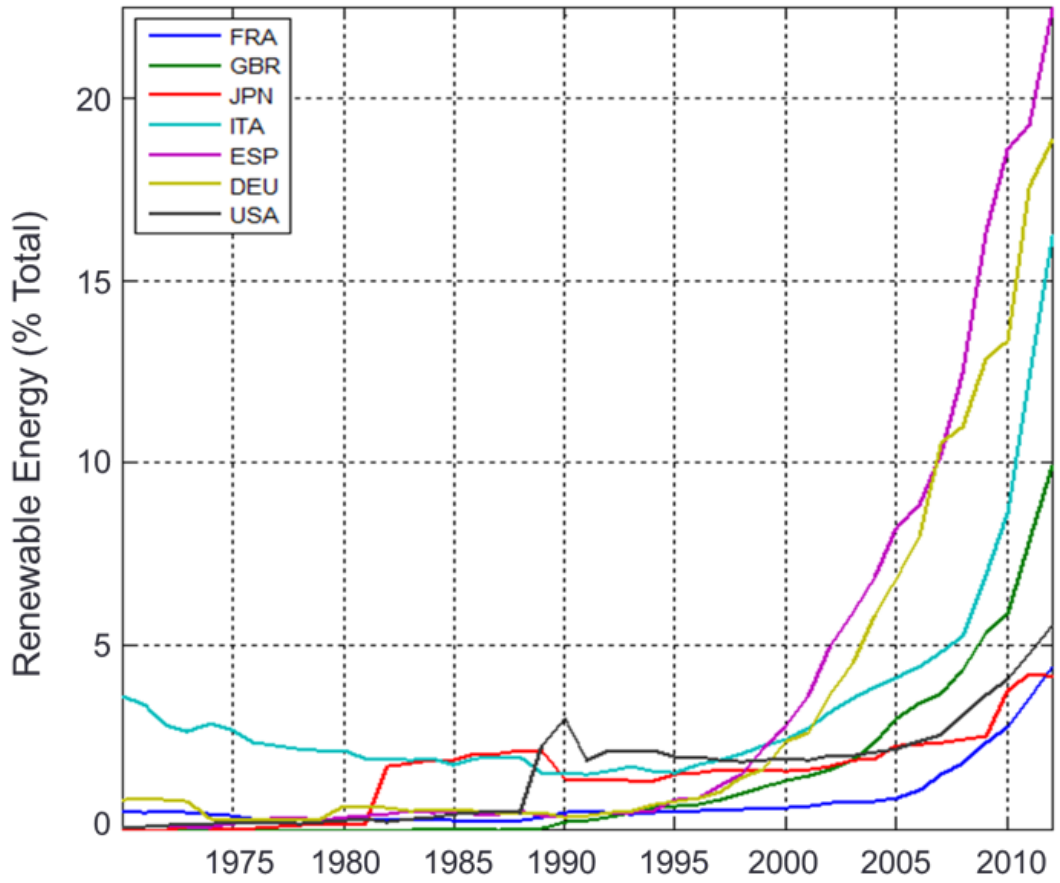
This increase can be seen for several of the top electricity producers in Figure 1. According to the EIA, renewable energy is projected to continue to be the fastest growing form of energy in coming decades (US EIA, 2014).

The dramatic increase in renewable energy production over the past few decades has recently begun drawing attention to the societal changes that impact electricity generation globally, leading us to question the root causes of this shift from non-renewable to renewable sources. Over the last three decades in Germany, for example, a large portion of the approximately 1.5 million solar systems have been installed on the roofs of homes, producing nearly seven percent of the nation's electricity (Fraunhofer ISE, 2015). Germany recently produced so much renewable energy that it had to pay people to use electricity (Berke, 2017). Spain, the fourth-largest producer of wind energy and a nation that recently began requiring solar panels on all new construction, generated more than 27 percent of their total electricity from wind and solar in 2014 (REE, 2015). Kenya has emerged as one of the top producers of geothermal electricity, generating 13 percent of their total electricity from geothermal resources in 2014 (World Bank, 2013). With a variety of geothermal projects underway, Kenya has high expectations that number will continue to rise, while similar projects are taking place in Tanzania and Ethiopia. In 2014, a solar power plant consisting of more than 310,000 solar panels and covering 250 acres was developed in Chile. At the time, it was the largest solar power plant in the southern hemisphere, and it remains the largest in Latin America. Such cases continue to emerge, highlighting the concerted focus on moving toward producing electricity from renewable sources.

Increases in renewable energy production have the potential to significantly impact environmental outcomes worldwide. Therefore, understanding the factors associated with these

increases in electricity produced from renewable sources has significant implications for environmental policy and future efforts to affect ecological outcomes. Using fixed effects (FE) panel regression analyses, I ask this question: What factors contribute to increases in energy produced from renewable sources from 1970 through 2012? The results indicate the continued importance of affluence and economic growth for nations' adoption of renewable energy technologies, but the findings also highlight the impact of the Kyoto Protocol on increases in renewable energy production. The results bring into question previous conclusions about the effectiveness of the Kyoto Protocol by pointing to the relationship between ratification and increased renewable energy production.

Figure 1. Renewable energy production (% of total kWh) for select, top producers of electricity by year, 1970–2012



Theories and Arguments

Ecological Modernization Theory

From a modernization perspective, changes in environmental interests and policy emerge through both growing public concern and institutional developments (Mol, 2002). Ecological modernization theory is centered on the notion that not only is economic development the major driver of modernization, but also that as societies advance and become more affluent, ecological interests grow and environmental policies are formed (Mol, 2002; Rostow, 1990). Ecological modernization theorists attempt to explain the environmental transformative processes that occur in both institutions and social practices within industrialized nations (Mol, 2002). In doing so, they posit that further advancement in economic development is in fact the answer to resolving environmental issues. For instance, Baker (2007) suggests a link between economic growth and environmental protection; in other words, modernization is a necessary avenue toward addressing ecological crises. For a nation to prioritize the environment and decrease use of carbon-emitting fuels by producing electricity with renewable sources, a path toward development and modernization is necessary so that public support will grow, institutions such as the Environmental Protection Agency (EPA) will be established, and existing institutional structures will become more ecologically sustainable.

According to ecological modernization scholars, improvements in the environment are achieved through higher levels of economic development, which allow citizens and businesses to focus more of their attention on addressing environmental issues. Murphy (2000) explains that practices and policies emerge at these higher levels of economic development because businesses and groups are no longer focused on development issues, have formulated ideas and interests around the environment, and can dedicate efforts toward reducing ecological impacts. Mol

(2002) points to countries such as Denmark, Germany, Japan, Sweden, and the United States as places where ecological improvement has paralleled economic growth. Moreover, ecological modernization scholars argue that increases in modernization and economic growth are more likely to generate a higher standard of living and more access to technologies (Rostow, 1990), thus creating greater opportunities for nations to increase renewable energy production. Given the strong link between modernization and environmental improvement identified in ecological modernization theory, I suggest the following:

Hypothesis 1: Nations that are more affluent will have higher increases in renewable energy production.

Political Economy Perspectives

As a critique of ecological modernization theory, arguments from the political economy perspective emphasize the negative consequences of globalization on the environment. World system theorists identify ecological destruction as a key dilemma of modern capitalism (Jorgenson, 2003; Wallerstein, 1974). These scholars challenge ecological modernization theory by suggesting that various factors within the world system cause unequal environmental outcomes (Jorgensen, 2003). For instance, Jorgensen (2003) argues that there is a clear connection between environmental degradation and global modes of production and accumulation. In examining global increases in renewable energy production, world system analysis offers a useful framework for understanding the variations in environmental processes and outcomes, despite widespread knowledge of the consequences of environmental degradation (Roberts & Grimes, 2002; Smith, 1994).

<u>World System Theory, Export Dependency, and Foreign Direct Investment</u>

Scholars of the world system discipline are particularly concerned with the environmental crises central to modern capitalism and the failure of the system to find solutions to address environmental degradation (Foster, 1999; Wallerstein, 1974). The core-periphery model provides a perspective for understanding variation in development between nations and the environmental outcomes that result from these inequalities (Bergesen & Parisi, 1997; Wallerstein, 1974). In its depiction of exploitation, the core-periphery model can be understood as a global hierarchy in which environmental degradation occurs at greater rates in poor countries than in rich countries (Chase-Dunn, 1975; Wallerstein, 1974). Asserting that core countries export environmentally hazardous industries to peripheral nations (Grimes & Kentor, 2003), world system scholars posit that environmental degradation is perpetuated through unequal power relations based on a country's position within the global hierarchy. From this perspective, development in peripheral and semi-peripheral nations is dependent on core countries, but their access to technological advances, such as renewable energy production, is often secondary to other objectives, such as developing local economies and attracting investments from core nations (Bornschier & Chase-Dunn, 1985). In other words, national outcomes are largely determined by international relations and global stratification.

Export dependency reinforces the argument that renewable energy production can be explained through international relations and the unequal outcomes between peripheral and core countries. In order to expand local production, peripheral countries often require expensive, technologically advanced goods that are available only from core countries, which leaves the peripheral countries in a position of dependency (Bornschier & Chase-Dunn, 1985; Bunker, 1996). Because poor countries depend on richer nations not only for technologically advanced goods such as those necessary for the production of renewable energy, but also for other high-

priced goods essential to the development and expansion of local production, the funding available for investment in alternative industries is minimal. Governments, therefore, are limited in their abilities to invest in environmental-related industries, such as renewable energy production, because of the large amounts of money required for the purchase of other manufactured goods from richer nations.

The notion of foreign investment dependence suggests that countries, particularly nations that are less developed, accumulate stock from foreign investments. This results in a state of weakness, making countries susceptible to a multitude of economic conditions that often have detrimental effects on the population (Chase-Dunn, 1975). Additionally, world system scholars argue that poor nations that are left vulnerable by foreign investments are considered to have increased environmental degradation within their borders (Bornschier & Chase-Dunn, 1985; Chase-Dunn, 1975). Environmental degradation is the result of peripheral countries competing to attract foreign investments from core countries, which often includes exemptions from complying with environmental laws (Leonard, 1988). This further suggests that peripheral countries, which aim to attract foreign investment in order to expand local production, increase employment opportunities, and advance technology, are not primarily focused on alternative industries that address environmental crises, including renewable energy. Rather, peripheral countries minimize regulations around environmental laws for foreign investments, suggesting there are few peripheral nations that prioritize renewable energy production for the purpose of reducing carbon dioxide emissions. Considering the power of existing economic interests and the unequal environmental outcomes due to the global hierarchy, I argue the following:

Hypothesis 2: Economic dependency will be negatively associated with renewable energy production.

Economic Interests and the "Carbon Lock-In"

Scholars of the political economy perspectives suggest that environmental improvements are also hindered by existing economic interests. Despite growing evidence documenting the dangers of anthropogenic climate change and the benefits of reducing carbon emissions, countries continue to rely heavily on energy produced from fossil fuels that produce large quantities of carbon emissions. The notion of the "carbon lock-in" has been used to describe the persistence of carbon-intensive technologies that deter, or lock out, the adoption of alternative technologies with lower carbon emissions (Unruh, 2000; Unruh & Carrillo-Hermosilla, 2006). Unruh (2000) describes this process as being path dependent and "driven by technological and institutional increasing returns to scale" (p. 817). Previous researchers have found that the carbon-lock is greatest for coal power plants, gas plants, and oil-based vehicles (Erickson, Kartha, Michael, & Tempest, 2015). Therefore I suggest that countries that have historically invested in large oil rents and existing coal and natural gas industries are "locked in," making the transition to renewable energies more difficult. I posit the following:

Hypothesis 3: Nations with strong, existing fossil fuel industries will be negatively associated with renewable energy production.

World Society Theory

Moving away from functional and economic explanations for global transformations, world society scholars emphasize the role of norms and culture in driving global change. World society researchers draw attention to the surprising level of homogeneity in global change and the commonalities in international discourses. Worldwide, discourses on topics such as human rights, education, women's rights, and environmentalism are becoming exceedingly similar. These similarities across societies, also known as *isomorphism*, can be understood as the spread

of culture and norms that influence national societies (Meyer, Boli, Thomas, & Ramirez, 1997). Cultural models, like blueprints or recipes, create understandings not only of what a nation should look like, but also of how governments should act and how countries should interact with each other and organizations (Frank, Hironaka, & Schofer, 2000; Meyer & Boli et al., 1997). Notably, world society theorists highlight the growth of international organizations and treaties that serve to diffuse and institutionalize cultural models, which ultimately embody what is often referred to as a global culture.

The cultural models specifying and defining environmentalism are among the major blueprints that have become institutionalized in a global culture. To this extent, the rise in environmentalism is the product of macrosociological factors that have rationalized the environment and have socially constructed environmental issues through the use of scientific thought. The global environmental regime, which first emerged in the late nineteenth century, laid the groundwork for the rise of a new institution following the United Nations Conference on the Human Environment, held in Stockholm, Sweden, in 1972 (Hironaka, 2014). According to Meyer, Frank, Hironaka, Schofer, and Tuma (1997), the global environmental regime is composed of intergovernmental organizations, social movement organizations, treaties, and environmental professionals who aid in the diffusion of cultural models that ultimately spur social transformation globally.

Kyoto Protocol

World society theorists suggest that treaty ratification reflects a country's subscription to international governmental norms and indicates embeddedness within the civil society (Hironaka, 2014). As Frank (1999) explains, even when their local needs conflict with environmentalism, the countries most embedded within the world society are more likely to

ratify international environmental treaties. Hironaka (2014) further explicates the importance of international treaties in spurring social change, describing the process by which these institutions function as "workspaces" where environmental issues become part of a global political agenda. These workspaces are an integral part of defining and recognizing issues as well as bringing together relevant actors. The role of treaties in influencing environmentalism, particularly renewable energy production, is shaped by bringing together these actors, such as INGOs, that shape the language used to define guidelines and treaty policies and to monitor the compliance of the governments involved (Hironaka, 2014; Smith, 1995). As the global environmental regime prioritizes environmentalism, treaty participation is a demonstration of a nation's commitment to international governmental norms.

Motivation to take pro-environmental action began to rise following the Stockholm Conference in 1972 and the resulting global environmental regime (Hironaka, 2014). Since 1972, international and national pro-environmental structures have rapidly emerged with policies, laws, and organizations expanding worldwide. The growing focus on the environment has led to a new wave of countries aiming to address climate change, using approaches such as replacing traditional energy production with renewable energy. According to the IPCC (2013), the energy sector is responsible for nearly two-thirds of greenhouse gas emissions that are produced globally. The IPCC (2007, 2013) also points out that renewable energy, which has been on the environmental agenda for some time, is a necessary component to reducing greenhouse gas emissions. With environmental change on nearly every country's agenda, the United Nations Environment Programme (UNEP, 2005) lists more than 200 treaties and agreements that have been created in the field of the environment. The Kyoto Protocol was the first legally binding international agreement on climate protection.

At the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol was adopted in Kyoto, Japan, in December 1997 in an effort to coordinate a global reduction in greenhouse gas emissions. The treaty called for ratification from countries representing a minimum of 55 percent of the 1990 greenhouse gas emissions. In February 2005, this requirement was satisfied when Russia ratified the Kyoto Protocol, and the international treaty went into effect. The United States, the largest contributor to the 1990 levels of greenhouse gases, chose not to ratify or implement the Kyoto Protocol. By 2012, when the Kyoto Protocol expired, a total of 191 nation-states had ratified it to the UNFCCC, representing a worldwide commitment to decrease global warming that has largely been attributed to the effects of carbon-emitting fuels. Under the protocol, a country's commitment level was categorized based on its level of industrialization. Countries categorized in Annex I represented the most industrialized nations, who were responsible for 63.7 percent of 1990 emissions (UNFCCC). Annex II countries were less industrialized and historically had contributed less to greenhouse gases, so they were held to a different standard than Annex I countries.

Both skepticism and criticism surrounded the Kyoto Protocol. McKibbin and Wilcoxen (2000) criticized it as being a "deeply flawed agreement that manages to be both economically inefficient and politically impractical" (pg. 107). Though McKibbin and Wilcoxen's critiques largely focus on economic mechanisms, they are also concerned with the fact that the Protocol did not include an individual governing body responsible for enforcing the agreement. International environmental structures, such as the Kyoto Protocol, are often scrutinized for their inability to bring about real change and environmental improvement due to the lack of enforcement in upholding the agreements and policies (Hironaka, 2014). However, while international institutions often fail to meet specific requirements or mandates, there are often real

consequences with ameliorating effects (Hironaka, 2014). Considering these consequences as well as the potential for international treaties to incite global change, I suggest the following: *Hypothesis 4: Kyoto Protocol ratification will be positively associated with increases in renewable energy production.*

International Nongovernmental Organizations and Renewable Energy

While treaty ratification reflects an embeddedness within the civil society, INGO membership demonstrates connection to world society. World society theorists posit that international organizations play an important role in legitimizing environmentalism by establishing and reinforcing global cultural norms (Frank et al., 2000; Meyer, Frank, Hironaka, Schofer, & Tuma, 1997). Specifically, international nongovernmental organizations (INGOs) are viewed as transporters of world culture that spread global cultural models to local actors who then adopt these models. Meyer and Frank et al. (1997) explain how INGOs, environmental organizations, and other civil society groups who make up the world environmental regime promote environmental standards globally and advocate for universal adoption of environmental policies. In this way, INGOs are agents of the global environmental regime that not only carry cultural models that frame environmental degradation as a problem that demands attention, but also encourage local actors to take action to protect the environment (Hironaka, 2014; Meyer & Frank et al., 1997). Schofer and Hironaka (2005) further demonstrate that as international environmental standards diffuse by means of these civil society organizations, the presence of INGOs is linked to lower rates of carbon dioxide emissions. As agents of change that spread world culture, INGOs demonstrate a country's linkage to the global civil society.

Regarding renewable energy, INGOs help spread knowledge about these technologies and resources for adopting these forms of energy. Greenpeace, an INGO that has offices in forty

countries around the world and aims to promote a "green and peaceful future" through spreading awareness and solutions to environmental problems, boasts bold renewable energy objectives. Disseminating information about the dangers of continued fossil fuel use and the possibilities for clean, renewable energy, Greenpeace campaigns for 100 percent renewable energy production in order to combat climate change. Greenpeace is directly focused on environmental issues, but even INGOs with other missions incorporate renewable energy objectives. INGOs such as Care International and Mercy Corps, both of which fight poverty, and Médecins Sans Frontières, a medical humanitarian organization, have adopted renewable energy projects and objectives. Thus the presence of INGOs, whether or not they have specific environmental missions, has the potential to diffuse environmental standards and push a country toward using renewable energy sources. Therefore I hypothesize the following:

Hypothesis 5: The presence of INGOs within a nation will be positively correlated with increases in renewable energy production.

World society scholars focusing on the global environmental regime have looked mainly at the impact on environmental degradation. Being connected to, and perhaps embedded within, world society is shown to diminish the negative effects of foreign direct investment on the environment in less-developed countries (Jorgenson, Dick & Shandra, 2009; Jorgenson et al., 2011). Other scholars have demonstrated how the presence of INGOs can reduce the loss of biodiversity (Shandra et al., 2009), slow the pace of deforestation (Shandra, 2007), and markedly reduce environmental degradation globally (Schofer & Hironaka, 2005). However, I argue that integration in world polity and the rise of the environmental regime goes beyond affecting environmental degradation and in fact reframes understandings of the environment to include *remediation*. Instances of reforestation and the vast increase in renewable energy production are

evidence of a world culture that prioritizes the environment and sparks global action to focus on remediation processes that aid in environmental protection. As suggested by world society scholarship, renewable energy production needs to be considered through both a country's connection to the global civil society and its commitment to global norms, in particular the Kyoto Protocol. I predict that nations subscribing to international government norms associated with the environment will have increased production from renewable energy sources.

Data ad Methods

Data

This paper analyzes unbalanced cross-national panel data on electricity production from renewable sources for 119 countries (see Appendix) from 1970 to 2012. All countries that have annual data on renewable energy production, as reported by the World Bank's *World Development Indicators* (2014), are included in the analyses. Using indicators of ecological modernization theory, political economy of the world system perspective, and world society theory, in addition to a series of controls, I analyze the effects on renewable energy production over this period of time.

Dependent Variable

The dependent variable is the total kilowatt hours (kWh) produced in a country from renewable sources annually. In the analyses, the dependent variable is divided by 10,000,000 for interpretation of the coefficients. Also, it is logged since it is highly skewed. According to the U.S. Environmental Policy Agency (2014), "Renewable energy includes resources that rely on fuel sources that restore themselves over short periods of time and do not diminish." Included within this definition, the dependent variable measure of renewable energy produced includes six different types of energy sources: solar, wind, geothermal, biomass, biofuels, and tides.

Solar energy sources convert sunlight into electricity; for example, through photovoltaics (PV). *Wind* energy sources produce electricity through turbines driven by airflow. *Geothermal* energy sources convert heat from the earth's core into electricity. Globally, only a small portion of renewable energy is produced by geothermal means, with approximately 24 countries using geothermal production. With *biomass energy sources*, electricity is produced from organic materials, wastes, and agricultural and municipal processes. The material used to produce biomass electricity varies by region based on the resources available. For example, in the United States, wood is used in the production of electricity through biomass. *Biofuels* are gas, liquid, or solid fuels made from plant material (biomass) that can be used to produce electricity. Lastly, *tidal* energy is a way of converting the energy of ocean tides to electricity. However, because of its high costs and limited access, very few areas use tidal energy.

The dependent variable excludes energy produced from hydroelectric sources because those sources are fixed in place. Additionally, the driving factors behind this form of renewable energy and the environmental impact of implementing hydroelectric technology differ significantly from those of the emerging forms of renewable energies included in this study. There are also historical differences; existing hydroelectric power has mainly consisted of large-scale dam projects concentrated in specific areas. For these reasons, I do not consider hydroelectric energy as being comparable to the recent shift in renewable energy production in the analysis. Nonetheless, in an effort to rule out the possibility that previous hydroelectric energy production does not impact other forms of renewable energy production, I ran a check by including hydroelectric energy as an independent variable. There were no significant differences in the models.

Data limitations make it impossible to disaggregate the dependent variable beyond excluding hydroelectric energy production. While different forms of renewable energy may vary in both increases as well as the reasons behind these increases, the World Bank's development indicators (2014) at this time do not include data on these energy forms separately and instead aggregates these energies to form the dependent variable, renewable energy.

Control Variables

In the analyses, I control for total population, democracy, and secondary education. Data for these variables are from the World Bank's World Development Indicators (2014) and range from 1970 through 2012. Additionally, I include a five-year, lagged dependent variable in the model to address serial autocorrelation.

Independent Variables

Gross Domestic Product (GDP) per capita (ln): Data on gross domestic product per capita is in constant 2005 U.S. dollars. Gross domestic product is logged in order to correct for its skewed distribution. In the World Bank's World Development Indicators (2014), gross domestic product is the sum of gross value added by resident producers in the economy plus product taxes and minus subsidies not included in the value of the products. Gross domestic product is divided by midyear population. This variable is a measure of economic development. According to ecological modernization theorists, higher levels of gross domestic product will indicate higher levels of renewable energy production.

Foreign Direct Investment (% of GDP) (ln): Foreign direct investment is the sum of equity capital, reinvestment of earnings, and other long-term and short-term capital. Foreign direct investment is used to test the hypothesis put forth by the political economy perspective that countries with high amounts of foreign direct investments will have lower levels of

renewable energy production. Foreign direct investment is also logged in order to correct for its skewed distribution.

Exports of Goods and Services (% of GDP): This variable, exports as a percentage of total gross domestic product, is a measure of the level of integration of a country in the international trading system. Exports of goods and services is a measure of all goods and services that a country provided to the rest of the world. According to world system theory, higher levels of exports will have a negative relationship with electricity produced from renewable sources.

Fossil Fuels (% of GDP): This variable, fossil fuels, includes oil rents, coal rents, and natural gas rents as a percentage of gross domestic product. The World Bank's World Development Indicators (2014) state that oil rents are "the difference between the value of crude oil production at world prices and total costs of production." Coal rents are then "the difference between the value of both hard and soft coal production at world prices and their total costs of production," and natural gas rents are "the difference between the value of natural gas production at world prices and total costs of production." This variable is used to test the hypothesis that existing fossil fuel industries will be negatively associated with renewable energy production.

Kyoto Protocol Ratification—Annex I: This variable indicates which countries categorized by the UNFCCC as Annex I countries have ratified the Kyoto Protocol and in what year they ratified. World society theory asserts that treaty ratification will have an effect on measures taken to reduce carbon dioxide emissions; thus increases in renewable energy production are anticipated following ratification. The UNFCCC divides countries into groups according to varying levels of commitment. Annex I countries are industrialized countries and include all the Organisation for Economic Co-operation and Development (OECD) countries and

economies in transition (EIT). Annex I countries committed to the goal of returning their greenhouse gas emission to their 1990 levels by the year 2000 either individually or jointly.

Kyoto Protocol Ratification—Non-Annex I: This variable indicates which countries in the Non-Annex I group have ratified the Kyoto Protocol of the UNFCCC and in what year they ratified. By default, countries not included in Annex I are referred to as Non-Annex I countries. These are mainly developing countries, including those classified by the Convention as the least developed countries (LDCs). Additionally, some of these countries are recognized as being particularly vulnerable to the effects of climate change or the possible economic impacts of climate change measures. The Kyoto Protocol Ratification—Non-Annex I variable tests the assertion of world society theory that treaty ratification will have an effect on measures taken to reduce carbon dioxide emissions, so increases in renewable energy production are anticipated following ratification for countries with lower levels of commitment.

International Nongovernmental Organizations (ln): The total number of INGO memberships in a nation is included in this variable. The number of INGO memberships a country has is a measure of linkage and how embedded a country is within the world culture. World society theory suggests that the presence of INGOs will increase renewable energy production. I log this variable in order to correct for its skewed distribution.

Table 1. Renewable Energy Production Descriptive Statistics

Data Set for Energy Production from Renewables (N = 119)		
	Mean	*Std. Dev.*
Renewable Energy Production (total kWh/10,000,000) (ln)	1.715444	2.346518
Total Population (ln)	5.711749	2.33163
Level of Democracy	1.039783	7.424738
Secondary Education	0.593203	0.341111
Gross Domestic Product per capita (ln)	7.992986	1.623102
Exports of Goods and Services (% of GDP)	37.50756	26.69624
Foreign Direct Investments (%of GDP) (ln)	1.025577	0.906352
Fossil Fuels (% of GDP)	3.998261	12.58045
Kyoto Protocol Ratification—Annex I	.0400868	.196172
Kyoto Protocol Ratification—Non-Annex I	.1333711	.3399914
International Non-Gov. Organ. (ln)	5.674525	1.475589

Analyses

I use fixed effects regression models with a lagged dependent variable to evaluate the factors affecting renewable energy production for an annual country-level dataset from 1970 to 2012. Since countries are measured repeatedly over time, cases in my dataset are not independent, potentially leading to correlated error among my observations and underestimation of standard errors. In addition to including a lagged dependent variable, both random effects (RE) and fixed effects (FE) regression models may be appropriate for panel data of this type. The RE estimator has the advantage of greater efficiency, but it requires the strong assumption that country-specific error is uncorrelated with other independent variables in the model. The FE model controls for all case-specific unobserved heterogeneity and therefore is less efficient but more conservative. I conducted a Hausman test to evaluate the models. The significant result from the Hausman test statistic indicates that the RE model is biased and the more conservative

FE model is preferred (Halaby, 2004). The FE approach is commonly used in this type of analysis (Jorgenson, 2007).

Additionally, I include a lagged dependent variable in my analysis. By including a lagged dependent variable in the fixed effects model, the dependent variable is regressed on itself at an earlier point in time along with the independent variables at that same point in time. There is a five-year lag between the dependent variable and the lagged dependent variable and independent variables. It is important to include a lagged dependent variable in order to address serial autocorrelation.

Results

The results of the FE regression models are presented in Table 2. I report and discuss the findings individually in relation to ecological modernization theory, political economy perspective, and world society theory. I report the unstandardized coefficients, which are marked to indicate statistical significance, standard errors, and R^2 overall. Table 2 presents four FE models. Every model includes all of the variables in model 1: the lagged dependent variable, total population, level of democracy, and secondary education. Controls for total population, level of democracy, and secondary education are typical in this type of analysis (Jorgenson, 2007). Model 2 includes gross domestic product, which is associated with ecological modernization theory. Model 3 incorporates the variables that measure political economy

Table 2. Fixed effects regression models with lagged dependent variable evaluating the factors affecting renewable energy production for an annual country-level dataset from 1970 to 2012

	Model 1	Model 1	Model 3	Model 4
Control Variables				
Renewables (ln) 5-year lag	0.748***	0.672***	0.658***	0.634***
	(0.013)	(0.014)	(0.014)	(0.014)
Population (ln)	0.126	0.205*	0.119	0.010
	(0.103)	(0.099)	(0.101)	(0.113)
Democracy (ln)	-0.001	0.004	0.002	0.003
	(0.004)	(0.004)	(0.004)	(0.004)
Secondary Education	1.552***	0.692***	0.715***	0.649***
	(0.154)	(0.160)	(0.161)	(0.162)
Ecological Modernization				
Gross Domestic Product per capita (ln)		1.102***	1.006***	0.846***
		(0.076)	(0.079)	(0.081)
Political Economy/World system				
Exports of Goods and Services (% of GDP)			0.004*	0.004*
			(0.002)	(0.002)
Foreign Direct Investment (% of GDP)			0.113***	0.090***
			(0.025)	(0.024)
Fossil Fuels (% of GDP)			-0.006**	-0.006**
			(0.002)	(0.002)
World Society				
Kyoto Protocol Ratification—Annex I				0.523***
				(0.068)
Kyoto Protocol Ratification—Non-Annex I				0.137**
				(0.053)
International Nongovernmental Organizations (ln)				0.061*
				(0.028)
Constant	-1.009	-9.837***	-8.621***	-6.846***
	(0.686)	(0.900)	(0.939)	(1.011)
Observations	3,031	3,031	3,031	3,031
R-squared	0.648	0.672	0.676	0.684
Number of newid3	119	119	119	119

perspective: fossil fuels, exports of goods and services, and foreign direct investment. And lastly, model 4 is the full model that incorporates INGOs and Kyoto Protocol ratification for world society theory.

Let me begin by focusing on the significant findings associated with each theory tested. As shown in Table 1, the findings indicate different levels of support for variables associated with all three theories. First, I will discuss the results for ecological modernization theory. The independent variable gross domestic product, a measure of affluence and modernization, is significant and positively associated with the dependent variable, renewable energy. Although the coefficient for gross domestic product slightly decreases as variables associated with political economy perspective and world society theory are incorporated, model 4 indicates that the magnitude of gross domestic product remains large. In other words, affluence is a strong indicator of increases in renewable energy production at the national level. To this extent, ecological modernization theory is supported in that the level of development impacts the energy produced from renewable sources within a country.

For political economy perspective, I find support for the theory of a carbon lock-in and the argument that existing industries can limit environmental improvements, in this case by impeding renewable energy production. The fossil fuels coefficient is both negative and significant, indicating that nations with large coal, oil, and natural gas industries have lower increases in renewable energy production. However, I did not find support for the political economy of the world system perspective in relationship to the notion of dependency. Both the foreign direct investment and exports of goods and services are measures of dependency, and world system theory suggests that high levels of these variables indicates high levels of dependency on core countries. The coefficients for both foreign direct investment and exports of

goods and services are significant, but positively associated to renewable energy production where I hypothesize there would be a negative relationship. These unexpected findings suggest that dependency is not an indicator of electricity produced from renewable sources.

Lastly in the analysis, I measure support for world society theory through Kyoto Protocol ratification for Annex I groups, Non-Annex I groups, and INGOs. The coefficient for Kyoto Protocol ratification for Annex I and Non-Annex I, which are used to measure a country's subscription to international governmental norms associated with the environment, are significant and positively associated with renewable energy production. The significant result for Kyoto Protocol ratification for Non-Annex I group is particularly interesting, considering that this group includes not only the least developed countries identified by the UNFCCC, but also countries that are vulnerable to both climate change and economic impacts of addressing climate change. It is also important to note the magnitude of the Kyoto Protocol ratification coefficients, which, while holding all other variables constant, indicates that ratification of the Kyoto Protocol for Annex I and for Non-Annex I is substantial. The magnitude of the effect provides considerable support for world society theory. Additionally, the coefficient for INGOs, a measure of linkage to the global civil society, is also significant and positively associated with renewable energy production, signifying that countries with higher levels of INGO memberships also have higher increases in renewable energy. This finding provides further support for world society theory.

Discussion and Conclusion

This study contributes to the growing sociological literature on globalization and the environment. Through the multiple lens of ecological modernization theory, political economy perspective, and world society theory, this paper identifies factors related to increases in

renewable energy production cross-nationally. As expected, I find support for ecological modernization theory and the continued importance of economic growth and affluence for a nation. As Mol (2002) suggests, there is evidence that the growing public concern over the environment and, consequently, policies that aim to protect the environment are the result of a country's economic development and affluence. The results from the gross domestic product variable support ecological modernization theory, indicating that as countries become more affluent, electricity generated from renewable energy sources increases. Conversely, lower levels of affluence correspond with lower levels of renewable energy, which suggests that less modernized and poorer countries do not have the ability to prioritize environmental concerns as long as other developmental interests remain imperative. There is evidence that as a country continues to develop and become more affluent, it is more likely to increase energy production from renewable sources, because its citizens and businesses can gradually shift their attention to focus on addressing environmental issues. While this could be partially explained by the fact that countries with high levels of renewable energy production, such as Germany, often have a lot of government investment in alternative energy, ecological modernization theory does not fully explain the renewable energy phenomenon. This is particularly evident considering the variation in renewable energy production among highly developed nations. Additionally, ecological modernization theory cannot explain why some poorer nations, such as Tanzania and El Salvador, are producing large quantities of renewable energy.

The political economy perspective, which emphasizes the negative aspects of globalization and the detrimental consequences on the environment, helps explain some of this variation through the notion of a carbon lock-in. In support of this theory, I demonstrate that existing fossil fuel industries are negatively associated with renewable energy production. This

finding supports the idea that environmental improvements are hindered by means of existing economic interests. Unruh (2000) posits that anthropogenic climate change is deeply embedded in the production and consumption patterns of modern capitalism. The economic patterns of industrialized societies are largely dependent on carbon-based energy technologies and systems to meet consumers' demands for goods and services. In support of this notion, countries with large oil rents and preexisting natural gas and coal industries do appear to lock out the adoption of alternative technologies—specifically, renewable energy. While the notion of a carbon lock-in is supported, the world system's argument that renewable energy production can be explained through the unequal outcomes between peripheral and core countries measured by export dependency is not supported in this study. Foreign direct investments and exports of goods and services are both measures of political economy's notion of dependency within the world system, which I predicted would have a negative relationship with renewable energy production. Jorgensen (2007) finds that foreign investors in less-developed countries are more likely to invest in power generation technology that produces pollutants, such as carbon dioxide emissions. This would suggest that less-developed countries with large amounts of foreign direct investments would be negatively associated with renewable energy. Conversely, foreign direct investment is positively associated with renewable energy. Thus, dependency is not an indicator of increases in renewable energy production, signifying that there is more to the renewable energy phenomenon than economic dependence.

World society theory further explains the dramatic increases in renewable energy production worldwide by focusing on the rise of the environmental regime and the growing global interest in environmental issues. World society scholars suggest that treaty ratification is a demonstration of commitment to international governmental norms—in this case, those

associated with the environment. With specific emphasis on the Kyoto Protocol to UNFCCC, the analysis supports the hypothesis that Kyoto Protocol ratification is positively linked to renewable energy production, not only for industrialized countries but also for the least developed countries and those vulnerable to climate change and economic change due to climate change measures. This finding is particularly important for understanding national policy and country-level behavior. The UNFCCC and the Kyoto Protocol have been criticized for being too weak and failing to affect state-level outcomes and climate change. However, the findings highlight the impact that Kyoto Protocol ratification has on increases in renewable energy production at the national level. In other words, global institutions matter in terms of their effect on national policy. The findings further support the idea that participation in international treaties can foster interests in an issue while also changing behavior at the domestic level. However, the findings also suggest that environmental treaties are involved in a process where physical changes to infrastructure and reframing understandings of the environment shift the focus from merely slowly degradation to remediation. As international collaboration continues in response to global, anthropogenic climate change, it is important to note that although treaty ratification is shown to be significant, carbon dioxide emissions continue to grow along with the effects of climate change. Thus treaty ratification is just the first of many steps necessary for mitigating the effects of climate change and finding its solution.

Additionally, world society theory can be used explain the global prioritization of the environment as a result of a world culture that is in part spread through the growing presence of INGOs. As INGOs intervene in social and political processes, they reinforce global cultural norms (Shandra et al., 2009), including environmental values that identify renewable energy as a potential replacement for conventional forms of energy in order to decrease carbon dioxide

emissions and reduce climate change. These findings help explain the lack of support for the world systems' dependency theory, suggesting that after something becomes a part of the global normative regime, dependency matters less. This is supported through the findings for world society theory and the notion that as countries become more connected to the global civil society, as measured through INGO membership, they also experience increases in renewable energy production.

CHAPTER 3

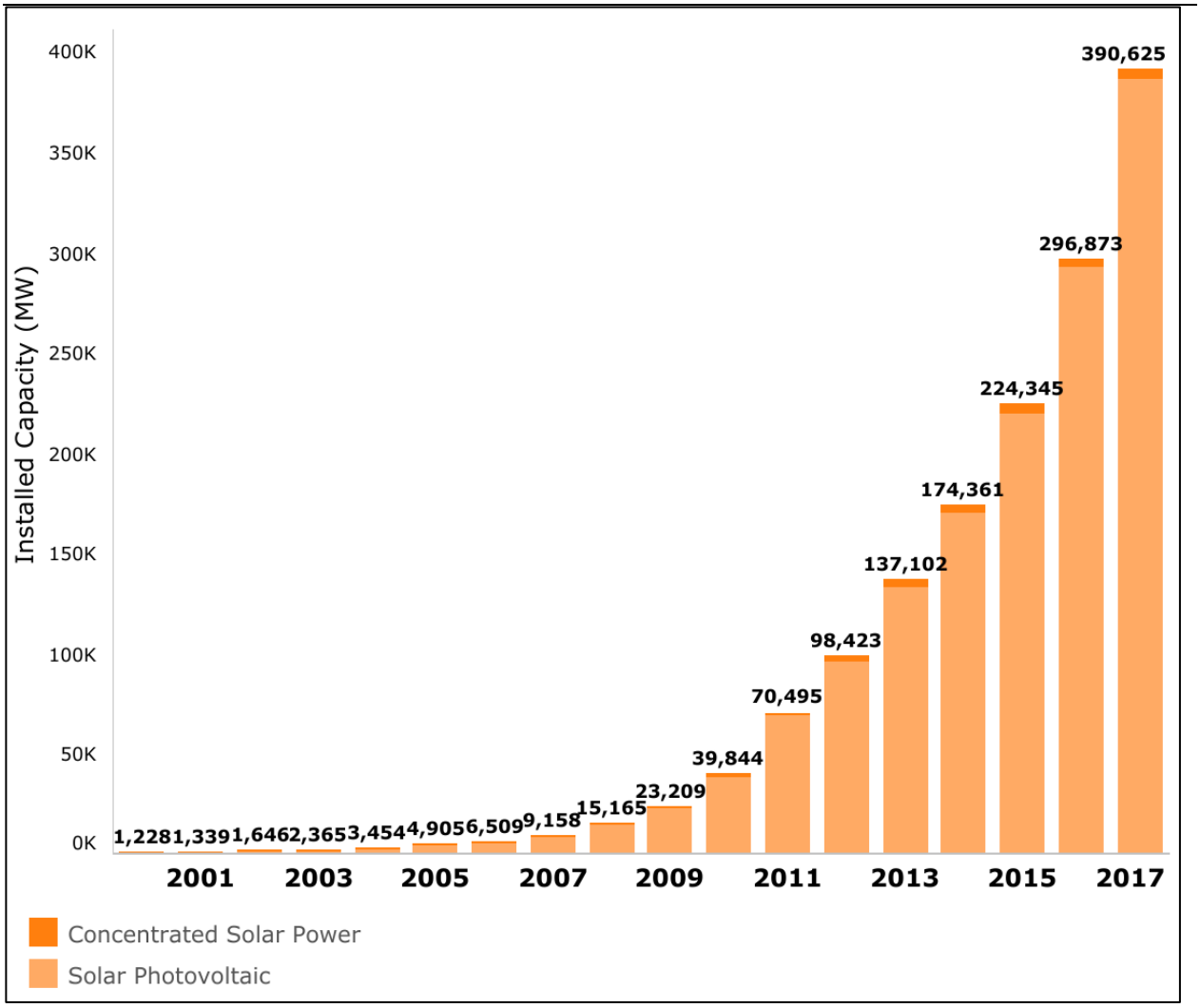
Turning Toward the Sun:

A Cross-National Analysis of Solar Energy Generation

Anthropogenic climate change has been well established as having a clear connection to industrialization and the rise in energy production (IPCC, 2014; Smil, 2003). The burning of fossil fuels is the primary method of energy production and one of the leading human-induced contributors to greenhouse gases (GHG) (IPCC, 2014). Nonetheless, the demand for energy continues to increase, despite concern over climate change and existing and potential threats to the environment. The Intergovernmental Panel on Climate Change (IPCC) is tasked with formulating realistic responses to anthropogenic climate change, including identifying alternative methods for energy production.

Globally, interest in renewable energy is growing (EIA, 2017). The renewable energy industry has experienced a rapid deployment of technologies in recent years that employ alternative methods for producing electricity. Solar energy, which is largely responsible for the steady growth in renewable energy expansion, is one of the fastest growing forms of energy globally. In 2016, photovoltaic additions, used to transform solar rays into electricity, surmounted the net growth of any other fuel (EIA, 2017). The IPCC identifies solar, the most abundant of all energy sources, as a feasible alternative to fossil fuels with great potential in addressing climate change and predicts that its use will continue to increase worldwide (Arvizu et al., 2011).

Figure 2. Trends in Solar Energy Generation Worldwide, 2000–2017



In consideration of its steady rise, I aim to understand the factors influencing solar energy generation cross-nationally. While research concerning environmental issues such as water pollution, deforestation, and consumption (Bryant & Bailey, 1997; Jorgenson, 2003; Jorgenson et al., 2011; Shandra et al., 2009) is commonplace in macrosociology and other social sciences, there has been less emphasis on environmental remediation and global progress toward improving the environment. In this study, I contribute to this area of social-scientific inquiry by investigating the extent to which a broad set of sociological theories explain the rise in solar

energy generation. An analysis of the key factors associated with increases in solar energy generation from 2000 to 2016 holds great potential for helping us understand what is guiding country-level behavior in consideration of the threat of climate change. Using fixed effects (FE) panel regression analysis, I test variables associated with ecological modernization theory, notions of world economy and foreign direct investment dependence, and assertions of world society theory and the role of international nongovernmental organizations in spreading global environmentalism. Additionally, the models include a variety of theoretically relevant controls. Findings for the analysis are consistent with previous studies on the global environmental regime and the spread of environmentalism worldwide in influencing country-level behavior in relation to the environment.

In the following section, I review the sociological theories tested in my analyses and prior research related to this study.

Arguments

Ecological Modernization

As the needs of society expand, humans continue to meet these demands by transforming the world in a variety of ways. In relation to the environment, these societal needs and subsequent transformations have an immense impact. Social scientists have heavily focused on how economic development, especially as driven by social needs, impacts the environment and alters nature. The ecological consequences, including climate change, of the demand for energy to support economic development have been well established. One major theoretical argument that seeks to understand the relationship between these ecological ramifications and economic development is ecological modernization theory. In analyzing how societies respond to environmental problems, ecological modernization scholars argue that economic development

leads to the adoption of government regulation, more sustainable practices, and investments in cleaner technologies. While ecological modernization scholars acknowledge environmental destruction as an outcome of development, continued modernization gives countries the capacity to acquire environmental interests and adopt policies to reduce environmental degradation.

From this perspective that environmental concerns emerge through continued economic development, solar energy is viewed as an outgrowth of ongoing social development (Hawken, 1993). As nations modernize, there is growing consumer demand for environmentally friendly practices and products. With added pressure and interest from society, nations will increasingly adopt more sustainable practices along the trajectory of economic development. Ecological modernization theorists suggest that ongoing economic development allows nations to adopt regulations and policies that incorporate ecological concerns, translating to new technologies that reduce environmental degradation (Mol, 1995, 2001). These "green" technologies, such as solar energy, contribute to creating a more sustainable society within a growing economy without drastic reform to the current economic system. Therefore, as ecological modernization scholars argue, continual economic development will increase the demand for renewable energies, such as solar, ultimately resulting in reduced ecological degradation and a more sustainable society.

World Economy, Foreign Investment Dependency, and Fossil Fuel Industries

In reaction to ecological modernization theories, scholars of the world system tradition argue that modern capitalism is incompatible with environmental sustainability. Instead, the modern world system creates unequal positions within the world economy that subsequently lead to unequal environmental outcomes (Jorgensen, 2003). Scholars have applied the core-periphery model, a way of categorizing nations within the global division of labor, to understand a variety of environmental outcomes (Foster, 1999; Wallerstein, 1999). The core-periphery model has

been used to explain variations in development among nations and the environmental outcomes that result from these inequalities (Bergesen & Parisi, 1997; Wallerstein, 1974).

In this study, I draw from sociologists who emphasize the role of the world economy in shaping nation behavior and environmental outcomes. Rooted within world system analysis, scholars advancing the notion of foreign investment dependence have focused on the effects of accumulated stocks of foreign investments within and between nations (Jorgenson, Dick, & Mahutga, 2007; Jorgenson et al., 2011; Jorgenson & Kuykendall, 2008). Chase-Dunn (1975) posits that foreign investments contribute to a highly stratified world economy in which less-developed countries become more vulnerable within the world system. One of the major consequences of this global stratification is the suppression of economic development for less-developed nations (Firebaugh, 1992).

While previous researchers testing the theory of foreign direct investment have focused on examining the economic impacts, social outcomes, income consequences, and influence on urbanization (Alderson & Nielsen, 1999; Bornschier, Chase-Dunn, & Rubinson, 1978; Bradshaw, 1987), sociologists have recently begun to analyze the impacts of foreign direct investment on the natural environmental (Grimes & Kentor, 2003; Jorgenson, 2006b, 2007). With particular attention paid to environmental degradation, scholars argue that less-developed countries seek to attract foreign investments in order to expand local production, increase employment opportunities, and advance technology. As countries accumulate stock from foreign investments, resulting in a state of weakness and vulnerability, the negative economic conditions often have a detrimental effect on the population and the natural environment (Chase-Dunn, 1975). World-system scholars argue that poor nations that are left vulnerable by foreign investments have increased environmental degradation within their borders (Bornschier &

Chase-Dunn, 1985; Chase-Dunn, 1975). This environmental degradation is the result of peripheral countries competing to attract foreign investments from core countries, a process that often includes exemptions from complying with environmental laws, thus making it less likely that the peripheral countries will ratify environmental treaties (Leonard, 1988; Roberts, Parks, & Vasquez, 2004).

Social scientists posit that foreign investments in less-developed countries can be linked to a number of environmentally harmful practices. For example, foreign investments are used to finance environmentally hazardous industries, including highly polluting manufacturing processes and facilities (Jorgensen, 2006b). Also, transnational corporations and local populations in developed countries use power generation techniques that are less energy efficient and their facilities are less eco-efficient (Kentor & Grimes, 2006). Kentor and Grimes (2006) suggest that three factors—poor infrastructure, lack of new technology, and use of cheaper but more environmentally hazardous resources—all contribute to the environmental degradation from production financed by foreign investments within less-developed countries. As these countries try to attract foreign investments with their low wages and raw materials, they often have fewer domestic environmental regulations and less eco-efficient conditions and facilities, resulting in higher levels of environmental degradation.

This further suggests that peripheral countries, which aim to attract foreign investments in order to expand local production, increase employment opportunities, and advance technology, are not necessarily focused on alternative industries, such as solar energy, that address environmental crises. Instead, peripheral countries loosen any regulations around environmental laws for foreign investments, which suggests that there are few peripheral nations that prioritize solar energy generation for the purpose of reducing carbon dioxide emissions.

Because peripheral nations are focused on competing to attract foreign investments from core nations, they are unlikely to engage in concerted efforts to increase environmental regulations and invest in newer technologies to increase electricity generated from solar.

Scholars focused on the world economy have also suggested that countries that are well invested in carbon-intensive industries will be less likely to invest in renewable energies such as solar technologies. Despite substantial evidence of the dangers of anthropogenic climate change and increasing global pressure to reduce carbon emissions, select countries remain heavily dependent on energy produced from fossil fuels that expel large quantities of carbon emissions. Scholars describe the reliance on fossil fuels as path dependent and "driven by technological and institutional increasing returns to scale" (Unruh, 2000, pg. 817). To some extent, countries with persistent carbon-intensive technologies actually deter the adoption of alternative technologies that produce less carbon emissions (Unruh, 2000; Unruh & Carillo-Hermosilla, 2006). Previous researchers have found that this is particularly evident for coal power plants, gas plants, and oil-based vehicles (Erickson et al., 2015). From a world economy perspective, countries that have historically invested in large oil rents and existing coal and natural gas industries are less likely to make the transition to alternative forms of energy production, including solar energy.

In the subsequent analyses, I investigate the relationship between solar energy generation and foreign investment dependence, with an understanding of the negative effects that foreign direct investments have on the environment. In the proceeding section, I will discuss the theorized positive aspects of environmental nongovernmental organizations on mitigating some of these harms and potentially remediating environment conditions.

Global Civil Society and International Nongovernmental Organizations

More recently, within the globalization and the environment literature, scholars of world society theory have drawn attention to the importance of global civil society and the diffusion of cultural norms. Scholars focusing on civil society argue that economic and political networks do not sufficiently explain worldwide transformation; instead, they consider the role that international organizations play in establishing and reinforcing global cultural norms (Meyer & Boli et al., 1997; Schofer & Hironaka, 2005). From this perspective, international nongovernmental organizations (INGOs) serve to diffuse and institutionalize cultural models that embody what is often referred to as a world culture (Boli & Thomas, 1999; Clark, 2007). As avenues of world culture, INGOs play an important role in spreading global models related to the environment, which are then adopted by local actors. World society scholars point to the rise of the global environmental regime and how civil society groups diffuse cultural models that specify and define environmentalism (Frank et al., 2000; Meyer & Frank et al., 1997).

Scholars of this tradition argue that the rise in environmentalism is the product of macrosociological factors that have rationalized the environment and have socially constructed environmental issues through the use of scientific thought. The global environmental regime, which first emerged in the late nineteenth century, laid the groundwork for the rise of a new institution following the Stockholm Conference in 1972 (Hironaka, 2014). According to Meyer & Frank et. al (1997), the global environmental regime—which includes intergovernmental organizations, social movement organizations, treaties, and environmental professionals—aids in diffusing these cultural models that ultimately spur social transformation globally. A key component of world society theory regarding the global environmental regime is that the spread of environmentalism goes beyond environmental institutions, organizations, and professionals.

Environmentalism has become embedded within the global civil society and consequently has produced a sense of responsibility among nations to address environmental issues (Frank et al., 2000). These structures that make up world society and spread environmental cultural models are thus influencing national agendas and action taken to address environmental issues such as climate change.

The emphasis on global civil society and the role INGOs play in diffusing and reinforcing environmentalism has drawn skepticism and criticism. Buttel (2000b) questions to what extent, if at all, the diffusion of organizational structures and policies leads to actual change in environmental practices. Since this critique, world society researchers have demonstrated a relationship between the global environmental regime and improvements in environmental outcomes, including deforestation, carbon dioxide emissions, and organic water pollution (Jorgenson, 2007; Jorgenson et al., 2011; Longhofer & Jorgenson, 2017). Considerable evidence suggests that displacing fossil fuel emissions with increased use of solar energy could reduce carbon emission and mitigate climate change (IPCC, 2014). This study aims to expand upon previous research to further analyze how integration within the world society is associated with environmental remediation.

World society theory is often mistakenly understood to describe global environmental change as occurring uniformly at the national level. Although it does identify the surprising level of homogeneity across nations despite differences in resources and culture, world society theorists go much further to highlight cross-national differences in ties to the global civil society and global environmental regime. Nations individually adopt policies and frameworks based on state-level conditions that allow them to incorporate structures that are relevant nationally in a variety of ways (Boyle, McMorris, & Gomez, 2002; Hironaka, 2014). In assessing the

environmental impacts of world society integration, Schofer & Hironaka (2006) suggests that although the impacts will be uneven within and among nations based on state-level conditions, integration in the world society will lead to some level of environmental benefits. In measuring integration and variation of world society membership, researchers look at the presence of INGOs within a nation in relation to environmental outcomes. As agents of change working to spread world culture, INGOs demonstrate a country's linkage to the global civil society.

Scholars have also suggested that a strong presence of environmental INGOs in a nation is more likely to create beneficial environmental outcomes (Jorgensen et al., 2011; Schofer & Hironaka, 2005). Some INGOs are specifically identified as being environmentally focused, but a wide variety of INGOs have adopted some degree of environmental objectives, further demonstrating the expansiveness of the global environmental regime. For example, Care International and Mercy Corps, organizations aiming to fight poverty, and Médecins Sans Frontières, a medical humanitarian organization, have incorporated renewable energy projects and objectives, including solar energy projects. Since INGOs often intervene in the political processes that shape global policies, the spread of environmentalism through these organizations subsequently influences the normative content of global institutions. In terms of energy generation, the presence of INGOs thus potentially influences the global decisions around investments in solar energy.

Next, I evaluate the extent to which the presence of INGOs within a nation is related to increases in energy generated from solar. Additionally, I consider notions of economic development and modernization as a path toward environmental sustainability and solar energy generation. Finally, I consider foreign direct investments as part of world economic integration, the negative environmental outcomes of such investments, despite the well-established fact that

fossil fuel emission is a contributing factor to climate change, and how this relates to solar energy generation.

Data and Methods

In this paper, I analyze unbalanced cross-national panel data on electricity generated from solar energy for 135 countries from 2000 through 2016. The data for solar energy generation comes from the International Renewable Energy Agency (IRENA) (2017), an intergovernmental organization founded in 2009 to promote the adoption of renewable energy. IRENA, a United Nations' observer, provides data on power generation and capacity for all renewable energy technologies for all countries in the world. All countries that have annual data on solar energy generation are included in the analyses. I use indicators from the World Bank's World Development Indicators (2016) in the analyses associated with ecological modernization theory, world systems theory, and global civil society to investigate the relationship with solar energy generation over time.

Dependent Variable

The dependent variable in the analyses is solar energy generation. Solar energy is measured by the total megawatt hours (MWH) generated annually by each country in the analysis as reported by IRENA (2016). The dependent variable is logged (ln) to correct for skewness. Solar energy utilizes technologies that harness the energy from solar irradiance in order to convert sunlight into electricity. This is done primarily by using photovoltaics (PV) such as solar panels, and less often through the use of concentrating solar power (CSP) to produce thermal energy by employing mirrors to concentrate solar rays. IRENA (2016) reports approximately 385,674 MWH of electricity being generated by photovoltaic technologies in 2016, while only 4,951 MWH were produced through concentrating solar power. Both

technologies are included in the analysis since the primary focus of this study is to investigate the factors associated with the rising use of solar as a resource for generating energy.

Key Independent Variables

I use gross domestic product per capita, logged (ln) to address positive skew. The GDP data is in constant 2005 US dollars and was obtained from the World Bank's online World Development Indicators (2017). GDP is the sum of gross value added by resident producers in the economy plus product taxes and minus subsidies not included in the value of the products. GDP per capita is divided by midyear population. As a measurement of economic development, the GDP variable tests for a relationship between modernization and solar energy generation. Consistent with ecological modernization theory, higher levels of GDP per capita will lead to higher increases in solar energy generation.

To investigate theories of foreign direct investments, I employ the following predictor of solar energy generation (MWH): foreign direct investment (FDI) stocks as a percentage of total gross domestic product. Stocks as percentage of total GDP, a measure of foreign capital penetration, is a commonly used measure of foreign investment dependence in current analyses of this type (Dixon & Boswell, 1996; Firebaugh, 1996; Grimes & Kentor, 1998; Jorgenson, 2007). FDI stocks are a measure of the total level of direct investment for each country each year. The variable, measured in US dollars and as a share of GDP, specifically refers to the value of foreign investments in equity in and net loans to enterprises in different economies. This data was obtained from the United Nations Conference on Trade and Development statistics (2018) and the variable is logged (ln) to minimize skewness. Considering that FDI stocks have been demonstrated to create long-lasting links between economies and negative environmental

outcomes, countries with large percentages of FDI stocks will have lower levels of solar energy generation.

In further testing for world economy relationships and solar energy generation, I employ fossil fuel industries as a percentage of gross domestic product. This variable includes oil rents, coal rents, and natural gas rents as a percentage of gross domestic product as obtained from the World Bank's World Development Indicators (2016). The World Bank (2016) defines oil rents as "the difference between the value of crude oil production at world prices and total costs of production." Similarly, coal rents are "the difference between the value of both hard and soft coal production at world prices and their total costs of production" and natural gas rents are "the difference between the value of natural gas production at world prices and total costs of production." I consider the path-dependent relationship of existing fossil fuel industries and test the hypothesis that these existing industries will be negatively associated with solar energy generation.

I use the measure of international nongovernmental organizations (INGOs) in the analyses, which quantifies the number of INGOs that report having members in a given country. This variable refers to the total number of INGO memberships in a nation and is logged (ln) to minimize skewness. The number of a country's INGO memberships is a measure of linkage to the global civil society and the extent to which a country is embedded within the world society. For solar energy generation, scholars emphasizing world society theory suggest a positive relationship between INGO presence and positive environmental outcomes, and thus an increase in solar energy generation.

Other Independent Variables

In all of the models, I include the following control variables: cost of solar, population, democracy, and exports of goods and services. The cost of solar refers to the average cost of photovoltaic cells in US dollars per watt. This data, from the Bloomberg New Energy Finance (2018), is used to control for decreases in the price of solar technology for energy generation. The total population data, obtained from the World Bank (2017), is measured in thousands and logged (ln) to correct for skewness. According to structural human ecology, total population is directly related to scale-level environmental outcomes (York, Rosa, & Dietz, 2003). The democracy variable is a is a measure of democratization within a nation.

Finally, I include exports of goods and services as a percentage of GDP. This variable, a measure of all goods and services a country provides to the rest of the world, controls for the extent to which a country is integrated into the international trading system. Obtained from the World Bank (2017), this data is logged (ln) to control for skewness. While neoliberal perspectives argue that trade integration is important for the spread of technological innovations leading to more sustainable forms of extraction and production (Perkins & Neumayer, 2009), more critical theorists posit that countries will lower their environmental standards in response to pressures from international trade (Jorgenson & Kicks, 2006).

I use STATA Version 15.1 software to test the variables. I use fixed effects regression models with a lagged dependent variable to evaluate the factors associated with solar energy generation for an annual country-level dataset from 2000 through 2016. When countries are measured repeatedly over time, cases are not independent, which can lead to correlated error among the observations and an underestimation of the standard errors. In macrosociology and other comparative social sciences, it is common to use OLS FE methods to correct for heterogeneity bias. In consideration, I used both random effects (RE) and fixed effects (FE)

regression models for my panel data. The RE estimator has the advantage of greater efficiency, but it requires the strong assumption that country-specific error is uncorrelated with other independent variables in the model. The fixed effects model controls for all case-specific unobserved heterogeneity and is therefore less efficient but more conservative. To evaluate the models, I conducted a Hausman test that was significant, indicating that the RE model is biased. Therefore I use the more conservative FE model (Halaby, 2004), which is commonly used in this type of analysis (Jorgenson, 2007).

Additionally, I include a lagged dependent variable in my analysis. By including a lagged dependent variable in the fixed effects model, the dependent variable is regressed on itself at an earlier point in time, along with the independent variables at that same point in time. There is a three-year lag between the dependent variable and the lagged dependent variable and independent variables. While I tested for a number of lags, a three-year lag minimizes the number of lost observations, which increases with longer lags. It is important to include a lagged dependent variable in order to address serial autocorrelation.

Results

The results from the FE regression models are presented in Table 3. I present and discuss the findings, one outcome at a time, in relation to the corresponding theoretical arguments. I report the unstandardized coefficients, which are marked to indicate statistical significance, standard errors, and R^2 overall. In Table 3, I present four FE models, each of which includes all of the variables in Model 1: the lagged dependent variable, cost of solar, total population, and level of democracy. In Model 2, I introduce gross domestic product per capita as a measure of ecological modernization theory. Model 3 introduces variables associated with the world economy including the control for exports of goods and services, as well as foreign direct

investment stocks and fossil fuels. Model 4 is the full model that incorporates the global civil society measure of INGOs.

The cost of solar is negative and statistically significant in all models; thus higher costs of solar per watt are associated with less solar energy generation. Likewise, population is negative and statistically significant across all models; thus high levels of total population are associated with lower levels of solar energy generation. This refutes the structural human ecology argument that total population is associated with related scale-level environmental outcomes. This is likely due to smaller countries investing proportionally larger amounts in solar technologies such as islands and countries with larger geographic space. The measure for democracy is positive, though not statistically significant across all models.

In relation to ecological modernization theory, GDP per capita, a measure of affluence and modernization, is not statistically significant in Models 2 through 4. The variable is positive in Models 2 and 3 and negative in Model 4. As additional variables are incorporated into the models, the association of GDP per capita to solar energy generation decreases in size and ultimately becomes negative in the final model. While affluence is commonly associated with positive environmental outcomes, GDP per capita is not a strong indicator for solar energy generation. This could have implications for understanding trajectories of nations and how energy generated from solar is not necessarily dependent on certain levels of modernization.

In analyzing the effects of the fossil fuel industry on solar energy generation, I incorporate fossil fuels as a percentage of GDP in Models 3 and 4. As expected, the variable is negative, though not statistically significant in both models. The negative relationship is consistent with the notion that existing fossil fuel industries—specifically coal, oil, and natural

gas—have the power to limit environmental improvements, for example by impeding investments in solar energy technologies and projects for energy generation.

In Models 3 and 4, I include exports of goods and services as a percentage of GDP as an additional statistical control for the extent to which a country is integrated into the world economy. Exports as a percentage of GDP is positively associated with solar energy generation and statistically significant in both models. As a measure of integration into the international trading system, the higher the exports as a percentage of total GDP for a country, the higher the solar energy generation. While integration into the international trading system can be an indicator of dependence and associated with higher levels of environmental degradation, in relation to solar energy generation, the findings indicate integration in the world economy has a positive association with a nation's investments in solar energy technologies. The effect of foreign direct investment stocks as a percentage of total GDP is negative in Models 3 and 4. The negative association between FDI stocks and solar energy generation supports the assertions of foreign direct investment theory, although the measure is not statistically significant in either model.

Table 3. Fixed effects regression models with lagged dependent variable evaluating the factors related to solar energy generation for an annual country-level dataset from 2000 to 2016

	1	2	3	4
Solar (ln) 3-year lag	0.496***	0.494***	0.479***	0.474***
	-0.026	-0.026	-0.027	-0.027
Solar cost (US $)	-0.491***	-0.483***	-0.487***	-0.447***
	-0.033	-0.034	-0.036	-0.038
Population (ln)	-2.232**	-2.418***	-2.084**	-1.873*
	-0.705	-0.719	-0.741	-0.743
Democracy (ln)	0.0040	0.0020	0.0010	0.0020
	-0.0050	-0.0050	-0.0050	-0.0050
GDP per capita (ln)		0.334	0.326	-0.134
		-0.303	-0.318	-0.357
Fossil fuels (% of GDP)			-0.025	-0.026
			-0.016	-0.016
Exports of goods and services (% of GDP)			0.014**	0.013**
			-0.005	-0.005
FDI stocks (% of GDP) (ln)			-0.056	-0.109
			-0.094	-0.095
International nongovernmental organizations (ln)				1.899**
				-0.678
Constant	43.425***	43.608***	38.051**	25.769*
	-11.642	-11.652	-11.997	-12.735
Observations	1,134	1,133	1,103	1,103
R-squared	0.701	0.702	0.708	0.711
Number of newid3	135	135	132	132

Standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05

Lastly, in Model 4, the full model, I introduce the INGO measure to analyze the effects of global civil society and assertions from world society theory. The INGO variable is positive and statistically significant in the model, indicating that world society integration increases solar energy generation. In addition to the measure being statistically significant at the 0.01 level, the magnitude of the coefficient for INGOs is also large, indicating for every 1 increase in the INGO (ln) measure, there is a 1.899 increase in solar generation (MWH). The significant result for

INGOs is particularly interesting considering the strong influence of global civil society integration while controlling for both levels of modernization and integration within the world economy. Although previous research has demonstrated a relationship between modernization and environmental outcomes, and the connection between energy generation and economic processes and the world economy is well established, the findings from this analysis suggest that global cultural trends are an important component of rising levels of solar energy. While the global environmental regime encourages state responsibility for the environment, resulting in a number of local and global policies and laws, world society theorists assert that the spread of environmentalism has become embedded within the global civil society beyond environmental institutions and organizations. These findings support this assertion and suggest that INGOs serve to spread a sense of state responsibility for the environment, and that pressure to find alternative energy sources is associated with the rise in solar energy generation globally.

Conclusion

This study contributes to the growing social science scholarship examining the relationship between globalization and environmental outcomes. More particularly, I aim to analyze the key factors influencing country-level behavior in remediating environmental degradation and addressing major environmental issues. The recent rise in solar energy generation is an endogenous phenomenon that is deeply connected to economic, social, and political factors worldwide. Although solar is an abundant resource affording vast opportunity for energy generation, the history of industrialization and energy produced from fossil fuels is deeply rooted globally in how the world imagines energy production and is technologically able to generate energy, due to investments and existing structures. However, the spread of global environmentalism has amplified state responsibility, not only to implement laws and policies to

address environmental issues such as climate change, but also to transform practices and behaviors that aim to mitigate the emergent crises. The growing global culture around environmental awareness has been accompanied by increased pressure, policies, and regulatory frameworks to address climate change. Technological innovations have made solar energy more affordable and accessible, contributing to the incorporation of solar energy generation worldwide.

While there remains much skepticism around the actual impact of global environmentalism as it relates to the adoption of policy and laws, existing research demonstrates that the global environmental regime does produce substantial change in reducing degradation of the natural world (Schofer & Hironaka, 2005). While rapid environmental degradation persists, it has been demonstrated that integration within the global world society slows the pace of environmental consequences (Schofer & Hironaka, 2005). In line with this research, I find that integration within world society has an immense effect on solar energy generation, which potentially reduces a country's greenhouse gas emissions. As an alternative to energy produced from fossil fuels, energy generated from solar is both renewable and sustainable (IPCC, 2014), suggesting the value of country-level increases in solar energy generation to displace energy produced from fossil fuels. Although York (2012) demonstrates that less than one-quarter of a unit of fossil fuel energy is displaced for each unit of energy from non-fossil fuel sources, the drastic increase in solar energy generation is a reflection of major changes in country-level behavior in relation to growing environmental concerns.

While this study does not address whether solar energy is significantly displacing energy generated from fossil fuels, it begins to explain what is influencing countries' adoption of solar as an alternative energy source. With a consistently increasing demand for energy worldwide, as

well as an awareness that carbon dioxide emissions are the primary contributors to climate change, the implications of these findings point to how integration within the global civil society has the potential to remediate environmental issues. The positive association between solar energy generation and the presence of international nongovernmental organizations is an indication that a global cultural understanding of environment issues coincides with action taken address and remediate the environment. Future research should further investigate how countries, through integration in the global civil society, adopt regulatory frameworks and enforce policies to reduce greenhouse gas emissions as a way to further explore the global effort to address climate change.

CHAPTER 4

Adapting to Alternative Energy:

A Qualitative Comparative Analysis of Renewable Energy Regulatory Frameworks

The recent rise in renewable energy generation worldwide demonstrates a dramatic shift in the way societies produce energy and plan for expansions in energy generation. The Intergovernmental Panel on Climate Change (IPCC) has identified renewable energy as having immense potential for significantly mitigating climate change. The panel highlights renewable energy's global potential to reduce carbon emissions by displacing energy produced from fossil fuels and the adoption of alternative energy technologies to meet the basic needs of the population as the social demand for energy continues to increase. Moreover, the IPCC emphasizes the adoption and implementation of policies in order to expand renewable energy generation and stimulate major changes in the energy system (IPCC, 2014).

Although the IPCC and other analysists assume that displacing one unit of energy generated by fossil fuels with renewable resources is an equal exchange, York (2012) demonstrates that simply developing technology to displace fossil fuels is not an adequate way of curbing emission. Rather, his findings indicate that less than one-quarter of a unit of fossil fuel energy is displaced for each unit of energy from non-fossil fuel sources (York, 2012). While efforts to move away from energy produced from fossil fuels has proven to be more complicated than a one-for-one exchange, the efforts of nations to reduce carbon emissions through modification in energy production remains integral to environmental outcomes and climate change (IPCC, 2014). York (2012) suggests that policies addressing climate change should also take into consideration political and economic contexts and human behavior. The IPCC (2014)

also points to public policies as having the ability to either inhibit or advance the development of renewable energy in the future. The role of regulatory frameworks for renewable energy adoption and expansion, such as Germany's *Energiewende* policy and Spain's *Régimen Retributivo Específico*, is equally important for developing countries where access to electricity remains limited and nearly 1.4 billion people still cannot access electricity (IPCC, 2014).

Regulatory frameworks provide infrastructure and foundations that support, guide, and maintain the implementation and control of adopted courses of action. Over the last half century, nations worldwide have adopted numerous regulatory structures around environmental issues, following the emergence of the international environmental regime (Schofer & Hironaka, 2005). Worldwide there has been a boom in national laws and international treaties, focused on environmental change, that provide regulatory frameworks to which societies must adhere. As part of the international environmental regime, these structures inform national agendas and provide policy prescriptions on a variety of environmental issues while also pressuring nations to adopt specific practices (Meyer & Frank et al., 1997). The formation of regulatory structures around climate change is among the most prominent worldwide, with an extensive range of national-level policies, international treaties, and local and global laws to address practices that contribute to this global crises. Most notable are the Kyoto Protocol of the United Nations Framework on Climate Change Conference and the Paris Agreement, which set emission reduction targets cross-nationally. As part of this regulatory framework, national policies and regulations focused on renewable energy implementation and expansion have emerged worldwide. Although these regulatory structures are implemented at the national level, they are informed by the global environmental regime, which emphasizes state responsibility to adopt policies while providing blueprints of these frameworks.

Despite an increase in environmental policies, there is much skepticism and criticism concerning the effectiveness of regulatory structures (Lindstrom & Smith, 2001; Vogel, 1995). In relation to the environmental regime, Buttel (2000b) questions whether an increase in institutional structures in fact affects concrete environmental outcomes. Responding to the notion that the adoption of national policies are all "for show" and without consequence, a number of studies have focused on the environmental regime, global civil society, and real-world environmental improvements related to carbon dioxide emissions, but also to deforestation, water pollution, and synthetic fertilizer and pesticide use (Jorgenson, 2007; Longhofer & Jorgenson, 2017; Shandra, 2007; Shorette, 2012;). Moreover, Hironaka (2014) points out that much of the skepticism concerning the effectiveness of policies is focused on short-term outcomes. Instead, Hironaka (2014) highlights the indirect and long-term effects of regulatory structures, which amount to substantial real-world change. While prior research demonstrates a decoupling between the formalization of policy and actual social changes (Bromley & Powell, 2012; Meyer & Rowan, 1977), there is considerable evidence demonstrating that the existence of regulatory frameworks is associated with observable social changes in the long term (Schofer & Hironaka, 2005; Shandra et al., 2009; Shorette, 2012).

In consideration of scholarship that emphasizes the proliferation in regulatory structures and the impact of environmental policies, as well as experts and researchers who stress the value of regulations for altering practices and behavior (IPCC, 2014; York, 2012), my primary focus in this study is on regulatory frameworks of renewable energy. In 2015, nations worldwide formulated and agreed upon the Sustainable Development Goals (SDGs) which includes the Sustainable Energy for All initiative that seeks to provide access to reliable and sustainable energy globally. In relation to these goals, Regulatory Indicators for Sustainable Energy (RISE)

compiles information and scores for nations regarding national policy and regulatory frameworks for renewable energy. With respect to these scored indicators, I consider this question: Under what conditions do countries adopt multidimensional renewable energy regulatory frameworks to address changes in the energy sector?

In this paper, I seek to contribute to scholarship focused on the implementation of policies and regulations by taking into consideration prevailing perspectives on the adoption of regulatory structures. I argue that advanced regulatory frameworks that focus on renewable energy within a country are the result of cultural, political, and economic factors. Using the RISE dataset, I specify what constitutes an advanced regulatory framework and analyze the context in which these frameworks exist. I use fuzzy set qualitative comparative analysis (fsQCA), which examines complex and multiple causal arguments (Ragin, 1987, 2000), to analyze the conditions under which nations adopt and implement renewable energy policies and regulations. Although research often aims to isolate specific variables associated with theories to explain social phenomenon, I argue that fsQCA is best suited for identifying the complex causal combination resulting in advanced regulatory frameworks for renewable energy. My results highlight the combination of conditions that can explain why certain nations have advanced regulatory structures to regulate the generation and expansion of renewable energy.

In the following section, I outline the key arguments included in my analyses to facilitate an understanding of the adoption of renewable energy regulatory frameworks. The rise in renewable energy and the proliferation of policies and regulators around renewable energy is a complex, endogenous phenomenon that should be considered as a combination of conditions that lead to advanced regulatory frameworks for renewable energy. These arguments serve as a piece

of the recipe in understanding the adoption of regulatory frameworks in the analyses that proceed.

Regulatory Frameworks and the Environment

Modernization and Environmental Policy

From a modernization perspective, economic development and public concern over social conditions drive the emergence of regulatory structures (Inglehart, 1997; Mol, 1997). In terms of environmental policies, ecological modernization scholars argue that there is a connection between modernization and environmental regulations. These scholars aim to explain under what circumstances societies begin to incorporate environmental interests into daily life (Mol, Sonnenfeld, & Spaargaren, 2009). Previous research has demonstrated that although initially there is a negative relationship between development and the environment, further economic development leads to reductions in environmental degradation (Grossman & Krueger, 1991; Mol et al., 2009). Environmental interests and policies emerge through growing public concern and institutional developments triggered by economic development (Mol, 2002). Scholars argue that economic development is the major driver of modernization and that as societies advance and become more affluent, ecological interests grow and environmental policies are formed (Mol, 2002; Rostow, 1990). As suggested, the relationship is not linear, and societies in the early stages of economic development experience an increase in environmental issues. However, as development persists, there is a turning point at which societies' interests in the natural environment increase and environmental harms begin to decrease as regulatory structures are put in place.

Ecological modernization arguments claim that advancements in economic development are the key solution to environmental issues (Mol & Sonnenfeld, 2000). Baker (2007) posits that

economic growth and environmental protection are linked and that modernization is a necessary avenue toward addressing ecological crises. Institutions of modernity such as the state, technology, industrialization, and markets have the capacity to advance society from environmental degradation toward environmental sustainability (Mol, 2002). Scholars argue that through this process of modernization emerges an "ecological rationality" whereby social actors begin to incorporate environmental concerns into social policies and decision-making processes (Mol, 2001).

Thus regulatory frameworks that support improving the environment are motivated by higher levels of economic development, when citizens and businesses can alter their attention to focus on addressing environmental issues. Central to this theory is the idea that in late modernization exists inherent mechanisms that influence society to internalize environmental degradation and seek methods of ensuring environmental sustainability. Murphy (2000) explains that practices and policies emerge at these higher levels of economic development because businesses and groups are no longer focused on development issues, have formulated ideas and interests around the environment, and can dedicate efforts toward reducing ecological impacts. The "greening" of markets begins at this level of modernization in part due to consumer demands for sustainable products and services and regulatory frameworks that support greener practices. Mol (2002) points to countries such as Denmark, Germany, Japan, Sweden and the United States as places where ecological improvements have paralleled economic growth, in what he refers to as the "ecologization of economy." During this process, societies begin to dematerialize while the economy and nature slowly become decoupled, reducing the demands on nature that previously led to environmental degradation (Jorgensen, 2006b; Mol, 1995).

In sum, ecological modernization scholars make it clear that modernization is the answer to ecological crises. As Mol argues in *The Refinement of Production*, "The only possible way out of the ecological crisis is by going further into the process of modernization" (1995, p. 42). Two years later, Spaargaren makes a similar case in *The Ecological Modernization of Production and Consumption*: "The environmental crisis can and should be overcome by a further modernization of the existing institutions of modern society" (1997, p. 25). Modernization precedes the integration of environmental concerns, regulations, and policies, leading to an increase in sustainable choices and changes in markets for sustainable consumption (Spaargaren & Mol, 2009). Ultimately, ecological modernization theory contributes an understanding of how and under what conditions current institutions and social actors will respond to environmental degradation. In relation to regulatory frameworks for renewable energy, nations that have higher levels of economic development will in turn have more advanced regulatory structures.

World Society Theory and the Global Environmental Regime

Ecological modernization theorists argue that environmental policies will follow industrialization and economic development; however, there is ample evidence indicating that this is not always the case. In fact, concern over the environment and interest in environmental protection has grown worldwide despite affluence and modernization (Dunlap & York, 2008). The global spread of environmentalism is a major focus of world society theory. Scholars of this tradition aim to explain the spread of cultural and political traits worldwide. Through this institutional approach, scholars examine and explain the surprisingly high level of homogeneity in global change and the commonalities in international discourses. In contrast to ecological modernization theory, world society theorists hold that the diffusion of environmental regulatory structures is global and not limited to nations that are more industrialized and affluent. Rather,

national policies and regulations are formulated and implemented in response to international pressures from the global civil society (Frank et al., 2000; Frank, Longhofer, & Schofer, 2007; Longhofer & Schofer, 2010; Meyer & Frank et al., 1997).

World society theorists argue that through embeddedness in the world polity, nations learn which behaviors and actions are legitimate and which diverge from the world culture. Cultural models, often referred to as blueprints or recipes, create understandings of not only what a nation should look like, but also how governments should act and interact with each other and organizations (Frank et al., 2000; Meyer & Frank et al., 1997). Notably, world society theorists emphasize the growth of international organizations and treaties that serve to diffuse and institutionalize cultural models that ultimately embody a world culture. Cultural models specifying and defining environmentalism are among the major blueprints that have become institutionalized across the globe. Scholars argue that the rise in environmentalism is a product of macrosociological factors that have rationalized the environment and have socially constructed environmental issues. The global environmental regime that emerged in the late nineteenth century laid the groundwork for the rise of a new institution following the 1972 United Nations Conference on the Human Environment in Stockholm, Sweden (Hironaka, 2014). According to Meyer and Frank et al. (1997), the global environmental regime includes intergovernmental organizations, social movement organizations, treaties, and environmental professionals who aid in the diffusion of these cultural models, which ultimately spur social transformation globally. The proliferation of environmental regulations and policies is the result of the environmental regime that places environmental issues on national agendas.

Researchers have demonstrated that nations with ample ties to the world society are more likely to prescribe to environmental regulations and policies (Frank, 1999; Frank et al., 2000;

Schofer & Hironaka, 2005). A nation's ties to the world polity are often measured through international organizations that play an integral role in reinforcing world cultural norms (Meyer & Frank et al., 1997; Schofer & Hironaka, 2005). Specifically, international nongovernmental organizations (INGOs) transport world culture and diffuse global models to local actors. Environmental nongovernmental organizations (EINGOs) are particularly significant in the diffusion and promotion of environmental standards and the universal adoption of environmental policies (Meyer & Frank et al., 1997). As agents of the global environmental regime, EINGOs advocate for cultural models that frame environmental issues and encourage local actors to take action to protect the environment (Hironaka, 2014; Meyer & Frank et al., 1997). Jorgenson et al. (2011) demonstrates that the presence of EINGOs in less-developed nations mitigates the negative effects of foreign investments on deforestation. World society scholars agree that a strong EINGO presence and the persistence of EINGOs will have a notable impact on the environment (Schofer & Hironaka, 2005).

Of particular interest in this study is the role of EINGOs in the adoption of advanced regulatory frameworks for renewable energy. As members of the world society, EINGOs spread environmental models and have the ability to intervene in political process and influence the language and content of global institutions. In addition, EINGOs are often in a position to monitor behavior and compliance related to environmental issues and treaties, while placing pressure on nations to adopt certain behaviors, international norms, and regulatory structures (Hafner-Burton & Tsutsui, 2005). While the presence of EINGOs within a nation can influence standards and hold nations accountable, they also can support social movement activities, change public opinion, and influence government priorities (Boyle et al., 2002; Frank et al., 2000). As this often leads to regulations and policies, research has also shown that the penetration of

EINGOs within a nation can impact environmental outcomes (Jorgenson, Dick & Shandra, 2011; Schofer & Hironaka, 2005). In sum, EINGOs have the potential to influence the development and implementation of environmental regulations and policies, and thus their collective presence is hypothesized to be a key component for the presence of advanced regulatory frameworks for renewable energy.

World Economy, Dependency, and State Interests

Despite the global spread of environmentalism and the proliferation of environmental regulations and policies worldwide, scholars emphasizing the world economy point to the role that power and inequality play in establishing norms and behavior (Beckfield, 2003; Smith, 2000). Moreover, Shorette, Henderson, Sommer, and Longhofer (2017) urges sociologists to consider the relationship between world economy and world society to further examine how factors related to these theories interact and influence environmental conditions. Based on these suggestions and critiques, I consider the relationship between the world economy and environmental regulation, specifically how it relates to renewable energy regulatory frameworks.

As a critique of ecological modernization theory, arguments from the political economy perspective emphasize the negative consequences that globalization has on the environment. World system theorists identify ecological destruction as a key dilemma of modern capitalism (Jorgenson & Burns, 2003; Wallerstein, 1974). These scholars challenge ecological modernization theory by suggesting that there are various factors within the world system that result in unequal environmental outcomes (Jorgensen, 2003). For instance, Jorgensen (2003) argues that there is a clear connection between environmental degradation and global modes of production and accumulation. In addition, scholars from these perspectives are critical of world society theory for inadequately considering the role that power and inequality play in

establishing global norms and behaviors (Beckfield, 2003; Smith, 2000). In an examination of advanced regulatory frameworks around renewable energy, these perspectives offer a useful framework for understanding variations in environmental processes, including the adoption of environmental policies and regulations, despite widespread knowledge of the consequences of environmental degradation (Roberts & Grimes, 2002; Smith, 1994).

Scholars of world system analysis are particularly concerned with the environmental crises central to modern capitalism and the failure of the system to find solutions to address environmental degradation (Foster, 1999; Wallerstein, 1999). The core-periphery model offers a framework for understanding variations in development among nations and the environmental outcomes that result from these hierarchical relationships (Bergesen & Parisi, 1997; Wallerstein, 1974). The connection between global modes of production and accumulation is continually linked to environmental degradation. Additionally, by depicting exploitation, the core-periphery model can be better understood as a global hierarchy that results in environmental degradation occurring at a greater rate in poor countries than in rich countries (Chase-Dunn, 1989; Wallerstein, 1974). With the assertion that core countries export environmentally hazardous industries to peripheral nations (Grimes & Kentor, 2003), world system scholars posit that environmental degradation is perpetuated through unequal power relations based on a country's position within the global system.

Foreign investment dependence is rooted in world system analysis and emphasizes the manner in which foreign direct investments perpetuate various forms of environmental degradation (Jorgenson et al., 2007; Jorgenson et al., 2011; Jorgenson & Kuykendall, 2008). Chase-Dunn (1975) posits that foreign investments contribute to a highly stratified world economy in which less-developed countries become more vulnerable within the world system.

One of the major consequences of this global stratification is the suppression of economic development for less-developed nations (Firebaugh, 1992). Scholars argue that less-developed countries aim to attract foreign investments in order to expand local production, increase employment opportunities, and advance technology. Through foreign investments, countries accumulate stock, leading to a state of weakness and vulnerability. Poor nations that are left vulnerable with inferior economic conditions are argued to have detrimental consequences on the natural environment (Bornschier & Chase-Dunn, 1985; Chase-Dunn, 1975).

In part, environmental degradation within specific nations stems from countries having lax environmental laws and policies as a result of peripheral countries competing to attract foreign investments from core countries (Leonard, 1988; Roberts et al., 2004). Regarding environmental policy and regulations, foreign investment dependence is argued to force peripheral nations to lower their standards in order to attract investments and advance economic development. Global reports have also pointed to the acceleration of industrial pollution intensity in less-developed nations associated with stricter regulations and policies in core nations (Lucas, 1992). The rise in policy implementation around pollution-intensive production in nations that are more developed is suggested to be negatively associated with a rise in industrial pollution as a result of location displacement (Lucas, 1992). As a result of the pressure, typically driven by debt, on periphery nations to develop export economies, their environmental regulatory frameworks are generally weak. I consider this to be true of regulatory frameworks for renewable energy as well. Countries with a higher degree of foreign direct investments will be less likely to have advanced regulatory frameworks for renewable energy because of their dependency on core nations.

A great deal of scholarship centered on the world economy raises doubts about the implementation and effectiveness of laws and policies that could potentially hinder a state's economic interests (Lindstrom & Smith, 2001; Susskind & Ozawa, 1992; Vogel, 1995; Yearley, 1991). Countries that rely heavily on energy produced from fossil fuels and benefit from the production of the fossil fuel industry have a vested interest in carrying out "business as usual," which means avoiding the adoption and enforcement of environmental policies that threaten this industry, despite growing evidence documenting the detrimental impacts of anthropogenic climate change. The term *carbon lock-in* refers to the persistence—driven by strong state interests—of carbon-intensive technologies that deter, or lock out, the adoption of alternative technologies with lower carbon emissions (Unruh, 2000; Unruh & Carrillo-Hermosilla, 2006). To favor the fossil fuel industry and increase revenue, the United States recently rolled back environmental policies, despite predictions that such action will contribute to a higher level of emissions (Biesecker & Brown, 2018). In addition to strong lobbying and existing investments, this path-dependent phenomenon is perpetuated through increasing technological and institutional returns to scale (Unruh, 2000). The carbon lock-in is most resilient in countries that have strong coal power plants, gas plants, and oil-based vehicles (Erickson et al., 2015). Accordingly, I hypothesize that countries with existing fossil fuel industries have strong state interests that impede on the implementation of advanced regulatory frameworks for renewable energy.

In sum, I consider these macrosociological perspectives to analyze advanced regulatory frameworks within nations. While ecological modernization theorists argue that affluence and industrialization lead to the implementation of environmental policies and laws, world society scholars emphasize the proliferation of environmental policies worldwide despite level of

modernization. Scholars of world system analysis challenge the assertion of ecological modernization theory that capitalism can ameliorate environmental degradation, while also questioning the absence of power and inequality in world society theory. Scholars have employed various methods to analyzing the relationship between embeddedness within the world society while also considering the role of the world economy (Beckfield, 2003; Shorette, 2012). However, I argue that it is important to identify the complex causal combination stemming from these perspectives that lead to the development of advanced regulatory frameworks for renewable energy to better understand variation among nations.

Data and Methods

I use fsQCA to assess and identify the combination of causal arguments that satisfy the research question: Under what conditions do countries adopt multidimensional renewable energy regulatory frameworks to address changes in the energy sector? QCA is best suited for appraising causal combinations (Ragin, 2008), such as the causal recipes that are involved in a country having advanced regulatory frameworks for renewable energy. While other methods can identify specific variables correlated with an outcome, QCA is better suited for depicting the complex causal combinations that result in a given outcome. This method enables me to analyze the multiple-path explanations for the outcome measure, advanced regulatory frameworks. I employ fuzzy sets considering the outcome and independent measures are interval variables where fuzzy sets, as opposed to crisp sets, allow for the calibration of the data to include partial membership. I employ data reported from the Regulatory Indicators for Sustainable Energy (RISE) dataset, which consists of indicators that allow for comparisons in national policy and regulatory frameworks for sustainable energy. This is a relatively new dataset that includes 27 indicators on national policy and regulatory frameworks for renewable energy in 111 countries.

Additionally, I utilize indicators from the World Bank's World Development Indicators (2016) and UNCTAD (2018) and data collected on the presence of EINGOs and government ideology in the analyses. The factors from these datasets are associated with ecological modernization theory, world society theory, and world system analysis to investigate the causal combination leading to advanced regulatory frameworks for renewable energy.

Outcome Measure

The outcome measure in the model is taken from the RISE indicators, which calculate a score for each country in the analysis and allow for comparison in national policy and regulatory frameworks for renewable energy. The renewable energy regulatory framework score includes seven scored indicators that reflect a multidimensional approach for comparing different aspects of the regulatory framework for each country. These indicators include legal framework for renewable energy, planning for renewable energy expansion, incentives and regulatory support for renewable energy, attributes of financial and regulatory incentives, network connection and pricing, counterparty risk, and carbon pricing and monitoring. The scores for renewable energy regulatory framework fall between zero and 100 and are weighted equally. In the analysis, I examine what causal combinations lead to the presence of an advanced regulatory framework. The fsQCA method requires the calibration of sets. I calibrate the raw data into fuzzy set membership scores based empirically and theoretically grounded thresholds to determine full membership, the crossover point, and full non-membership. Therefore, I further define the outcome measure in the following manner: an advanced regulatory framework for renewable energy is fully in the set if a country scores 84 or higher as reported by the RISE dataset; the crossover point is 67 and the threshold for non-membership is 34.

Table 4. Conditions and Calibration Thresholds			
Outcome and Causal Conditions	Full Membership	Crossover Point	Full Non-Membership
Renewable energy regulatory framework score	84	67	34
GDP per capita (current US$)	42000	10000	1000
Environmental international nongovernmental organizations (total)	22	10	2
Level of democracy (scale +10 to -10)	10	4	-6
Exports of goods and services (% of GDP)	60	30	10
Foreign investment stocks (% of GDP)	29	3	1
Fossil fuel (% of GDP)	16	7	1
Right government ideology (dichotomous)	1		0

Causal Measures

I include six causal measures in the analysis that are associated with ecological modernization theory, world society theory, and political economy of the world system analysis. The combination of these measures is predicted to best explain the presence of an advanced renewable energy regulatory framework within a nation. The measures include gross domestic product per capita, environmental nongovernmental organizations, level of democracy, exports of goods and services as a percentage of GDP, foreign direct investment stocks as a percentage of GDP, fossil fuels as a percentage of GDP, and right government ideology. All of the causal measures are for the year 2014, when the outcome measure became available in the RISE dataset. I define the causal conditions in more detail below.

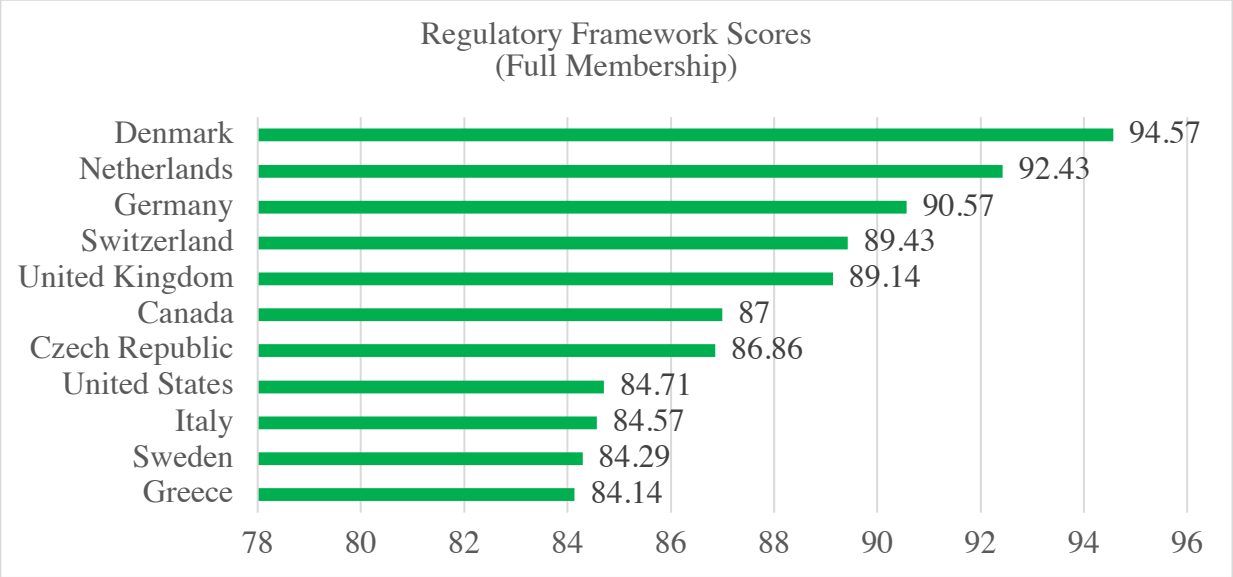
Gross domestic product per capita (GDP) is in constant 2005 US dollars. From the World Bank's World Development Indicators (2016), GDP is the sum of gross value added by resident producers in the economy plus product taxes and minus subsidies not included in the value of the products. GDP is divided by midyear population. This causal measure is an indicator of economic development. According to ecological modernization theory, higher levels of GDP

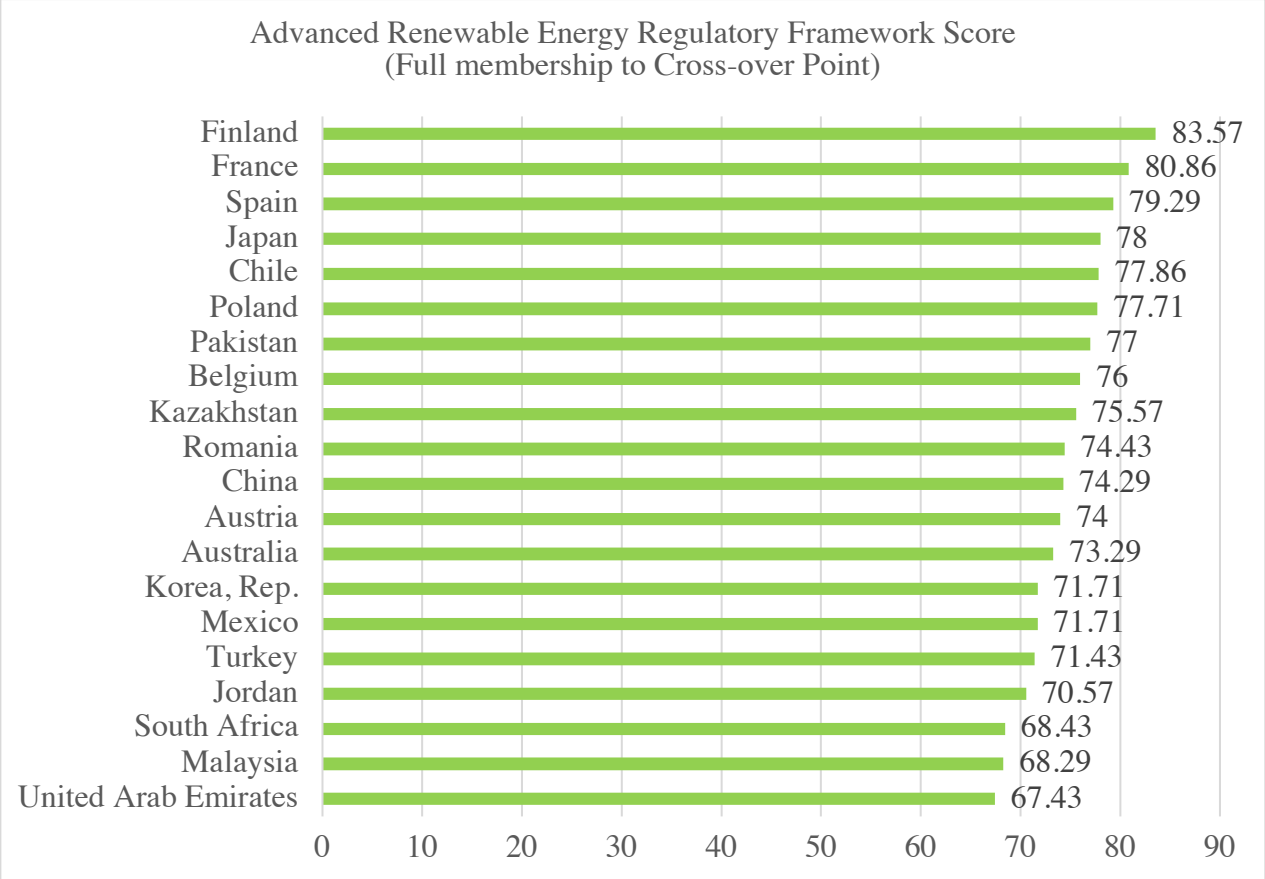
will lead to advanced regulatory frameworks. This condition is calibrated based on determination of qualitative differences in GDP and clear gaps in the distribution of the data: full membership is $42,000, the crossover point is $10,000, and the full non-membership is $1,000.

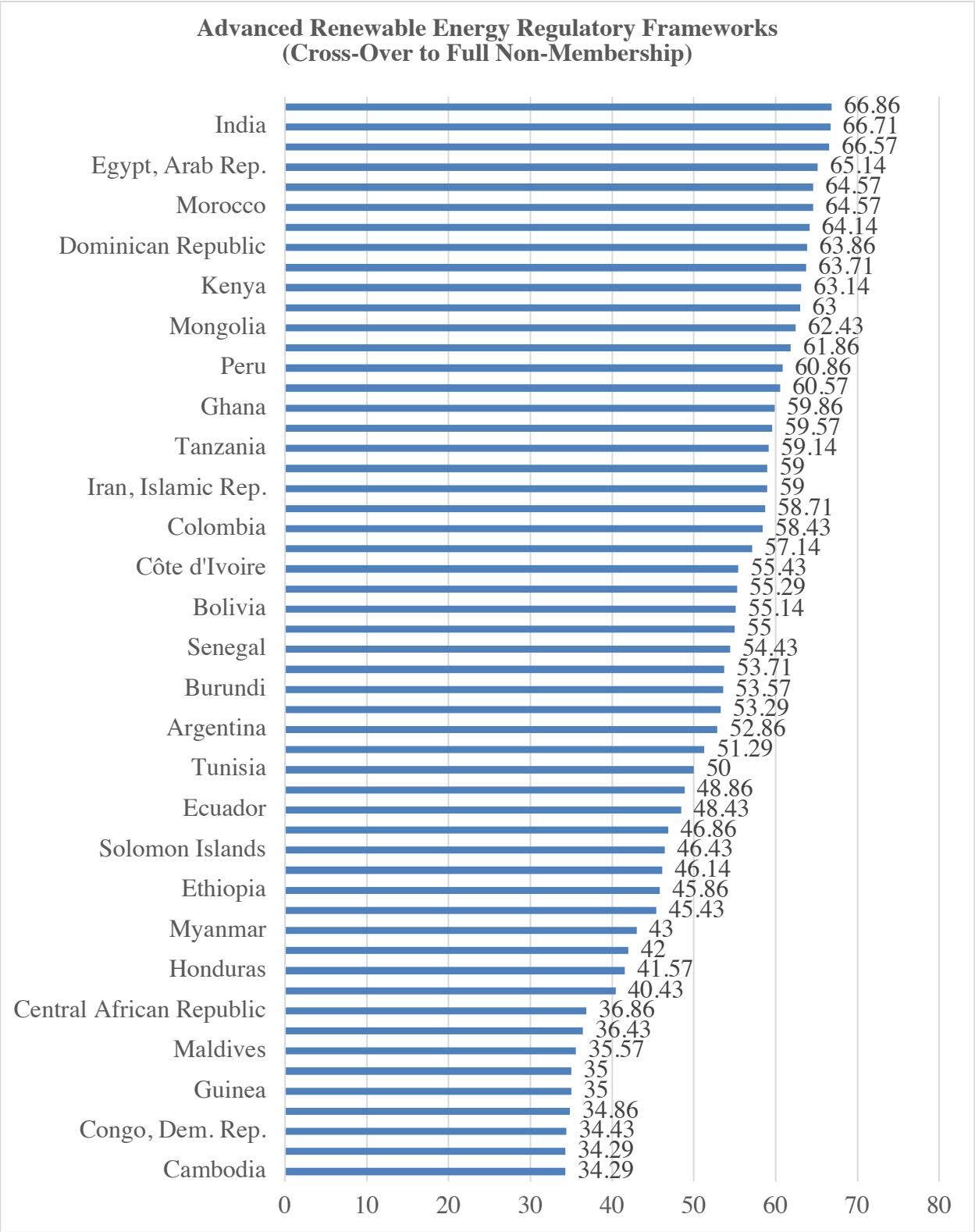
Environmental nongovernmental organizations (EINGOs) quantifies the number of EINGOs that report having members in each country. International nongovernmental organizations (INGOs) is a measure of linkage and how embedded a country is within the world culture. EINGOs are a subgroup of INGOs that focus on the environment and work on environmental issues. From the world society scholarship, I hypothesize that the presence of EINGOs will be related to advanced renewable energy regulatory frameworks. This variable is calibrated based on careful examination of gaps in the distribution: full membership is 22, the crossover point is 10, and full non-membership is 2.

Level of democracy is a measure of democratization within a nation. World society scholars suggest that the wave of democracy worldwide is associated with global culture and the delegitimation of the authoritarian state (Schofer, Hironaka, Frank, & Longhofer, 2012). Nations that are more embedded within the world society will have higher levels of democracy, allowing for the adoption of regulatory frameworks for renewable energy. In a related vein, level of democracy is also related to ecological modernization theory, which emphasizes the role of democracy in encouraging environmental responsibility (Mol, 2002). As a causal condition, a higher level of democracy is expected to lead to advanced regulatory frameworks for renewable energy, considering that democratization is associated with providing favorable conditions for the development of environmental policy. The variable ranges from +10 to -10 and is calibrated based on qualitative differences between cases: full membership is 10, the crossover point is 4, and full non-membership is -6.

Figure 3. Renewable Energy Regulatory Framework Scores






Advanced Renewable Energy Regulatory Frameworks
(Cross-Over to Full Non-Membership)
India 66.86
66.71
66.57
Egypt, Arab Rep. 65.14
Morocco 64.57
64.57
Dominican Republic 64.14
63.86
Kenya 63.71
63.14
Mongolia 63
62.43
Peru 61.86
60.86
Ghana 60.57
59.86
Tanzania 59.57
59.14
Iran, Islamic Rep. 59
59
Colombia 58.71
58.43
Côte d'Ivoire 57.14
55.43
Bolivia 55.29
55.14
Senegal 55
54.43
Burundi 53.71
53.57
Argentina 53.29
52.86
Tunisia 51.29
50
Ecuador 48.86
48.43
Solomon Islands 46.86
46.43
Ethiopia 46.14
45.86
Myanmar 45.43
43
Honduras 42
41.57
Central African Republic 40.43
36.86
Maldives 36.43
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Guinea 35
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Congo, Dem. Rep. 34.86
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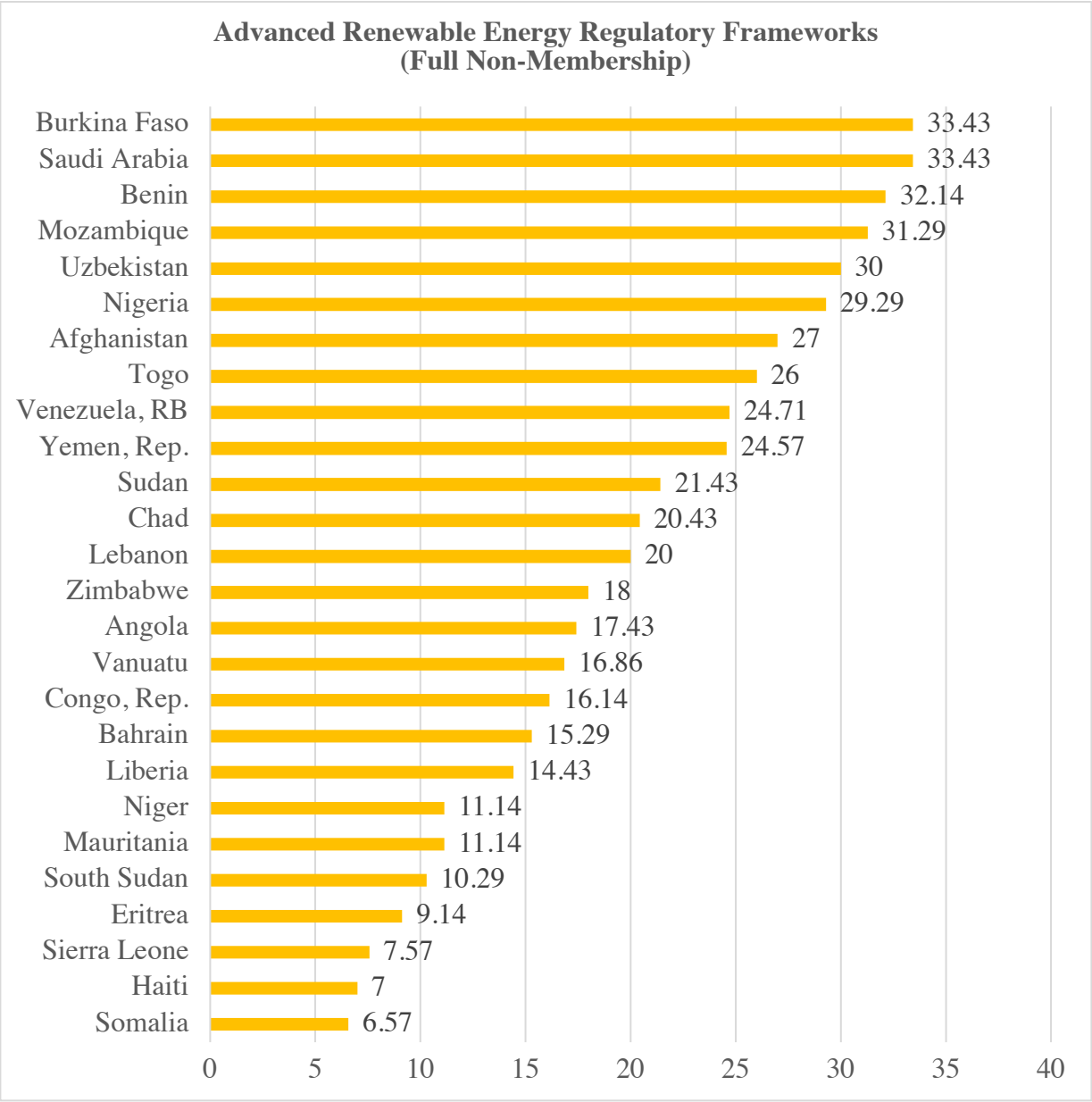
Cambodia 34.29
34.29
0 10 20 30 40 50 60 70 80



Exports of goods and services as a % of GDP is a measure of the level of integration of a country into the international trading system. Exports of goods and services is a measure of the all goods and services that a country provided to the rest of the world. According to world systems analysis, higher levels of exports lead to greater environmental degradation. I hypothesize that higher levels of exports will be absent in the causal combination leading to advanced renewable energy regulatory frameworks. In calibrating this condition, I carefully

analyze the data to consider high levels of dependency as measured by exports: 60% or higher is considered full membership, 30% is the crossover point, and 10% is the threshold for full non-membership.

Foreign direct investment stocks as a % of GDP (FDI) is a measure of the total level of direct investment for each country each year. Measured in US dollars and as a share of GDP, this variable specifically refers to the value of foreign investments in equity and net loans to enterprises in different economies. Considering that FDI stocks have been demonstrated to create long-lasting links between economies and negative environmental outcomes, I hypothesize large percentages of FDI stocks will be absent in the causal combination leading to advanced regulatory frameworks for renewable energy. This measure is calibrated based on a qualitative examination of the data as well as breaks in the distribution: full membership is 29%, the crossover point is 3%, and full non-membership is 1%.

Fossil fuels as a % of GDP includes oil rents, coal rents, and natural gas rents. The World Bank's World Development Indicators (2016) defines oil rents as "the difference between the value of crude oil production at world prices and total costs of production." Similarly, coal rents are "the difference between the value of both hard and soft coal production at world prices and their total costs of production," and natural gas rents are "the difference between the value of natural gas production at world prices and total costs of production." From a political economy perspective, I hypothesize that this measure, fossil fuels as a % of GDP, will be absent from the causal combination leading to the large percentages of electricity being produced from renewable energy. This is primarily due to the carbon lock-in effect in which countries with existing investments in fossil fuel industries are less likely to adopt technologies that emit less carbon dioxide. This measure is calibrated based on careful examination of the data and qualitative

differences between the cases: full membership is 16%, the crossover point is 7%, and full non-membership is 1%.

Right government ideology comes from the World Bank Database of Political Institutions (DPI). In the dataset, government ideology is categorized as right, left, or center. In the analysis, I dichotomize this measure, coding right government ideologies as 1 and all other countries as 0. Right government ideologies are defined in the dataset as conservative, Christian democratic, or right wing. From a world society perspective, government ideology would only minimally limit the influence of the global civil society. On the other hand, political economy scholars would argue that a government ideology dominated by capitalists would greatly deter a nation from adopting renewable energy regulatory frameworks.

Qualitative Comparative Analysis

I begin by comparing the theoretical expectations from ecological modernization theory, world society theory, and political economy of the world system analysis. By using fsQCA, I am able to take a middle path combining both quantitative and qualitative approaches toward examining the combination of conditions that result in advanced regulatory frameworks for renewable energy within nations. In the analysis, fsQCA identifies the various combinations of causal conditions that are associated with the outcome, advanced regulatory frameworks, as well as the coverage and consistency. Measured on a scale of 0 to 1, coverage is the proportion of the sum of the membership scores in the outcome that is covered; it is undermined by cases with low membership in the causal combination coupled with high membership in the outcome. Coverage is further divided into two separate categories: raw coverage, which represents the coverage of all cases accounted for in a specific combination of conditions, and unique coverage, which reflects the proportion of memberships in the outcome that are unaccounted for by other causal

conditions or combinations. Measured on a scale of 0 to 1, consistency is the degree to which a combination of conditions is a subset of the outcome; it is undermined by the cases whose memberships in the causal combination far exceed their memberships in the outcome. In general, a meaningful consistency is benchmarked at 0.8; however, existing research identifies scores of 0.9 or greater as being highly consistent.

The truth table is the principal unit of analysis in fsQCA, and the algorithm for the table requires a two-step analytic procedure. The first step consists of the creation of the truth table from the fuzzy data, including a specification of the outcome for each configuration and a determination of the configurations to include in the analysis. Having calibrated the outcome and causal conditions, I am then able to generate a truth table (Table 4) that displays the observed configurations of the cases and the corresponding membership scores. The table lists the observed combinations of the causal conditions and the cases that correspond to them, as well as the outcomes with which they are associated. The second step in the process involves logical minimization. For the analysis, only configurations represented by at least five cases were included. Additionally, through examining the gaps in the upper range of consistency, I set the threshold for coding configurations as theoretically consistent subsets of the outcome at 0.9. This threshold limits the configurations to those that reach or exceed this level of consistency.

Findings

The configurational theoretical expectations from these perspectives for advanced renewable energy regulatory frameworks are as follows:

GDP*EINGOs*DEMOCRACY*exports*fossil*stock*right*[2]
→Advanced RE Regulatory Frameworks

This expression reads as follows: Countries with a high GDP per capita and a large number of EINGOs and high levels of democracy and low levels of exports and low percentages of fossil fuels and low levels of foreign direct investment stocks and non-right wing government ideologies are expected to have advanced regulatory frameworks for renewable energy. There are 128 theoretically possible combinations of the six fuzzy causal conditions; however, only 30 combinations of conditions were found to identify advanced regulatory frameworks for renewable energy within nations. Additionally, after minimizing the table to include only configurations represented by at least five cases and setting the threshold for consistency at 0.9, only eight combinations remain. Finally, after performing a standard analysis, the resulting truth table analysis derives three solutions: complex, parsimonious, and intermediate. Table 5 presents the intermediate results of the fsQCA for advanced regulatory frameworks for cases with greater than 0.5 membership. The intermediate solution uses only the remainders that survive the counterfactual analysis, which I input based on the theoretical arguments and knowledge of each condition. Consistent with the existing research testing ecological modernization theory, world society theory, and world system analysis, this figure demonstrates that the solution for the outcome, advanced regulatory frameworks for renewable energy, is comprised of the following combination:

GDP*EINGO*DEMOCRACY*fossil*stock* →Advanced RE Regulatory Frameworks

This configuration reveals the conditions that must be present for nations to have advanced regulatory frameworks for renewable energy. In this configuration, 16 cases are

[2] The notation is fsQCA should be read as follows: a measure written with all capital letter denotes its presence and a measure written in all lowercase letters denotes is absence. Additionally, an asertick (*) indicates the logical operator "and."

accounted for in terms of advanced regulatory frameworks for renewable energy. Countries must have high EINGO memberships, high GDP per capita, low levels of fossil fuels as a % of GDP, low foreign investment stocks as a % of GDP, and high levels of democracy to have the outcome of advanced regulatory frameworks for renewable energy. The consistency for the intermediate solution is 0.95 and the solution coverage is 0.54. This path explains a high portion of the outcomes, as indicated by the coverage. Additionally, this solution suggests that the path toward an advanced regulatory frameworks for renewable energy includes a number of conditions and not one unique variable or approach. The condition of exports of goods and services, as a measure of dependency, does not appear in the solution, which suggests that exports is not an important component in the recipe for nations adopting advanced renewable energy regulatory frameworks. Additionally, the condition of right wing ideology does not appear in the solution, suggesting that a more conservative political ideology has only limited influence on the adoption of these forms of regulatory frameworks.

Theoretically, the causal conditions within the solution are consistent with existing scholarship; however, the solution expands upon these individual theories to demonstrate the complexity in understanding the adoption of policies and regulations that incorporate and expand upon innovative and developing forms of energy. The significance of this solution highlights not only the involvedness of regulatory frameworks and the energy sector, but also the endogenous nature of renewable energy. Globally, renewable energy generation has drastically increased, as has the incorporation of regulations and policies around renewable energy. While individual factors are often associated with regulatory frameworks, the complexity of these frameworks is demonstrated in the intermediate solution from this analysis, which shows that a combination of these factors is associated with this outcome.

Table 5. Truth Table Analysis (Intermediate Solution)

Model:	policy = f(gdp, eingo, democracy, exports, stock, fossil, right)		
Frequency cutoff:	5		
Consistency cutoff:	0.929664		
Assumptions:	gdp (present) eingo (present) democracy (present) ~exports (absent) ~fossil (absent) ~stock (absent) ~right (absent)		
Solution:	GDP*EINGO*DEMOCRACY*~stock*~fossil		
Coverage:	Raw	Unique	Consistency
	0.535923	0.535923	0.947487
Solution coverage	0.535923		
Solution consistency	0.947487		

Table 6. Coverage and Consistency for Cases

Solution: GDP*EINGO*DEMOCRACY*~fossil*~stock* → Advanced RE Regulatory Frameworks		
Germany	0.95	0.98
Sweden	0.95	0.95
Austria	0.95	0.77
United States	0.94	0.96
Italy	0.92	0.96
France	0.92	0.92
Denmark	0.91	0.99
Japan	0.9	0.87
Belgium	0.88	0.83
Greece	0.75	0.95
United Kingdom	0.72	0.98
South Korea	0.68	0.7
Spain	0.65	0.9
Argentina	0.55	0.22
Switzerland	0.54	0.98
Mexico	0.51	0.7

Conclusion

To summarize, I argue that adoption of advanced regulatory frameworks for renewable energy results from a combination of social, political, and economic factors. While the IPCC (2014) identifies public policies as having the potential to either advance or hinder renewable energy generation, previous research suggests the examination of policies related to climate change need to take multidimensional approaches to incorporate political, economic, and social contexts (York, 2012). My primary aim in this study is to expand upon existing scholarship that focuses on global environmentalism and the adoption of environmental policies and regulations. Regulatory frameworks provide the necessary infrastructure and foundation to support and maintain a specific course of action. The adoption and expansion of regulatory frameworks for renewable energy is an integral component of addressing climate change across the globe. Despite the rise in renewable energy in recent decades, carbon emissions produced from fossil fuels also continue to increase. The IPCC (2014) emphasizes the adoption and implementation of policies focused on the expansion and regulation of renewable energy in order to stimulate major changes in the energy sector.

I use fsQCA to move beyond methodological approaches that predominantly assess the separate impact of competing independent variables; instead, I seek to define logically possible combinations of causal conditions (Ragin, 2000). This approach allows me to analyze the contexts and conditions that support a relationship between theoretically specified causal conditions and the outcome of advanced regulatory frameworks for renewable energy. Macrosociological approaches focused on environmental issues are often theoretically founded in ecological modernization theory, world society theory, and political economy of the world systems analysis. By incorporating key components of these theories into my analysis, I treat the

proliferation of renewable energy policy as an endogenous phenomenon that cannot be fully explained by individual or competing independent variables. I find that countries with advanced renewable energy regulatory frameworks have high levels of EINGO membership, high levels of GDP, low levels of fossil fuel industries, low foreign investment stocks, and high levels of democracy. In theoretical terms, countries that are more linked to global civil society, more modernized or industrialized, and less dependent on core nations and existing industries have advanced renewable energy regulatory frameworks.

According to world society theorists, the diffusion of environmentalism has led to a proliferation of environmental policies worldwide (Hironaka, 2014). The presence of EINGOs within a nation is a measure of linkage to world society, considering that EINGOs carry environmental models and have the ability to intervene in political processes in favor of global environmentalism. Likewise, the global spread of democracy creates favorable conditions for policy adoption and is deeply connected to notion of legitimacy in the world society. While these factors impact policy formation and adoption, the solution indicates that the presence of advanced renewable energy regulatory frameworks within a nation is the result of a combination of factors. As theorized, economic development, or modernization, and the resultant public concern over environmental conditions that drive the emergence of regulatory structures (Ingelhart, 1977; Mol, 1997) is supported in the solution as a causal condition. Still, modernization in itself is but one component in producing the outcome independently. Finally, the absence of dependency and existing industries are causal conditions that enable countries to adopt advanced renewable energy regulatory frameworks. The absence of foreign investment stock indicates a lack of dependency on core nations that would inhibit efforts focused on the

environment. As for fossil fuel industries, the solution indicates that the absence of a carbon lock-in is a key component in the recipe for advanced renewable energy regulatory frameworks.

With the rise of environmentalism worldwide and the rapid propagation of regulatory frameworks addressing environmental issues, the findings of this study contribute to understanding the complexity of the contexts that enable nations to develop progressive regulatory structures and adopt advanced policies for renewable energy. Although world society scholars emphasize the role of the global environmental regime and the top-down dynamics that shape national policy structures as nations conform to global norms and standards, additional country-level conditions are necessary for determining the quality of the resultant regulatory frameworks. As the IPCC (2016) urges energy generation to shift away from fossil fuels and toward alternative energy sources, research has demonstrated that this shift is more challenging than a simple unit-for-unit exchange and that there is a need for explicit policies that have the potential to make a substantial difference (York, 2012). The rise in renewable energy regulatory frameworks is an indication that major changes in the energy sector are underway; nonetheless, more advanced regulatory frameworks have a higher potential to address the growing climate change crisis. A general implication of these findings is that while renewable energy regulatory frameworks are proliferating, global efforts to address climate change need to take into consideration the multifaceted contexts that lead to variations in the quality of the regulations and policies within nations.

CHAPTER 5

Conclusion: Global Environmentalism and Renewable Energy

The rise in renewable energy is transforming the energy sector globally while the world is facing major concerns about the effects of climate change. As anthropogenic climate change continues to disrupt the physical world and poses observable threats to human civilization, the global shift towards renewable energy offers a possible solution where collective action can remedy the situation (IPCC, 2014). Yet, while overall global trends in renewable energy generation are steadily increasing, there remains immense variation amongst nations in the amount of total electricity produced from renewable sources. The world is facing an historic crossroads as international discourse around climate change and renewable energy is at a record high.

With substantial variation in renewable energy generation amongst nations and uncertainty around the future of global, collective efforts to mitigate climate change, there is a significant need to further understand country-level behavior in the energy sector. CNN (2017) described the Paris Agreement as "a landmark deal, ratified by 147 parties or countries… aimed at cutting emissions and keeping global temperatures from rising more than 2 degrees Celsius above pre-industrial levels." Inherent in this agreement is the push for nations to invest in renewable energy sources and adopt regulatory frameworks that allow for the future development of renewables. Nonetheless, while some nations continue to makes strides to meet their commitments, other nations, for example, the United States and Australia, have pulled out of the agreement or are signaling their exit. While global environmentalism places the climate change issue at the forefront of international agendas, questions about varying levels of nations' responsibility surface around the renewable energy phenomenon.

This dissertation research focuses on examining factors influencing the global rise in renewable energy with an in depth look at solar energy specifically as well as the conditions associated with renewable energy regulatory frameworks. The overall goal of this research is to contribute to a broader understanding of the connection between global environmentalism, country-level variables, and renewable energy generation. Analyzing these relationships is beneficial to understanding the current global initiatives and efforts to mitigate climate change. As social science research remains imperative to addressing human induced climate change, I contribute to the growing environmental sociology scholarship that emphasizes environmental remediation. This dissertation research does so by highlighting the impact of international treaties, emphasizing the role of non-governmental organizations, and identifying configurations of country-level conditions that lead to advanced regulatory frameworks.

More broadly, through my research, I aim to expand upon existing sociological theories that focus on the environment. In the second chapter, I analyze factors related to increases in renewable energy production and I test variables associated with ecological modernization theory, political economy perspectives, and world society theory. I find support for ecological modernization theory and the importance of economic growth and affluence for a nation in relation to renewable energy production. As Mol (2002) suggests, there is evidence that the growing public concern over the environment and consequently policies that aim to protect the environment are the result of a country's economic development and affluence. Still, ecological modernization theory fails to grasp fully the expansiveness of the renewable energy phenomenon and does not completely explain the variation amongst nations in terms of renewable energy production. For instance, many poorer nations are leading the way in the renewable energy

revolution and have succeeded in producing large percentages of their total electricity from renewable sources.

In relation to political economy perspectives, I expand upon previous research identifying the impact of the "carbon lock-in." Unruh (2000) posits that anthropogenic climate change is deeply embedded in the production and consumption patterns of modern capitalism. In this study, the findings demonstrate that existing industries, specifically those that are fossil fuel related, hinder renewable energy production. Considering the history of fossil fuels in energy generation, the economic patterns of industrialized societies remain dependent on carbon-based energy technologies and infrastructure. These findings support this notion where evidence that the adoption of renewable energy technologies are "locked-out" within nations that have advanced pre-existing oil, coal, and natural gas industries.

Still, the most profound finding from this study is the magnitude of the impact of international treaty ratification for renewable energy production. For environmental remediation and the role of the environmental regime, the findings indicate that the effect of Kyoto Protocol ratification was highly significant in association with renewable energy generation. In relation to environmental issues, world society scholars emphasize the role of the global environmental regime in influencing national agendas, providing policy prescriptions, and pressuring nations to act (Meyer et al, 1997; Schofer & Hironaka, 2006). Supporting this argument, the findings suggest that a nation's participation in international treaties can foster interests in an issue while also changing behavior at the domestic level. For what is often considered a "failed treaty," the impact of the Kyoto Protocol ratification on renewable energy production supports the notion that participation in global civil society influences country level behavior. The implications of these findings highlight the role of international treaties in addressing environmental issues and

shaping the actions countries take to remediate the situation. With the current uncertainty around the value and effectiveness of the Paris Agreement, these findings provide a clear understanding of the potential impact of international treaty ratification as the first of many steps to mitigating climate change.

The findings in this chapter also point to the role of international nongovernmental organizations (INGOs) in prioritizing the environment for nations through the process of spreading world culture. World society scholars point to the manner in which INGOs intervene in social and political processes while reinforcing global cultural norms, such as responsibility over the environment (Shandra, 2009). In this study, the presence of INGOs was positively associated with renewable energy production, suggesting that being connected to the global civil society can impact actions toward environmental remediation. In chapter three, I further expand upon the notion that integration within world society is important for environmental remediation. By disaggregating renewable energy and honing in specifically on solar energy generation, I find that integration within world society, as measured by INGO membership, has an strong impact on the amount of solar energy generated within a nation. Seeing that solar energy is the fastest growing form of renewable energy worldwide, these findings indicate that being connected to the global civil society has considerable potential for addressing climate change through increases in solar energy generation. Energy generated from solar is defined as renewable and sustainable, as opposed to energy produced from fossil fuels, suggesting that country-level increases in solar energy generation displaces energy produced from fossil fuels (IPCC, 2014). The global environmental regime encourages state responsibility for the environment which influence the adoption of local and global policies and laws around environmental issues. These findings support world society theorists who assert that the spread of environmentalism has become

embedded within the global civil society, and not just environmental associations, organizations, and institutions. Instead, INGOs act as carriers of world culture that stress the importance of state responsibility over the environment and the need to invest in alternative forms of energy, such as solar.

The findings from these two chapters point to the power of international norms as being potentially stronger than previously considered in addressing environmental issues. Furthermore, the results underscore the development of regulatory frameworks globally for supporting renewable energy generation. The IPCC (2014) identifies the role of public policies in either promoting or obstructing the progression of renewable energy production, emphasizing that policies focused on the expansion and regulation of renewable energy can stimulate major transformation in the energy sector. In chapter four, I expand upon existing scholarship that focuses on global environmentalism and environmental policies and regulation by examining advanced renewable energy regulatory frameworks. The rapid proliferation of renewable energy regulatory frameworks worldwide is captured by the RISE (2017) dataset, which scores nations based on a multitude of criteria regarding the policies and regulations countries have adopted. I use fsQCA to define the logically possible combinations of causal conditions leading to advanced regulatory frameworks for renewable energy. While my previous findings highlight the role of nongovernmental organizations in relation to increases in renewable energy generation, the findings of this study indicate that additional country-level conditions need to be considered in determining the quality of renewable energy regulatory frameworks within nations. The causal combination indicates that countries that are more linked to global civil society, more modernized or industrialized, and less dependent on core nations and existing industries have advanced renewable energy regulatory frameworks. Although world society scholars emphasize

the role of the global environmental regime and the top-down dynamics impacting the policies nations adopt based on global norms (Frank et al., 2000), the quality of these regulatory frameworks varies based on the combination of country-level conditions. As renewable energy regulatory frameworks are expanding worldwide, there are vast variations amongst nations in the quality of these frameworks, as well as in the amount of renewable energy being produced. As global efforts to address climate change progress, it is important to take into consideration the multifaceted contexts that contribute to this variation.

In sum, this dissertation research contributes to the growing environmental sociology literature that generally focuses on environmental degradation and less often addresses how society is developing and growing around issues related to environmental remediation. The rise of renewable energy across the globe indicates a major transition in the energy sector. This research highlights the role of the global environmental regime, including international treaties and INGOs, in influencing this worldwide trend towards renewable energy generation. Moreover, this research contributes to understanding the complexity of transitioning the energy sector to renewable energy by identifying the configuration of conditions leading to advanced regulatory frameworks for renewable energy.

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Appendix A.
Countries in the Cross-National Renewable Energy Production Analysis

Albania
Algeria
Angola
Argentina
Armenia
Australia
Austria
Azerbaijan
Bangladesh
Belarus
Belgium
Benin
Bolivia
Botswana
Brazil
Bulgaria
Cambodia
Cameroon
Canada
Chile
China
Colombia
Congo
Costa Rica
Croatia
Cuba
Cyprus
Czech Republic
Côte d'Ivoire
Dem. Rep. Congo
Denmark
Dominican Republic
Ecuador
Egypt
El Salvador
Eritrea
Estonia
Ethiopia
Finland
France
Gabon
Georgia
Germany
Ghana
Greece
Guatemala
Honduras
Hungary
India
Indonesia
Iran
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Korea
Kuwait
Kyrgyz Republic
Latvia
Lebanon
Libya
Lithuania
Luxembourg
Macedonia
Malaysia
Mexico
Moldova
Mongolia
Morocco
Mozambique
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Nigeria
Norway
Oman
Pakistan
Panama
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Romania
Russia
Saudi Arabia
Senegal
Slovak Republic
Slovenia
South Africa
Spain
Sri Lanka
Sudan
Sweden
Switzerland
Syrian Arab Republic
Tajikistan
Tanzania
Thailand
Togo
Trinidad and Tobago
Tunisia
Turkey
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Uzbekistan
Venezuela
Zambia
Zimbabwe