Spring 2017

Diffusion of Renewable Energy Policies

Khatera Alizada
Old Dominion University

DIFFUSION OF RENEWABLE ENERGY POLICIES

by

Khatera Alizada
B.S. May 2010, Old Dominion University
M.A. May 2012, American University

A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

INTERNATIONAL STUDIES

OLD DOMINION UNIVERSITY
May 2017

Approved by:

David C. Earnest (Director)

Steve A. Yetiv (Member)

David D. Selover (Member)

ABSTRACT

DIFFUSION OF RENEWABLE ENERGY POLICIES

Khatera Alizada
Old Dominion University, 2016
Director: Dr. David C. Earnest

This study examines the global diffusion of renewable energy policies: feed-in tariffs (FIT) and renewable portfolio standards (RPS). Existing studies of policy diffusion have failed to differentiate between four possible mechanisms of policy diffusion: emulation, suasion, learning and competition. To test these competing explanations, the study uses a mixed-method research design that combines statistical analysis of time-series cross-sectional data with an agent-based model of diffusion processes. The findings of the statistical analysis show strong support for the suasion (European Union Membership, Clean Development Mechanisms) and emulation mechanisms (cultural similarity or common language) in the diffusion of FIT. In the diffusion of RPS there is strong support for suasion mechanism (European Union Membership and Clean Development Mechanisms), and emulation (common colonial history and language similarity). There is no support and weak support for competition and learning respectively. The study identifies future areas for research on the emulation, suasion, learning and competition mechanisms.

For my family.

ACKNOWLEDGEMENTS

I am grateful for the support and guidance of many people who have contributed to the successful completion of this dissertation. I extend many thanks and gratitude to my committee members Dr. David C. Earnest, Dr. Steve Yetiv, and Dr. David D. Selover for their patience and hours of guidance on my work and editing of this manuscript. I would like to acknowledge the special effort of my committee chair David Earnest without whom the project could not be completed. His specific suggestions and recommendation helped me organize my thought process from the beginning of the project until the end. Every time he reviewed my work, he offered detailed suggestions that helped improve the project. When I felt overwhelmed, he encouraged me with his understanding and sympathy. When there were moments when I felt stuck, his advice and guidance helped me progress. Steve Yetiv offered practical comments, support and assistance in finding data sources. David Selover provided suggestions that added great value to the project.

While I received valuable support from my committee, I would like to thank the rest of Graduate Program in International Studies (GPIS) at Old Dominion University. Regina Karp offered me advice and continuous encouragement. Jessi Richman deserves special mention with offering his support whenever I needed it. I am grateful to Kurt Taylor Gaubatz for teaching valuable programming skills that were very useful in managing my data and statistical tests. I would like to thank the all the GPIS team, faculty, staff and fellow students for inspiring me.

While I benefited immensely from GPIS, I would like to thank the rest of at Old Dominion University. I would like to mention Interdisciplinary Studies Teacher Preparation program and especially Elizabeth Esinhart for supporting me whenever I needed. Dr. Jennifer

Fish was always there for me offering her encouragement and advice. John Sokolowski and Catherine Banks were influential in my work.

I want to thank my family and friends who kept me motivated, believed in me and were eagerly waiting for the completion of the project. They always encouraged me to stick to it and were curious about my progress. Without their encouragement, this project would have not been successful. I would like to thank Eva Szalkai Csaky, Director of the Hunter and Stephanie Hunt Institute of Engineering and Humanity at Southern Methodist University, for providing me with support and office space to write my project. Finally, I would like to thank everyone at Old Dominion University.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

INTRODUCTION

Contrary to what rational self-interested actors would do based on costs, benefits and utility maximization, some of the top oil exporters in the world have adopted renewable portfolio standards (RPS) or feed-in tariffs (FIT) in less than a decade. These countries include Iran and the United Arab Emirates in the Middle East; Kazakhstan in Asia; Nigeria and Algeria in Africa; Norway and the United Kingdom in Europe; and Brazil in the Americas (Network 2014, U.S. Department of Energy and Administration 2012). Not only is Norway a top non-renewable energy producer, the share of renewable energy in the country's final energy consumption was 65 percent in 2012 (Eurostat 2014). Despite being the top oil exporters in the world, however, these countries have adopted renewable energy policies. One possible explanation for this puzzle is policy diffusion, the spread of new policies in the international system. Does adoption of renewable energy policies in one country affect the probability of adoption in others? If so which mechanisms explain the diffusion of renewable energy policies?

This study looks at the adoption of renewable energy polices at the national government level as a consequence of diffusion and of actors involved in the processes of diffusion. What is diffusion? "Diffusion occurs when one government's decision about whether to adopt a policy innovation is influenced by the choices made by other governments"(Graham, Shipan, and Volden 2013, 675) Diffusion is associated with external determinants. However, there is no consensus among scholars whether internal or external determinants are more important in policy adoption.

There is limited literature on renewable energy policy adoption and diffusion mechanisms. The literature mainly focuses on internal characteristics of states. There are separate studies about US states (Matisoff 2008, Jenner, Ovaere, and Schindele 2013), Europe (Jenner et al. 2012) and developing and emerging economies (Stadelmann and Castro 2014). A comprehensive study is needed to encompass broader geographic regions. There is a gap in the literature about the systematic studies of diffusion mechanisms, their links with different actors and with renewable energy policy adoption. This study will contribute by examining the role of actors in these different processes.

Simmons, Dobbin, and Garrett (2006) argue that governments' policy decisions are interdependent to decision of other countries. They identify four discrete diffusion mechanisms: coercion, competition, learning, and emulation through which policies diffuse (Simmons, Dobbin, and Garrett 2006). Dobbin, Simmons, and Garrett (2007) argue that diffusion studies often have failed to control for alternative diffusion mechanisms. For example, those that test for the competition mechanisms seldom control for alternative mechanisms. The same happens with other camps. This study will fill this gap by controlling for alternative diffusion mechanisms, which will also address the problem of over determination. Some studies do not make clear distinctions between the mechanisms while testing for the effects of these mechanisms. They do not test for which diffusion mechanism has taken place, but rather test only whether diffusion has occurred (Stadelmann and Castro 2014) This study will draw the distinction through operational measures of the independent variables that are associated with each of these mechanisms applying the suggestions of (Dobbin, Simmons, and Garrett 2007) .

Theories of diffusion make assumptions about the primary actors, their motivation to behave in certain ways, the information on which they base their decisions, and their objectives. There is a gap in the literature about a systemic analysis of the interaction among the primary actors (internal, external and go-betweens). "The existence and nature of the linkages among internal, external, and go between actors may influence which diffusion mechanisms are used" (Graham, Shipan, and Volden 2013, 675). Therefore, to understand the notion of interdependence of countries in making policy decision, it is important to understand the diffusion mechanisms and how they relate to primary actors in policy adoption and the link between the primary actors. According to Braun and Gilardi (2006) diffusion mechanisms affect effectiveness and payoffs, which drive policy change.

Policies are chosen by people who have different preferences, goals and capabilities, but studies only look at how they cluster geographically without paying attention to the actors who are involved in policy making (Graham, Shipan, and Volden 2013, 684). There are three sets of actors who are crucial in policy adoption: the internal actors in policy adopting government, the external actors from which policies are adopted, and the go-betweens who are involved across multiple governments (Graham, Shipan, and Volden 2013).

The internal actors within a country who influence potential policy adoption are politicians, electorates, policy advocates, interest groups and appointed officials. To understand policy adoption, one needs to understand the actors, their goals, preferences, capabilities and the environment within which they act. Federal governments play the role of facilitator in diffusing policies across states and international organizations across countries (Graham, Shipan, and Volden 2013).

In terms of external actors who may affect potential policy adopters, it is important to understand what causes external actors to innovate. For example, governments with expertise may be the leaders of diffusion processes and might be more likely to provide the information for potential adopters. Likewise, some states will be more likely to imitate wealthy governments who may be bigger in size and more likely to succeed in norm creation. So it is important to know the features of the external governments that make policy diffusion more or less likely. The earlier adopters will respond strategically as competition arises through business-friendly tax schemes and effective regulatory norms.

The go-betweens are the third parties that neither belong to the governments of potential adopters nor to the governments from which policy diffuse. They may be think tanks, academicians, research institutes, mass media, migrants and intergovernmental organizations. "Studying each of these three types of actors and the interactions between them is crucial to a better understanding of politics of policy diffusion" (Graham, Shipan, and Volden 2013). "Precisely when external and go-between actors (as well as the internal actors themselves) utilize each of the mechanisms, and to what ends, has not been studied systematically, but is ripe for future exploration" (Graham, Shipan, and Volden 2013, 693). Filling this gap in the literature, this study will look at the link between the crucial actors and diffusion mechanisms.

First the study provides a review of the most efficient renewable energy policies. The literature identifies feed-in tariffs (FIT) and renewable portfolio standards (RPS) as the most efficient renewable energy policies. Then it looks at the mechanism through which policies diffuse and the involvement of crucial actors in these processes. Then it discusses the alternative explanations to policy adoption. It follows with presenting the research design, results and the conclusion.

RPS AND FIT: THE MOST EFFICIENT RENEWABLE ENERGY POLICIES

Saidur et al. (2010) find that "FIT, RPS, incentives, pricing law & quota system" are the most efficient wind energy policies adopted by countries across the globe. An RPS policy requires electricity retailers to have a certain share of their electricity come from renewable sources of energy (Jenner, Ovaere, and Schindele 2013). “In contrast, the FIT is a mode of price regulation that stimulates investment by giving fixed price incentives to producers” (Jenner et al. 2012, 3). Saidur et al. (2010, 1745) define energy policy as the following: “Energy policy is the manner and the country’s strategy in which a given entity (often governmental) decides to address issues of energy development along with the development of the energy industry to sustain its growth including energy production, distribution and consumption.” However, they only look at wind energy policies. In another study Solangi et al. (2011) find that the most successful solar energy policies are FIT, RPS and incentives. “These policies provide significant motivation and interest for the development and use of renewable energy technologies” (Solangi et al. 2011, 2149). All the countries that consume solar energy have some sort of policy related to solar energy.

While these policies may have limitations, they are the ones widely used and considered appropriate to the context of the countries that adopted them. Table 1 depicts countries that adopted FIT and RPS. A total of 69 countries enacted FIT and fifteen countries adopted RPS by 2013 (Network 2014).

Table 1 Countries FIT/RPS Year of Adoption

Year	Cumulative	Countries added that year (FIT)	Cumulative	Countries added that year (RPS/Quota Policies)
1978	1	United States*		
1983				
1990	2	Germany		
1991	3	Switzerland		
1992	4	Italy		
1993	6	Denmark, India		
1994	9	Luxembourg, Spain, Greece		
1996				
1997	10	Sri Lanka		
1998	11	Sweden		
1999	14	Portugal, Norway, Slovenia	1	Italy
2000	14			
2001	17	Armenia, France, Latvia	2	Australia
2002	23	Algeria, Austria, Brazil, Czech Republic, Indonesia, Lithuania	3	UK
2003	28	Cyprus, Estonia, Hungary, South Korea, Slovak Republic	5	Japan, Sweden
2004	30	Israel, Nicaragua	6	Poland
2005	34	China, Turkey, Ecuador, Ireland		
2006	37	Argentina, Pakistan, Thailand		
2007	45	Albania, Bulgaria, Croatia, Dominican Republic, Finland, Macedonia, Moldova, Mongolia	7	China
2008	50	Iran, Kenya, Philippines, Tanzania, Ukraine	11	Chile, India, Philippines, Romania
2009	54	Japan, Serbia, South Africa, Taiwan		
2010	59	Bosnia and Herzegovina, Malaysia, Mauritius, Malta, UK	12	South Korea
2011	64	Ghana, Montenegro, Netherlands, Syria, Vietnam	14	Albania, Israel
2012	68	Jordan, Nigeria, Rwanda, Uganda	15	Norway
2013	69	Kazakhstan	15	

Source: (Network 2014)

Table 2 FIT/RPS Adoption by Geographic Region

	The Americas	European Union	Europe	Africa	Asia	Middle East	Oceania
1	USA	Germany	Switzerland	Algeria	India#	Israel#	*Australia
2	Dominican Republic	Italy #	Norway#	Kenya	Sri lanka #	Iran	#Palau
3	Brazil	Denmark	Turkey	Tanzania	Armenia	Syria	
4	Ecuador	Luxembourg	Albania#	South Africa#	Indonesia#	Jordan	
5	Argentina	Spain	Croatia	Mauritius	South Korea#	United Arab Emirates #	
6	Nicaragua	Greece	Macedonia	Ghana#	China#		
7	Chile*	Sweden#	Moldova	Nigeria	Pakistan		
8	Honduras	Portugal#	Ukraine	Rwanda	Thailand		
9	Peru	Slovenia	Serbia	Uganda	Mongolia		
10	Panama	France	Bosnia	Senegal#	Philippines #		
11	Uruguay	Latvia	Montenegro		Japan#		
12		Austria			Taiwan		
13		Czech Republic			Malaysia#		
14		Lithuania#			Vietnam		
15		Cyprus			Kazakhstan		
16		Estonia			Maldive		
17		Hungary			Tajikistan		
18		Slovakia					
19		Ireland					
20		Bulgaria					
21		Finland					
22		Malta					
23		UK#					
24		Netherlands					
25		Poland*					
26		Romania*					

Source: (Network 2014): regular font countries with FIT; *countries with RPS, # countries that have both RPS and FIT. In this table countries with that unknown year of adoption and countries that have discontinued from the policies are included.

Table 3 Countries with National RPS/FIT by Income Level

Number	FIT (high income)	Upper Middle Income	Lower Middle Income	Low Income
	Austria	Albania#	Armenia	Kenya
	Croatia	Algeria	Ghana#	Rwanda
	Cyprus	Argentina	Honduras	Tajikistan
	Denmark	Bosnia and Herzegovina	India#	Tanzania
	Estonia	Bulgaria	Indonesia#	Uganda
	Finland	China#	Moldova	Kyrgyzstan #
	France	Dominican Republic	Mongolia	
	Germany	Hungary	Nicaragua	
	Greece	Iran	Nigeria	
	Ireland	Jordan	Pakistan	
	Israel#	Macedonia	Philippines#	
	Italy#	Malysia#	Sri Lanka#	
	Japan#	Maldives	Syria	
	Latvia	Panama	Ukraine	
	Lithuania#	Peru	Vietnam	
	Luxembourg	Serbia	Senegal#	
	Malta	Thailand		
	Netherlands	Turkey		
	Portugal#	Palau#		
	Slovakia	Romania*		
	Slovenia	South Arica#		
	Switzerland			
	UK#			
	Chile*			
	Norway#			
	Poland*			
	South Korea#			
	Australia*			
	Sweden#			

Source: (Network 2014) regular countries with FIT, #countries with RPS and FIT, * countries with RPS only

The United States (US) adopted PURPA policy (1978), which was an early version of the FIT. Seven countries including (Brazil, Czech Republic, Mauritius, Spain, South Africa, South Korea, and the United States) have discontinued the policy. Seven countries (Honduras, Maldives, Peru, Panama, Senegal, Tajikistan, and Uruguay) have adopted FIT but their years of adoption are unknown. Countries including Ghana, Indonesia, Kyrgyzstan, Lithuania, Malaysia, Palau, Portugal, Senegal, South Africa, Sri Lanka, and United Arab Emirates adopted RPS/Quota policies, but their years of adoption are unknown (Network 2014). Any countries with known year of adoption that initially adopted the policies are included. However, those with unknown year of adoption are not included in this study. There are countries that have adopted the policies at the local level. However, this study does not include the countries that have adopted the policies at the local level, it only includes the countries that have adopted the policies at the national level. And it does not make any analysis about the implementation of these policies. The literature on diffusion mechanisms reviewed in this study implies rationalist and normative/constructivist thinking. The aim here is to explore and better understand how and to what extent these approaches influence the processes of diffusion of renewable energy policies. Conventional constructivist approaches focus on "how ideational factors influence policy outcomes" (Saurugger 2013, 889) and analyze "how ideational factors (worldviews, ideas, collective understanding, norms, values, cognitive schemes, etc.)" influence political behavior (Saurugger 2013, 888). Rejecting the rationalist assumptions that material factors are the main driving force, constructivists argue that ideational factors are the main independent variables (Mueller 2003). Emulation and learning mechanisms follow the logic of appropriateness. States do things for reasons other than instrumental rationality. They may desire to seek legitimacy and or credibility. Learning may occur through demonstration effects or through socialization. On the other hand, competition and suasion mechanisms follow the rationalist model where states respond to sanctions and incentives. States do things to advance their interest with a rational approach of cost and benefit analysis.

LITERATURE REVIEW: DIFFUSION MECHANISMS

Before defining diffusion mechanisms it is important to define policy innovation and the conditions under which diffusion occurs. Walker (1969, 881) defines innovation as “a program or policy which is new to the states adopting it, no matter how old the program may be or how many other states may have adopted it.” Similar words that are used to convey the term diffusion are “convergence” and “race to the bottom”. Braun and Gilardi (2006, 299) define diffusion as “a process where choices are interdependent, i.e. where the choice of a government influences the choices made by others and conversely, the choice of a government is influenced by the choices made by others.” According to Graham, Shipan, and Volden (2013, 675) “Diffusion occurs when one government’s decision about whether to adopt a policy innovation is influenced by the choices made by other governments.”

According to Leichter (1983) seven circumstances lead to policy diffusion.

> These were the need or desire to 1) remodel a nation’s political institutions; 2) deal with a new or unique situation; 3) respond to a situation requiring relatively quick policy action; 4) change an existing but unsuccessful policy; 5) gather information during the initial stages of the policy making process; 6) emulate a specific policy known to adopting nation; and 7) avoid the policy mistakes of other nations (Leichter 1983, 233).

In addition, when the decision makers see that their states are deprived of some needs that others have already responded, they are more likely to adopt new programs (Walker 1969).

According to Berry and Berry (Sabatier, 2007) the primary difference between various diffusion models are the channels of communication and influence. Berry and Berry (2007) argue that states emulate each other for three reasons: learning, competition and coercion.

A diffusion mechanism is thus a “systematic set of statements that provide a plausible account of how two variables are linked.”(Braun and Gilardi 2006, 299). In an effort to answer how and why policies diffuse Graham, Shipan, and Volden (2013, 684) divide policy diffusion mechanisms and processes into four categories: learning, competition, coercion and socialization.

Braun and Gilardi (2006) focus on learning, competition and cooperative interdependence, coercion, common norms, taken-for-grantedness, and symbolic imitation. Aside from proximity, competition, imitation (similar attributes), emulation (successful policy) influences states to adopt policies (Karch 2007).

According to Simmons, Dobbin, and Garrett (2006) policy diffusion occurs when countries' decisions to adopt policies are influenced by similar decisions in other countries. Sometimes this process occurs through the behavior of international organizations, private actors or organizations. Theories of diffusion highlights diverse tools such as "Bayesian learning to rational competition through hegemonic domination to unthinking emulation of leaders" (Simmons, Dobbin, and Garrett 2006).

In addition, diffusion mechanisms may be interrelated. For example, governments may learn how to compete better with one another (Graham, Shipan, and Volden 2013). Financial incentives can enhance learning and norm diffusion. The Clean Development Mechanism (CDM) contributes to greening India's energy policy in two ways: through transfer of technology or leapfrogging, and norm diffusion under the conditions that is embedding economic activities into local context and path dependencies are given due consideration (Benecke 2009).

SUASION

In the suasion form of diffusion, strong countries impose their policy preferences on weaker states where weaker states would not adopt those policies otherwise (Daley and Garand

2005; Gilardi 2005). This mechanism relates to the hegemonic stability theory, which claims that the dominant state enforces a stable global economic order and provides public goods (Kindleberger 1986). In the case of renewable energy policies, a hegemon arguably provides an environmental public good—clean air. The mechanism applies to situations where powerful countries themselves adopt certain policies and impose it on weaker countries. However, in the case of renewable energy policy, not all strong countries themselves adopt these policies. Berry and Berry (2007) argue that states adopt a policy adopted elsewhere because of coercion or pressure on states in a federal system to confirm to regional or national standards. Federal governments play the role of facilitator in diffusing similar policies across states and international organizations across countries (Graham, Shipan, and Volden 2013).

Hegemonic countries can influence or coerce other countries. To examine this effect Stadelmann and Castro (2014) use former colonizers' policy adoption effect on the developing countries as they continue to have strong economic and political ties. Another example of diffusion through financial incentive is the spread of environmental ministries in transitional democracies. Aklin and Urpelainen (2014) examine the spread of national environmental ministries. They find that during democratic transition period, international factors influence democratizing countries to adopt environmental ministries. However, the study does not directly examine policy adoption or diffusion. "[S]tudies linking policy diffusion to soft coercion should show that the policy ideas actively promoted by strong countries are more likely to be put into practice in weaker countries structurally or situationally dependent on them"(Simmons, Dobbin, and Garrett 2006).

International organizations can also coerce countries to adopt identical policies. Powerful countries and international organizations can use financial incentives to affect policy change.

International organizations like the IMF and the World Bank influence countries to liberalize their economies through financial incentives and loans. Kelemen and Sibbitt (2004) show that economic liberalization and political fragmentation affect the spread of American style legal system around the world.

Stadelmann and Castro (2014) argue that the international climate regime and the emission targets of transition countries under the Kyoto Protocol are not strict enough to force countries into action. But there are specific international climate policy components such as the Clean Development Mechanisms (CDM) that target developing countries and provide them with financial incentives. In a study, Benecke (2009) asks how and to what extent the Clean Development Mechanism (CDM) contributes to greening India's energy policy and argues that in two ways CDM contributes: through transfer of technology or leapfrogging and norm diffusion under the conditions that embed economic activities to the local context, and path dependencies are given due consideration (Benecke 2009).

The European Union can use its coercive power to impose policies (e.g. renewable energy targets) on its members. While EU imposes renewable energy targets, it does not impose the adoption of RPS/FIT. Countries around the world and specially EU countries have set targets to decrease their energy dependence through domestic generation of renewable energy (Eurostat 2014). Countries with the highest change target from 2012 to 2020 are the Netherlands, the United Kingdom, France, Ireland, Malta and Luxembourg while Malta, Luxembourg, Cyprus, Ireland, and Italy are on the top of the list in terms of energy dependence. It is interesting to see Norway, which is the highest oil producer in Europe, but also has the highest (64.5%) renewable energy consumption. It is followed by Sweden, Latvia, Finland, and Austria. On the other hand, Malta, Luxembourg, United Kingdom, Netherlands, Cyprus and Belgium had the lowest share of renewable energy consumption in 2012. They have set the highest targets to increase their renewable energy consumption by 2020.

Jenner et al. (2012) examine the effect of EU membership, representing EU Directive 2001/77/EC on generation of electricity from renewable energy sources (RES-E) on policy adoption (RPS, FIT). It has been the first binding directive that obliges state legislators to support RES-E. Therefore, it can be treated as a coercion mechanism.

Pfeiffer and Mulder (2013) look at factors that affect renewable energy adoption. Their dependent variable is adoption of non-hydro renewable energy (NHRE), which is measured by the per capita NHRE per kilowatt hours (kWh) in developing countries between 1980-2010. The external independent variables include adoption of Kyoto Protocol and official development assistance (ODA), which are instruments of coercion from an international organization. They find a negative effect from openness and aid, and a weak influence of the Kyoto Protocol (Pfeiffer and Mulder 2013).There is not enough pressure from international climate change regime to achieve climate goals. Since Kyoto Protocols are not binding therefore, it will not be used as a measure of coercion. Saikawa (2013, 13) uses international aid as a proxy for international pressure or coercion by using "Official Development Assistance (ODA) and other official aid values as a share of GDP (in percentage)" on the adoption of emission standards.

“[T]he preferences of the U.S. government, the European Union, the International Monetary Fund (IMF), and the World Bank may shape policies in countries reliant on those entities for trade, foreign direct investment, aid, grants, loans, or security” (Dobbin, Simmons, and Garrett 2007). The IMF or the EU set conditions for loans, aid or other incentives. Powerful countries may set conditions themselves or through international institutions. Powerful countries may act unilaterally and change the status quo, which influences the weaker country to alter their policy as well. Gruber (2000) gives the example of the effect of US and Canada's decision to liberalize on Mexico's liberalization even before it was ready to do so.

Unilateral policy leadership may solve coordination problems when there exist multiple equilibria that require nation-states to coordinate their policies. Nation-states may follow the leader as focal points (TC. 1960). The models that leaders provide may be well examined. Garrett and Weingast (1993) argue that Germany's model of central bank and political structure was adopted by the EU without Germany seeking to influence Europe. Dobbin, Simmons, and Garrett (2007) suggest some ways to test for coercion. One way to illustrate that coercion mechanism is at work is testing for adoption of a policy while countries are negotiating trade, accession to the EU or the World Trade Organization (WTO), or loan disbursement from the IMF. In addition, studies should illustrate that countries subject to aid, loans or security dependence are adopting policies promoted by powerful actors. When carrot or stick is involved from the go-between actors or external actors in the process of diffusion, it falls under suasion mechanism.

According to Braun and Gilardi (2006), the payoff of policy diffusion is a function of voting rewards and policy rewards. Coercion and symbolic imitation impact payoffs and affect the policy component while electoral payoffs is a more domestic determinant rather than external one. In vertical coercion, actors who are neither part of the adopting government nor government from which policy diffuse impose their policy preferences through carrots and sticks. In horizontal coercion one external government can impose pressure on a country to adopt a policy. Asymmetric power is important in coercion. Powerful states or international organizations can apply sanctions and issue linkages, "making behavior in one policy area contingent on behavior in another" (Graham, Shipan, and Volden 2013, 693). One needs to review the nature of these agreements for any stick or carrots attached to them to categorize the diffusion as coercion where a change will be associated to the payoffs rather than the effectiveness. To further examine the nature of these relationships or the links between the crucial actors interaction terms are used.

In the suasion/coercive mechanism of policy diffusion, the most important relationship among actors are vertical. When internal actors are structurally or situationally dependent on strong external actors, the suasion mechanism is at use in the diffusion process (Simmons, Dobbin, and Garrett 2006). When external actors or go-betweens have the capability and have interest in changing policy of others, they use coercive strategies to change policies. Unilateral policy leadership of external actor may change the status quo for the internal actors (TC. 1960). As go between actors, national policy makers or international organizations in federal system and international organization may use coercive strategies through grants and aid requirements, pre-emptive laws, sanctions or military force to influence internal actors (Graham, Shipan, and Volden 2013).

COMPETITION

Competition theorists have these assumptions:

> First, they assume that the policy under examination has the potential to affect the flow of international production and capital or the attractiveness of a nation's exports…Second, they assume that the policies that diffuse have consequential effects in the short to medium term… Third, competitive models assume an information-rich (in fact, close to perfect) environment…Finally … competition theorists assume that the most important relationships are horizontal" (Simmons, Dobbin, and Garrett 2006).

Competition is more decentralized than the coercion mechanism of policy diffusion. This mechanism focuses on the attractiveness of economic policies in the international market for the buyers and investors. "Simplifying regulatory requirements, ameliorating investment risks, and reducing tax burdens are often viewed as policy choices that can, quite quickly, make a local investment more attractive, exports more competitive, and an economy more vital" (Simmons, Dobbin, and Garrett 2006, 792). Mooney illustrates that competition matters in the early phase of the adoption process. Countries with similar economic structures can use competition diffusion mechanisms. Membership to similar economic and regional blocs can be used as a proxy for competition (Stadelmann and Castro 2014).

The geographic proximity of states influence neighboring states in policy adoption (Karch 2007). The jurisdiction proximity influences some policies adoption but not others. For example, "In policy areas where outcomes, externalities, and citizen or business mobility across jurisdictional boundaries are plausible, we should expect to see competitive processes working in the diffusion of policy innovations" (Tucker, Stoutenborough, and Beverlin 2012). When a policy outcome is contained within the jurisdiction it is less likely that the policy adoption will occur in the neighboring state. By adopting policies states want to avoid being competitively disadvantaged (Berry and Berry 2007).

Berry and Baybeck (2005) use close geographic proximity as a proxy for competition. A regional diffusion model focuses on regions and proposes that states are influenced by the states in geographic proximity. They assume that neighboring states influence the potential adopter and the probability of a state adopting a policy is related to the number of its neighbors that have already adopted it. Fixed region models divide nation-states into specific regions and argue that states adopt policies if other states within the same region adopted it (Berry and Berry 2007, 229). According to Berry and Berry (2007) one realistic assumption is that states are influenced by nearby states depending on the distance between states vary their influence. Matisoff (2008) finds that the percentage of neighboring states that adopted RPS has statistically significant and positive effect on renewable energy programs and policies adoption.

Berry and Berry (2007) argue that states adopt policies being adopted elsewhere to compete with other states to have an advantage over other states or to avoid being disadvantaged. Competition and efficiency cause states to liberalize their economies. For example, Kelemen and Sibbitt (2004) show that economic liberalization and political fragmentation affect the spread of American-style legal systems around the world.

According to Baccini, Lenzi, and Thurner (2013) oil producing countries join energy related international governmental organizations (IGOs) if their competitors, main trade partners in the energy sector, other oil and gas producers and consumers joined the organizations. In addition, countries that share oil and gas pipelines also join energy IGOs. States use energy IGOs to make them better off in the energy market.

Prakash and Potoski (2006) argue that countries adopt ISO 14001, a voluntary environmental regulation, if their main export markets have done so. Vogel Cooper (1995) argues stringent emission standards in California prompted car companies to adopt the standards so that they can sell their products in California. After, acquiring the technology, these companies pressured their domestic governments to adopt higher standards so that the companies profit in the domestic markets. Saikawa (2013) argues that countries adopted emission standards regulations to be competitive in international automobile market: “Adoption by importers creates pressure (direct export pressure, that is, a 'California effect') and in other adoption by economic competitors create pressure (indirect export pressure) to adopt such standards…” (Saikawa 2013, 2). Saikawa (2013) states that adoption of automobile emission standards creates competitive advantage for exporting country if the importing country adopted the standards. The competitive advantage declines as the number of countries adopting the standards increases. He creates four independent variables to test the effect: exporting countries emission standard, importing countries adoption status, the interaction term of the two previous variables and the log of number of standards.

In the competition mechanism, the most important relationships among actors are horizontal (Simmons, Dobbin, and Garrett 2006). External and internal actors who compete are more likely to have similar economic structures (Stadelmann and Castro 2014). In national policy governments or international organizations in federal system and international organization “may help restructure competitive environments, such as with the European Union facilitating the reduction of trade barriers or the US Constitution limiting inter-state regulation of commerce by the states” (Graham, Shipan, and Volden 2013, 693).

Internal actors use competition mechanism when they do not want to be competitively disadvantaged (Berry and Berry 2007). Policies diffuse from external actors to internal actors when they are competitors or trading partners (Berry and Berry 2007). In other cases external and internal actors compete in third-country markets or they might be competing for a third country’s investment in the case of foreign direct investment (FDI) (Dobbin, Simmons, and Garrett 2007).

Internal actors use competition mechanisms when externalities, citizen and business mobility across jurisdictional boundaries are plausible. According to Tucker, Stoutenborough, and Beverlin (2012) geographic proximity influences policy diffusion because of competition. “In policy areas where outcomes, externalities, and citizen or business mobility across jurisdictional boundaries are plausible, we should expect to see competitive process working in the diffusion of policy innovation” (Tucker, Stoutenborough, and Beverlin 2012). When a policy is contained within a jurisdiction it is less likely that the policy diffusion occurs in the neighboring states because of competition.

LEARNING

According to Simmons, Dobbin, and Garrett (2006, 792) the learning mechanism suggests that success or failure of a policy mostly affect the policy adoption elsewhere especially among those countries with similar experiences. Spread of successful policy is labeled as learning (Graham, Shipan, and Volden 2013, 644). Gilardi, Füglister, and Luyet (2009) propose that learning increases in the later stages as knowledge accumulates. In addition, there are specific projects such as renewable energy-related capacity-building under development and environmental finance initiatives of international climate policy that target developing countries that can be a depiction of learning (Stadelmann and Castro 2014). Similarly, one of the reasons that democracy spread in post-communist countries is the success of earlier efforts. (Bunce and Wolchik 2006).

Berry and Berry (2007) argue that states emulate each other because they learn from each other when they adopt policies perceived successful elsewhere. Chandler (2009) argues that RPS spread among US states through interstate learning. He finds positive association of neighboring effects. In the learning mechanism, evidence of success increases the probability of adoption. This connection fades when moving towards emulation.

Some studies examine the effect of renewable energy policies on the adoption of renewable energy resources (Carley 2009; Pfeiffer, Mulder 2013). There are mixed results. However, studies do find that energy diversification decreases foreign energy dependence which increases energy security (Aslani, Helo, and Naaranoja 2014). Carley (2009) examines the association between renewable portfolio standards (RPS) and the percentage of renewable energy in electricity generation across US states. The result shows that RPS is not a predictor of renewable energy mix as part of electricity. The study finds that for each additional year the renewable energy increases with an RPS policy. Salim and Rafiq (2012) find that Carbon Dioxide (CO_2) emissions is a significant factor in renewable energy sources consumption.

Research focusing on the learning mechanism should show that the efficacy of a policy increases the likelihood of its adoption elsewhere (Dobbin, Simmons, and Garrett 2007). However, many studies are lacking evidence of efficacy in policy diffusion. They rather assume the spread of a policy as the learning effect.

States learn about the economic benefits of renewable energy sources and adopt the policies. Schreurs (2012) argues that economic benefits to small and medium size businesses motivates Germany's renewable energy adoption. Gallagher (2013) argues that economic motive is a key factor in renewable sources adoption. Economic benefits from major wind energy manufacturing companies motivate countries to promote renewable sources technologies (Colgan, Keohane, and Van de Graaf 2012). Apergis and Payne (2010) examine the relationship between renewable energy consumption and economic growth organization for economic cooperation and development (OECD) member countries. They find that there is a bidirectional relationship between economic growth and renewable energy consumption. The variables that were statistically significant included real gross domestic product (GDP), renewable energy consumption, real gross fixed capital formation, and the labor force (Apergis and Payne 2010).

Pfeiffer and Mulder (2013) look at factors that affect renewable energy adoption. The dependent variable is adoption of non-hydro renewable energy (NHRE), which is measured by the per capita NHRE per kilowatt hours (KWh) in developing countries between 1980-2010. The independent variables include adoption of Kyoto Protocol, trade intensity, net foreign direct investment (FDI) inflow, renewable energy technology (RET) policies, growth in electricity consumption, official development assistance (ODA), secondary enrollment, hydro share, coal production, gas production and per capita income. The study controls for Kyoto Protocol, ODA, trade intensity and FDI, which are measures of diffusion. Economic and regulatory instruments, per capita income and schooling level, and stable democratic regimes have positive and statistically significant effect on NHRE. There is a negative effect from openness and aid, institutional and strategic policy support programs, growth of electricity consumption and fossil fuel production. Diverse energy mix increases the probability of NHRE adoption. There is a weak influence from Kyoto Protocol and no significant effect from financial sector development (Pfeiffer and Mulder 2013). Aslani, Helo, and Naaranoja (2014) find that increasing renewable energy capacity by implementing the action plan saves $4 billion in expenditure on natural gas imports. Energy diversification reduces energy dependency and increases energy security in Finland.

The findings of a study by Al-mulali, Fereidouni, and Lee (2014) reveal that renewable energy consumption; non-renewable energy consumption in electricity generation; gross fixed capital formation; total labor force; and total trade have a positive effect on economic growth in Latin American countries. Renewable energy consumption is more significant than non-renewable energy consumption in electricity on economic growth. The reason is that renewable energy consumption in electricity constitutes more than half of electricity generation (Al-mulali, Fereidouni, and Lee 2014). Yildirim, Saraç, and Aslan (2012) examine the role of renewable energy on economic growth in USA. The result shows that renewable energy consumption from biomass waste has a positive and significant relation on real GDP. The other variables including total renewable energy consumption, geothermal energy consumption, hydro-electric energy consumption, biomass energy consumption and biomass-wood-derived energy consumption, employment and investment were not statistically significant (Yildirim, Saraç, and Aslan 2012). Countries learn about the effectiveness of a policy as other countries adopt it.

In the learning mechanism, external actors increase the knowledge about a policy's effectiveness. Their policy adoption does not have externality on the internal actors or potential adopters. External actors are not actively seeking to change policies of potential adopters using carrots and sticks. Internal actors are more active and are seeking effective public policies. They learn from others about the success and political viability of policies adopted elsewhere (Graham, Shipan, and Volden 2013). As go-betweens, national governments or international organizations in federal system and international organization can facilitate learning (Graham, Shipan, and Volden 2013). For example, the EU can have a learning effect on European countries in transition or through capacity building projects under "development and environmental finance initiatives of international climate policy" for developing countries (Stadelmann and Castro 2014).

EMULATION

The emulation mechanism focuses on the role of shared cultural beliefs, norms, common language, history, and religion as having significant effect on policy diffusion, which cannot be explained by learning and competition (Simmons, Dobbin, and Garrett 2006, 792). Socially accepted norms and policies may diffuse even when countries are not developmentally ready to implement them. For example, many developing and developed countries sign international conventions on human rights as a sign of commitment to global norms. International non-governmental organizations (INGOs), NGOs, policy professionals, and academics can influence governments to adopt new policies.

On the other hand, Stadelmann and Castro (2014) combine learning and emulation. They use common language, colonial experience or membership to similar economic and regional block to examine learning and emulation effects.

> Such learning-imitation due to socially constructed policy norms (Simmons et al., 2006) is more likely to take place in case of neighboring countries, or countries within the same region (MacGarvie, 2005), because such peers are more likely to meet in common forum and exchange information with each other (Berry and Berry, 2007). In addition, countries with cultural, historic or economic commonalities are also more likely to learn from each other (Simmons and Elkins, 2004) or even to compete for markets, e.g. for RE technology. Adoption of policies from culturally or historically similar countries can be understood as learning or emulation of peers "with psychological proximity", an idea based on constructivist theories… (Stadelmann and Castro 2014, 416).

Stadelmann and Castro (2014) find that EU membership and common colonial history have statistically significant and positive effect on FIT adoption and financial incentives through tax reduction, grants, and concessional loans. Common colonial history and Global Environmental Facility (GEF) funding have statistically significant and positive effects on framework policies (strategies, plans, generic law). Only EU membership has a positive and statistically significant effect on renewable energy target adoption.

Isomorphism in organizational theory refers to "the mechanisms leading one unit in a population to resemble other units facing the same set of environmental conditions" (Radaelli 2000, 40). Isomorphism may help explain why states emulate policies of similar states who have common ideology (conservative-liberal), political demographic and economic characteristics and "channels of cultural commonality and historic connection". In vertical influence, the policy is diffused from national government to states (Berry and Berry 2007). MacGarvie (2005) finds that "technological knowledge diffuses faster across countries that share a [common official] language or that are geographically proximate."

Walker (1969) emphasizes the role of interstate communication in the process of diffusion. In a national interaction model, when potential adopters interact with officials from adopting states, their probability of adoption increases. Their probability of adoption is proportional to the number of interactions they have with already adopted state officials (Gray 1973a). The model assumes that during any time period, each potential adopter is equally likely to adopt the policy. The variable that influences the probability of adoption is the previous cumulative number of adopters, but not all potential adopters are similar.

Common norms emerge with increased interaction and socialization within networks. Common norms are appropriate behaviors within certain context for actors (Finnemore and Sikkink 1998, 891). Networks of professionals, regulators, and international organizations can be platforms for the development of common norms. Through socialization in these networks actors develop similar views about effectiveness of policies. Lee (2013) compares Northeast Asia and European energy cooperation. The history of European cooperation on energy initiatives suggests that economic integration, institutional development and policy coordination are prerequisites for energy cooperation. It suggests domestic efforts and sub-regional institutional buildup for Northeast Asian cooperation. It highlights the regional multilateral institutions as a useful platform for renewable energy coordination and cooperation. How does the ratification and signing of multilateral environmental agreements affect renewable energy policy adoption?

Advocacy groups, epistemic communities, common language, cultural heritage and religion can be used to test the effect of emulation (Simmons, Dobbin, and Garrett 2006). Colgan, Keohane, and Van de Graaf (2012) state that pressure from environmental groups motivate countries to promote renewable sources technologies. Jenner et al. (2012) find that the presence of International Solar Energy Association has positive and significant effect on states to adopt regulations (RPS, feed-in tariffs) that support electricity generation from renewable energy sources (RES-E). Lyon and Yin (2010) test for the effect of American Energy Association on the adoption of RPS.

According to Finnemore's constructivist IO theory, elite government officials socialize in IOs and adopt policies as appropriate state behavior. For example, government officials' socialization in the United Nations Educational, Scientific and Cultural Organization (UNESCO) has led to the diffusion of state science bureaucracies (Kim 2013). On the other hand, Kim (2013) argues constructivists IO theories ignore the role of international non-government organizations, which have mediated the diffusion of national human rights organizations.

Saikawa (2013) argues that as the number of countries adopting emission standards increases, it changes the norms for other countries on environmental issues. It becomes more appropriate and encourages other countries to adopt the standards. The increased number of epistemic communities and transnational movements encourage the use of the emulation mechanism. When the carrot or stick is not involved through external and go-between actors, the process of diffusion will be categorized as emulation mechanism.

In the emulation mechanism, as go-betweens national policy governments or international organizations in federal systems and international organization can facilitate socialization by establishing information facilities, organizing conferences and recommending best practices (Graham, Shipan, and Volden 2013). NGOs, policy professionals, and academics can influence governments to adopt policies (Simmons, Dobbin, and Garrett 2006).

Socialization or emulation mechanisms aim to change preferences of actors, without expecting immediate policy change, but rather would lead to long-term policy change (Graham, Shipan, and Volden 2013). Despite a policy outcome being contained within a jurisdiction boundary, if it diffuses to neighboring states (internal actors) it is because of emulation, the common cultural and historical characteristics and increased interaction.

Increased interaction among actors can lead to norm diffusion (Walker 1969, Finnemore and Sikkink 1998). In addition, norms can diffuse among external and internal actors who have similar cultural and historical connections (Berry and Berry 2007). External actors with soft power can appeal to others by becoming role models (Graham, Shipan, and Volden 2013).

While socialization through international organizations or more specifically the norm creation through multilateral environmental agreements do not involve financial incentives or sanctions in the process of diffusion, it falls under the emulation mechanism, which affects the effectiveness. It may not affect the payoffs of policy adoption (Braun and Gilardi 2006).

OTHER EXPLANATIONS

States might adopt renewable energy policies for reasons unrelated to the four mechanisms of diffusion. This study draws a clear distinction between policy adoption and diffusion. It sees diffusion as a component of policy adoption, but policy adoption may be influenced by other factors. All examples of policy diffusion are examples of policy adoption, but not all policy adoptions are examples of diffusion. Internal characteristics of states are used as controls for policy adoption. A more detailed discussion of these characteristics follows.

There is no consensus among scholars on whether external (diffusion) or internal determinants are more important in policy adoption. There are scholars who argue for internal determinants being more important and there are scholars who gave more importance to external determinants. Stadelmann and Castro (2014) find that internal determinants are more relevant in explaining policy adoption than international factors. Recent studies claim that domestic factors are more important than diffusion factors in policy adoption (Lyon and Yin 2010); (Matisoff 2008). According to Graham, Shipan, and Volden (2013) internal characteristics of states play key role in policy adoption (Graham, Shipan, and Volden 2013). For example, Kelemen and Sibbitt (2004) show that economic liberalization and political fragmentation affect the spread of American-style legal systems around the world.

According to the previous studies presented in the below table, the factors that have positive effects on renewable energy adoption can be categorized as political factors, environmental concerns, economic factors, renewable energy endowment and international factors.

Political factors

Policy adoption is a combination of factors including motivation for policy change, availability of resources and barriers that prevents policy change (Walker 1969). Public opinions and uncertainty about the effect of to be adopted policy is an obstacle to policy adoption (Berry and Berry 1990).

Political ideology may affect RPS adoption (Lyon and Yin 2010). Biresselioglu and Zengin Karaibrahimoglu (2012) emphasize on the role of government orientation. According to them leftist and center oriented governments are more likely to adopt renewable energy than right oriented governments. They find that right oriented governments have negative significant effect on renewable energy consumption. Contrary to Biresselioglu and Zengin Karaibrahimoglu (2012), White (2009) finds that government orientation and green party representation in legislature do not have significant effect on renewable energy adoption. However, he finds that proportionality has positive and significant effect on renewable energy consumption. Stable democratic regimes, support from both ruling and opposition parties in the case of Germany and political factors are highlighted as key in political category to have positive association with renewable sources adoption (Pfeiffer and Mulder 2013); (Schreurs 2012); (Gallagher 2013). Matisoff (2008) finds positive and significant relationship between renewable energy policy adoption (RPS) and citizen liberalism. Carley (2009) finds that political institutions have significant effect on the percentage of renewable energy in electricity generation across US states (Carley 2009).

Private interests affect RPS adoption (Lyon and Yin 2010). Jenner et al. (2012) ask what drives states to adopt regulations (RPS, feed-in tariffs) that support electricity generation from renewable energy sources (RES-E). The findings show that the presence of International Solar Energy Association is positively correlated with the regulation adoption. Jenner, Ovaere, and Schindele (2013) examine how financial contributions by conventional energy interest groups (CEI) and renewable energy interest group (REI) affect RPS adoption. Their findings show that REI contributes more to Democrats and CEI donates more to Republicans state-level policy makers between 1998-2010. They found that CEI donations have negative significant effect on RPS adoption in a state while REI donations have positive and significant effect on RPS adoption. Colgan, Keohane, and Van de Graaf (2012) state that pressure from environmental groups motivate countries to promote renewable sources technologies. Marques and Fuinhas (2012) find that European Union’s established industries’ lobbies and renewable energy sources consumption are negatively associated.

Table 4 Barriers to Renewable Energy

Monopolistic structure of utilities (state owned public utilities (subsidization of electricity, regulated vs open market)
Lobbying effect of fossil fuel (contribution of fossil fuel as a percentage of GDP)
Long term non-renewable energy agreements with suppliers

Economic factors

Electricity sector subsidization is highlighted in the literature to be a barrier to the generation of renewable energy sources in the market because of the absence of competitiveness in terms of price. According to Bayülgen (Winter 2013) subsidization of electricity as a state-owned industry made it harder for the renewable energy to enter the electricity market. A study shows that the monopolistic structure of Turkish natural gas sector and the lobbying power of fossil fuel sector make the entry of renewables harder. Turkey is taking pride in being a transit country between the neighboring supplier and the European consumers and energy interdependence has become central to its foreign policy (Bayülgen Winter 2013).This study argues that the main obstacles to renewable energy reform is political not technical and financial in Turkey. Turkish government has not reduced the dominance of fossil fuel in its energy policy despite external pressure, political stability, civic activism and favorable public opinion. Energy policy in Turkey favors fossil fuel over renewables (Bayülgen Winter 2013).

Zhang (2008) looks at Asia's renewable energy policies. He suggests that Asia needs to get rid of its subsidies on fossil fuel energy so that they reflect the right prices in order to adopt clean energy (Zhang 2008). Burns (1982) argues that in order for solar energy to achieve a substantial market penetration, it needs to be competitive with the price of fossil fuel energy.

Carley (2009) finds that deregulation and electricity price have significant effect on the percentage of renewable energy in electricity generation across US states (Carley 2009).

Electricity market concentration has a negative effect on policy adoption (Jenner et al. 2012). States with regulated electricity markets or cost-based pricing are more likely to adopt RPS with in-state requirement than states with restructured electricity markets or competitive markets (Lyon and Yin 2010).

Lyon and Yin (2010) conduct an empirical study on the adoption of renewable portfolio standards (RPSs) in the US states. They examine the political and economic factors that contribute to the adoption of RPSs in US states. They find that states with slower economic growth are slower in adopting RPS. Local environment conditions and preference effects are not significant. Whether there is an in state requirement or not depends on the current level of renewable energy development. States that have a higher developed renewable energy capacity, are less likely to adopt an RPS with in-state requirement. Carley (2009) finds that gross state product per capita, and electricity use per person have significant effect on the percentage of renewable energy in electricity generation across US states (Carley 2009).

Pfeiffer and Mulder (2013) look at factors that affect renewable energy adoption. The dependent variable is adoption of non-hydro renewable energy (NHRE), which is measured by the per capita NHRE per kilowatt hours (kWh) in developing countries between 1980-2010. They include renewable energy technology (RET) policies, growth in electricity consumption, secondary enrollment and per-capita income among their independent variables. Economic and regulatory instruments, per capita income and schooling level, and stable democratic regimes have positive and statistically significant effect on NHRE. There is a negative effect from institutional and strategic policy support programs and growth of electricity consumption. There is no significant effect from financial sector development (Pfeiffer and Mulder 2013).

GDP is identified as a determinant of renewable energy consumption in various studies; therefore; it is included here. Countries' prosperity allows for investment in renewable sources of energy (Grossman and Krueger 1995). Salim and Rafiq (2012) find that GDP is a significant factor in the consumption of renewable energy. As GDP increases one percent, the consumption of renewable energy increases 1.228 percent in the emerging economies (Salim and Rafiq 2012). Sadorsky (2009) finds that per capita income has positive and statistically significant effect on per capita renewable energy consumption in the emerging economies. "In the long term, a 1% increase in real income per capita increases the consumption of renewable energy per capita in the emerging economies by approximately 3.5%" (Sadorsky 2009).

Erdogdu (2013) finds that there is a negative relationship between energy intensity of GDP and renewable energy R&D. Countries with higher energy intensity of GDP have lower budget for R&D in renewable energy. He measures energy intensity by dividing energy supply over GDP to show how much energy is used for producing one unit of GDP. Overall his results show that deregulation of electricity market leads to lower government spending on energy R&D. He explains this result by claiming that countries with high energy intensity of GDP invest in technologies that produce large amounts of energy to meet their high energy needs rather than focusing on renewable energy technology that produce lower amount of energy. Among the countries with highest energy intensity of GDP are USA, Canada, Finland, Czech Republic and Korea (Erdogdu 2013).

Jenner et al. (2012) argue that unemployment affect policy adoption (RPS, feed-in-tariffs) positively. Per capita income and renewable energy consumption are positively associated

(Pfeiffer and Mulder 2013); (Sadorsky 2009). While Pfeiffer and Mulder (2013) use per capita non hydro renewable energy, Sadorsky (2009) uses per capita renewable sources consumption as the dependent variable. Schreurs (2012) argues that economic benefits to small- and medium-sized businesses motivates Germany's renewable energy adoption. Gallagher (2013) argues that economic motive is a key factor in renewable sources adoption. Salim and Rafiq (2012) argue that income (GDP) is a major factor for renewable sources consumption. Economic benefits from major wind energy manufacturing companies motivate countries to promote renewable sources technologies (Colgan, Keohane, and Van de Graaf 2012).

It is important to control for the effect of oil prices, it might be that increased oil prices is the motivation for countries to adopt the policies simultaneously, which would not be because of diffusion, but rather a common response to rising prices. Failure to include this variable might lead to false conclusion about policy diffusion.

Factor endowments

Pfeiffer and Mulder (2013) look at factors that affect renewable energy adoption. The dependent variable is adoption of non-hydro renewable energy (NHRE), which is measured by the per capita NHRE per kilowatt hours (kWh) in developing countries between 1980-2010. They include hydro share, coal production, and gas production among their independent variables. There is a negative effect from fossil fuel production. Carley (2009) finds that natural resource endowments have significant effect on the percentage of renewable energy in electricity generation across US states (Carley 2009). Diverse energy mix increases the probability of NHRE adoption (Pfeiffer and Mulder 2013).

Jenner et al. (2012) ask what drives states to adopt regulations (RPS, feed-in-tariffs) that support electricity generation from renewable energy sources (RES-E). The findings show that solar potential measured as global radiation in kwh per square meter, and unemployment rate as a percent of total work force are positively correlated with regulation adoption. Matisoff (2008) finds positive and significant relationship between renewable energy policy adoption (RPS) solar density and the criteria pollutant index. Lyon and Yin (2010) conduct an empirical study on the adoption of renewable portfolio standards (RPSs) in US states, which examines the political and economic factors that contribute to the adoption of RPSs in US states. Local environment conditions and preferences effects are not significant. Whether there is an in state requirement or not depends on the current level of renewable energy development. States that have higher renewable energy capacity developed, are less likely to adopt an RPS with in-state requirement.

Environmental concern

In addition, environmental concern is another main factor highlighted in previous studies. Global warming and climate change concern policy makers on how to reduce Carbon Dioxide (CO_2) emissions and other greenhouse gases that are produced by energy consumption. If the concentration of greenhouse gases keeps increasing, the temperature at the earth's surface will continuously rise. With the industrial revolution, the amount of CO_2 emission increased as burning coal to produce electricity and factories increased. In 2005 CO_2 reached 379 parts per million, an increase of 35% from pre-industrial revolution period. Average global temperature increased by 0.76 degree Celsius since the end of the 1800s. Increased temperature could have adverse effects on the living habitat. Although most of CO_2 is natural, humans generate a great portion of CO_2 by burning fossil fuel. Growth in GDP and population growth increase human generated carbon. Other major sources of emissions are deforestation and burning bio mass (Yergin 2011).

Countries are under pressure by the environmental groups to mitigate their CO_2 emission. One of the barriers to clean energy transition is the high cost of clean energy. Technological innovation can reduce the cost of transition to clean energy. Renewable energy research, development and demonstration (RD&D) is a route towards adopting clean energy, which can lead to mitigation of CO_2 emission. There are previous studies on how pollutant emission increases renewable energy consumption, but there is not much focus on the role of pollutant emission on RD&D. Salim and Rafiq (2012) find that pollutant emission is a significant factor for renewable energy consumption. Their examination shows that one percent increase in pollutant emission increases renewable energy consumption by 0.033% in emerging economies (Salim and Rafiq 2012). Renewable energy sources endowment is also identified as a significant factor for adoption of renewable sources (Gallagher 2013). Jenner et al. (2012) find that solar radiation is a significant factor for policy adoption (RPS, feed-in tariffs). On the other hand, Pfeiffer and Mulder (2013) find that fossil fuel production is not a significant factor.

Geopolitical concerns are barrier to renewable energy adoption. Podobnik (1999) argues that the interaction of three systemic dynamics--geopolitical rivalry, commercial competition, and social unrest--paved the way to shift from coal regime to petroleum in the twentieth century (Podobnik 1999). While acknowledging the challenges that countries face in terms of energy such as not having secure energy supplies, environmental threats due to climate change, loss of biodiversity, water scarcity, growth in energy consumptions of individuals and industrial needs, economic and geopolitical concern influences countries' decisions on their energy policies. ÜSTÜN (2012) examines Turkey's energy and environmental policy and its geopolitical and economic needs and the agreements with the oil producing countries. Many factors such as "droughts, water scarcity, the passage of energy tankers from Black Sea and the decline of biodiversity force Turkey to use clean energy; on the other hand, economic and geopolitical concerns influence Turkey's decisions in having agreements with energy producing countries (ÜSTÜN 2012).

Gallagher et al. (2011) find that the investment in research, development and demonstration (RD&D) in energy has been volatile with an increase in the late 1970s, shrank in the next two decades with a decline in 1997 followed by a gradual increase during the 2000s. The investment has been dominated on research in nuclear and fossil fuel. While Brazil, Russia, India, Mexico, China and South Africa (BRIMCS) have been significant in the energy sector, little data is available about public and private investment in those countries. Similar to International Energy Agency (IEA) their investments have been predominantly on nuclear technology and fossil fuel (Gallagher et al. 2011).

Some of the top oil importers also have the highest budget for renewable sources RD&D. According to IEA data for 2011 these countries were the United States, Japan, Germany, Korea, France, Spain, Italy, and the Netherlands. Only two of the IEA members in the top oil importers (Turkey & Belgium) in Figure 2 are not in the list countries who are leading in renewable energy sources RD&D. However, it does not report the budget for non-IEA members from Asia & Oceania. According to Renewable 2014 Global Status Report (Network 2014) Asia & Oceania region, which is the most dependent on foreign energy, has the highest investment on renewable power and fuels. The investment in the Americas has been volatile. Europe's investment, which used to have the highest investment, has declined. Asia & Oceania where the main investors are

China and India surpassed Europe in 2012 and surpassed Americas in 2009. Africa & the Middle East has the lowest investment (Network 2014).

Dependence on foreign sources of energy is a great concern for the highly dependent countries, which are also major or emerging economies of the world. The concern for energy security (affordability and supply), vulnerability of energy sources infrastructure to terrorist attacks and natural disaster, the dominance of nationalized oil companies, increasing demand for the energy with the growth of emerging economies, environmental consequences of fossil fuel consumption are some of the challenges the world faces today. Most importantly there is only limited reserves of conventional energy sources available in the world. These sources are not sustainable and will deplete sometime in the future. Diversification of energy mix and energy sources is seen as one of the main solutions for energy security (Bahgat 2006). As sustainable development is highly dependent on renewable energy sources and to achieve energy security, countries need to develop renewable sources of energy.

Encouraging domestic production is valuable not only in decreasing the dependence, but also sustainable development. Development of technology will be vital for domestic production and decreasing dependence on foreign energy sources. This transition will ultimately become possible through investment in renewable sources research, development and demonstration (RD&D) to make renewable sources of energy more competitive in the world market.

World demand for energy is increasing. Energy dependency is measured by the difference between total primary energy consumption and energy production in different regions. According to the data from US Energy Information Administration (EIA) three regions (Asia & Oceania, Europe & North America) are highly dependent on foreign energy. There is an increasing trend in energy dependency of Asia and Oceania region. It has surpassed Europe's energy dependency. There has been a decreasing trend in North America’s energy dependence because of the energy boom in the United States. Central & South America, Africa, Middle East and Eurasia produce more energy than they consume.

RESEARCH DESIGN

To examine the diffusion of renewable energy policies, this study applies mixed methods. A statistical model will allow testing multiple hypotheses with a large sample size. In addition, an agent-based model is used to complement the statistical analysis. Studies use empirical findings to develop agent-based models for better understanding of the dynamics behind an observation. Others use theoretically informed agent-based models to compare with empirical findings (Poteete, Janssen, and Ostrom 2010).

The section will present the hypotheses for each of the mechanisms. Then it will discuss the specification and estimation techniques for the statistical model; the operational measures of all variables; and the data sources. The section ends with the discussion of developing an agent-based model.

DIFFUSION MECHANISMS' HYPOTHESES

This section discusses the hypothesis for each mechanism. First, it presents suasion mechanism's hypotheses followed by competition, learning and emulation respectively. There are eighteen hypotheses in total.

The Suasion Mechanism: Hypotheses

"[S]tudies linking policy diffusion to soft coercion should show that the policy ideas actively promoted by strong countries are more likely to be put into practice in weaker countries structurally or situationally dependent on them" (Simmons, Dobbin, and Garrett 2006). Membership in similar regional or multilateral organizations, preferential trade agreements

(PTAs), and military alliance can be used to examine their effect on policy outcome when the sticks or carrots of suasion are involved.

The European Union can use its coercive power to impose policies (e.g. renewable energy targets) on its members. While the EU imposes renewable energy targets, it does not impose the adoption of RPS/FIT specifically. Jenner et al. (2012) examine the effect of EU membership, representing EU Directive 2001/77/EC on generation of electricity from renewable energy sources (RES-E) on policy adoption (RPS, FIT). Because it is the first binding directive that obliges nation-states' legislators to support RES-E, it can be treated as a coercion mechanism.

International organizations and powerful countries can coerce countries through financial incentives to affect policy change. International climate policy components such as the Clean Development Mechanisms (CDM) target developing countries and provide them with financial incentives (Stadelmann and Castro 2014). To examine the effect of coercion from international organizations, one can use CDM projects as a proxy measure.

Hegemonic countries can influence or coerce other countries. To examine this effect Stadelmann and Castro (2014) use former colonizers' policy adoption effect on the developing countries as they continue to have strong economic and political ties.

Dobbin, Simmons, and Garrett (2007) suggest some ways to test for coercion. One way to illustrate that the coercion mechanism is at work is to test for adoption of a policy while countries are negotiating trade agreements; accession to the EU or the WTO; or loan disbursement from the IMF. In addition, studies should illustrate that countries subject to aid, loans or security dependence are adopting policies promoted by powerful actors. "[T]he preferences of the U.S. government, the European Union, the International Monetary Fund

(IMF), and the World Bank may shape policy in countries reliant on those entities for trade, foreign direct investment, aid, grants, loans, or security" (Dobbin, Simmons, and Garrett 2007).

Together, these previous studies suggest four hypotheses about suasion:

H1a Countries that are members of the European Union are more likely to adopt renewable energy policies than non-EU states.

H2a Countries for which their former colonizers adopted RPS/FIT are more likely to adopt them.

H3a Countries with CDM projects are more likely to adopt RPS/FIT than countries without them.

H4a Countries with high levels of FDI are more likely to adopt FIT/RPS than countries with lower levels of FDI.

The above hypothesis will examine the effect of different crucial actors on policy diffusion. The European Union and CDM are go-between actors. Former colonizers and FDI show the effects of external actors.

The Competition Mechanism: Hypotheses

To test the effects of competition on policy diffusion, Dobbin, Simmons, and Garrett (2007) provide some operational measures. First, it is important to identify what policies are important for a country and its competitors. Exporting countries are affected by wage and welfare policies elsewhere. Investment seekers compete on policies that reduce security or political risks and contractual hazards. In case of competition in a local market, the competition is with a trade partner. In other cases, countries compete in a third country's market. For example, if country A and B are competing in C's market, when A reduces trade barriers, B may follow A for gaining access to C's market. For countries who are seeking foreign direct investment, one may consider countries with similar social capital, infrastructure or natural resources endowment.

Trade openness can be used as a proxy for competition. Neumayer (2002) finds that trade openness promotes multilateral environmental cooperation. Exporting countries support those multilateral environmental agreements that do not hinder their economic interests. For example, fossil fuel exporters are less likely to sign the Kyoto Protocol because they see it as a threat to their economic interest. When the trade provisions in multilateral environmental agreements accommodate the interest of the exporters, they are more likely to cooperate. A measure of trade openness is membership to the World Trade Organization. Other proxy measures include the natural log of the sum of exports and imports divided by gross domestic product (GDP); the natural log of imports as a percentage of GDP; the natural log of exports as a percentage of GDP; the index of openness from the Fraser Institute; and the index of trade openness from the Heritage Foundation. The natural log of the variables are used to avoid the potential problem of hetroscedasticity (Neumayer 2002). Pfeiffer and Mulder (2013) use trade intensity and net FDI inflow, which are measures of competition, to find the drivers of renewable energy adoption.

Policies diffuse from external actors to internal actors when they are competitors or trading partners (Berry and Berry 2007). In other cases, external and internal actors compete in third countries' market or they might be competing for a third country's investment in the case of foreign direct investment (FDI) (Dobbin, Simmons, and Garrett 2007).

In the competition mechanism, the most important relationships among actors are horizontal (Simmons, Dobbin, and Garrett 2006). External and internal actors who compete are more likely to have similar economic structures (Stadelmann and Castro 2014). Stadelmann and Castro (2014) find significant effects of GDP per capita on FIT adoption in emerging and developing countries. Income level (low, medium, high) can be used to measure competition among countries.

The literature provides various measures of competition. Stadelmann and Castro (2014) use membership to similar economic and regional blocks, trade openness and countries with similar economic structure as proxies for competition. Baccini, Lenzi, and Thurner (2013) define competitors as main trade partners. Prakash and Potoski (2006) use the main exporter's market or partner(s) as a measure of competition. Saikawa (2013, 13) states that adoption by an importing country puts pressure on the exporting country to adopt the policy as well. Adoption of an exporting country gives it a competitive advantage. Geographic proximity is another proxy for measure of competition.

These findings suggest three hypotheses about the competition mechanism of diffusion:

H5a Countries are more likely to adopt FIT/RPS if their main export partner(s) (competitor) adopted them.

H6a Countries are more likely to adopt FIT/RPS if their competitors with CDM have adopted the policies.

H7a Countries are more likely to adopt RPS/FIT if their competitors with FDI adopted them.

Countries are more likely to adopt RPS/FIT if their prime competitors for trade and investment have done so. FDI will be used to measure competition between the receivers. However, it can be a measure of suasion if considered in terms of recipients and investors. The same can be true for CDM, the recipients compete for it, while from the perspective of relation between CDM providers and recipients, it is a measure of suasion. The hypotheses will examine the effects of external actors in the competition mechanism.

The Learning Mechanism: Hypotheses

Berry and Berry (2007) argue that states emulate each other because they learn from each other; they adopt policies that they perceive as successful elsewhere. The percentage of renewable energy in electricity generation, CO_2 emission per capita and economic growth could be used to measure RPS/FIT success. The following hypotheses test the learning mechanism of diffusion:

H_{8a} In comparing countries, those in regions with a high share of renewable energy are more likely to adopt FIT/RPS than those in regions with a low share of renewable energy.

H_{9a} In comparing countries of the world, the average share of renewable energy is higher in countries with FIT/RPS than countries without them.

H_{10a} In comparing countries, those in regions with lower average carbon emissions are more likely to adopt FIT/RPS that those in regions with high average carbon emissions.

H_{11a} In comparing countries of the world, the average carbon emissions are lower in countries with FIT/RPS than countries without them.

$_{H12a}$ In comparing countries, those in regions with higher average economic growth are more likely to adopt FIT/RPS than those in regions with lower average economic growth.

$_{H13a}$ In comparing countries of the world, the average economic growth is higher in countries with FIT/RPS than countries without them.

In the above hypotheses, the effects of external actors in the learning mechanism are considered. Covadonga (2004) assumes that governments are rational learners choosing to privatize. Governments use their prior beliefs of the impact of privatization on growth a year before they choose to privatize. In each period, a year before they adopt the policies, the countries will observe the average rate of renewable energy consumption, CO_2 emissions and economic growth for countries with the policies and without the policies. Governments will use this information to change their prior belief about the effectiveness of the policies.

The Emulation Mechanism: Hypotheses

In addition, by introducing a new independent variable and a broader reach, this study will contribute by examining whether and how socialization in international organizations affects the policy diffusion process. It investigates the question: how does membership in multilateral environmental agreements (MEAs) affect the diffusion of domestic renewable energy policies? The purpose is to examine the diffusion of renewable energy policies, whether socialization or membership in these networks or multilateral environmental agreements affect the adoption of RPS and FIT.

Stadelmann and Castro (2014) argue that the international climate regime and the emission targets of transition countries under the Kyoto Protocol are not strict enough to force countries into action. Therefore, multilateral organizations will be used as a proxy to examine socialization, which is one of the emulation processes. The independent variables are membership in multilateral environmental agreements (MEAs) such as Kyoto Protocol from the United Nations Framework Convention on Climate Change and the Cartagena Protocol on Biosafety. Neumayer (2002) categorizes MEAs as continuous and suggest that Cox proportional Hazards model or survival model is the appropriate estimation method. The model will also include independent variables to test the domestic determinants of renewable energy policy adoption.

MacGarvie (2005) uses geographic proximity as a proxy for communication barriers between two countries and measures the distance between the capital of two countries of the citing and cited patents.

Acting as go-betweens, national policy governments in federal system and international organizations can facilitate socialization by establishing information facilities, organizing conferences and recommending best practices (Graham, Shipan, and Volden 2013). NGOs, policy professionals, academics can influence governments to adopt policies (Simmons, Dobbin, and Garrett 2006).

These previous studies suggest the following hypotheses concerning the emulation mechanism of policy diffusion:

$_{H14a}$ States with a higher percentage of neighbors with the renewable energy policy are more likely to adopt renewable energy policy.

$_{H15a}$ States with a higher percentages of countries with FIT/RPS that share a common colonizer historically are more likely to adopt RPS/FIT

$_{H16a}$States with higher percentages of countries with FIT/RPS that share a common language are more likely to adopt RPS/FIT

$_{H17a}$ Countries that are signatories to the Cartagena multilateral environmental agreement are more likely to adopt renewable energy policies.

$_{H18a}$ Countries that are signatories to the Kyoto multilateral environmental agreement are more likely to adopt renewable energy policies.

The above hypotheses will examine the effects of external actors (neighboring countries, countries with common cultural/historical features) and go-between actors (MEAs) on internal actors. When and where policy diffusion occurs--in other words, the process of diffusion rather than the end result--"the existence and nature of the linkages among internal, external, and go between actors may influence which diffusion mechanisms are used" (Graham, Shipan, and Volden 2013). Graham, Shipan, and Volden (2013) suggest the examination of diffusion mechanisms and the interaction of crucial actors. Previous studies do not look at the interaction of neighboring states' and the policy advocates' influence. It is not known whether their interaction reinforces the learning processes or substitutes it. While the literature identifies the actors and the mechanisms, it does not examine the existence and linkages among the crucial actors and the diffusion mechanisms. Not only that, Braun and Gilardi (2006) suggest that policy change is driven by change in effectiveness and payoffs, which are affected by diffusion mechanisms through change in beliefs and preferences. For example, learning should be used in combination with some measures of payoff. They illustrate that learning by itself cannot affect the policy change but rather changes the beliefs about effectiveness of policy.

RESEARCH METHODS

Since the dependent variable in this study is dichotomous, that is, whether RPS/FIT is enacted is coded as 1 or not coded as (0), pooled random-effects logistic regression (logit) and event history methods will be used. There are some disadvantages in regression models that examine time series (Box-Steffensmeier and Jones 1997). Two of the problems with regression models are "right censoring" and "time varying covariates". Ordinary least squares regression models assume that time-varying predictors are fixed. Independent variables explain the variation in duration of change from one state to the other. For example, any state that does not adopt a policy during a period of observation is right censored (that is, future policy adoption is not directly observed). In this case, regression models fail to distinguish a state that has not adopted a policy by the end of the observation period from states that adopted a policy at the end of the period of observation. By using logit or pobit models, one loses information on when an event occurs. They give inefficient estimates with larger variances relative to event history estimates. To address these issues, event history models are considered for a robustness check whether the variables behave consistently across specifications within pooled logit models and within event history models and across pooled logit models and event history models.

An event history model's dependent variable is not one or zero. It analyzes the probability of an event occurring in a given time. How long does it take until a given event takes place? It solves the problem of serial correlation. How long does it take until a state adopts FIT/RPS?

Event history modeling focuses on duration, timing of events, and patterns and causes of change. "One indicator of issue innovation and diffusion might be to record the duration of time before adoption occurs" (Box-Steffensmeier and Jones 1997, 1415).

Why Use Agent-Based Models?

Statistical models allow observing correlation of regularities. However, because they use aggregate and/or pooled data, they do not allow directly observing how states change their preferences and make decisions. Agent-based models can close this gap by making it possible to model how actors receive information and update their preferences. "Agent-based models can be used to develop models based on agents making decisions with simple strategies that can explain the observed behavior in experiments" (Poteete, Janssen, and Ostrom 2010 ,178).

Conventional theories of collective action claim that actors make decisions based on rational utility maximization. However, the empirical findings challenge these predictions. The empirical findings show different outcomes in how individuals manage collective action. "The findings suggest the importance of communication, trust, and reciprocity, normative considerations, interactions among multiple types of actors, and the cognitive challenges presented by complex ecological systems" (Poteete, Janssen, and Ostrom 2010 ,194). Agent-based models use agents with a heterogeneity of attributes and preferences to explain outcomes. This justifies the use of agent-based modeling to study collective action and how individuals or agents act collectively to manage the commons in a sustainable way.

Agent-based simulation is used as a tool to analyze complex system. Social phenomena are complex in nature. Complexity refers to non-linearity, decentralization, and self-organization. A number of scholars including (Axelrod 1984, Jervis 1997, Rosenau 1990) used this concept. Geller and Moss (2008) describe complexity as a type of condition in which an agent's behavior and social interaction combine to generate macro-level outcomes that could not be predicted from knowledge of the behavior and nature of interactions alone.

ABM is an appropriate approach to analyze the relationships among actors and outcomes. In ABM terms, these can be rules that explain why or how the behavior of A influences the behavior of B. This study will contribute by examining the interactions using ABM rules and developing a new model.

According to Macy and Willer (2002, 155) a diffusion model would “start with some distribution of practices and a rule by which agents decide whether to abandon current practice in favor of one used by another agent.” An advantage of simulation is that it focuses on processes rather than equilibria (Johnson 1999, 1522). “They can thus supply insights on how different diffusion processes may lead to the same equilibrium (e.g. convergence) and more generally on the characteristics of diffusion processes, whereas formal analysis permits conclusions only on equilibria that are achieved, and thus gives much less information on the diffusion process itself” (Braun and Gilardi 2006, 316). According to Elkins and Simmons (2005) policy diffusion is an uncoordinated process, which cannot easily fall under the umbrella of rational decision making. Braun and Gilardi (2006) suggest that ABM can be used in contexts where changes can be applied to various parameters that may affect diffusion outcomes at aggregate level. They specify decision rules, which depend on payoffs and effectiveness that are affected by the decisions of other states through various decision mechanisms. Simulation could be used to model the aggregate pattern of diffusion that emerges from interdependent policy choices.

In the model, there will be leading countries that have already adopted the policies at the setup prior to simulation based on leader laggard and threshold models. Walker (1969) finds that because of their size, wealth and cosmopolitan nature, some states are leaders in policy innovations. “Similarly, the go-betweens of policy entrepreneurs and epistemic communities influence when and where policies spread" (Graham, Shipan, and Volden 2013, 697). In Leader-laggard models states emulate pioneers and leaders who are economically developed.

Threshold models state that early adopters have low threshold values. They have strong preferences for policy change, which lead them to policy change even when no one else adopted the policy. Their payoffs and effectiveness change independent of others' behavior. They face higher transaction costs than potential adopters. They face uncertainty about decision-making process.

DATA AND OPERATIONALIZATION

For the statistical model, the study uses time-series cross-sectional data covering FIT and RPS adoption between 1990 and 2011. The first enactment of FIT was in 1978 and the second enactment in 1990; however, because of lack of availability of data and occurrence of the first diffusion, the study begins from 1990. There are 1958 observations (See appendix 3). Some of the independent variables originally considered, will be dropped because of missing data (see Table 6). Data for RPS/FIT policies and some of the independent variables were compiled from Renewables 2014 Global Status Report (REN 21). The independent variables' data sources are: World Bank Development Indicators (WDI), Eurostat Database, International Energy Agency, World Bank Database of Political Institutions (DPI), Central European Free Trade Agreement, International Environmental Agreements, Clean Development Mechanism (CDM), Research and Expertise on the World Economy (CEPII), and U.S. Energy Information Administration (EIA). Table 5 presents the data sources and operationalization of each variable.

In 1990 only two countries had adopted a FIT policy. This number exceeded to 69 in 2013 (69 countries with known years of adoption and this number grows to 76 including the countries with unknown years of adoption). There are fewer countries which have RPS, but the number is growing. In 1999 only one country had RPS policy and this numbered reached to 15 in 2013 (This number exceed to 25 including the countries with unknown years of adoption).

Table 5 Data Operationalization

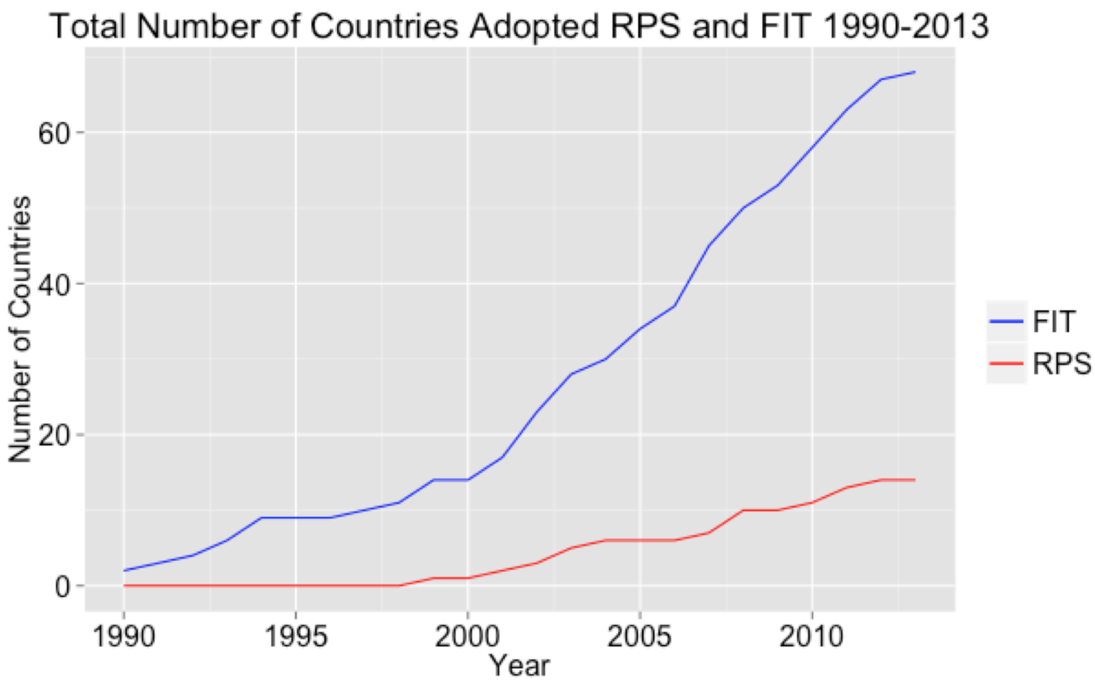
Variables operationalization	Abbreviation	Sources	#	Actor	H_a
Feed-in tariff [1] dummy	fit	Renewables 2014 Global Status Report	1, 2	Interna l	DV
+EU membership/non members (non=1,2)	eumem	EU	3	Go-betw	H1a
+former colonizer with/without FIT (1,2),	colonizer_fit	CEPII, created	5	extern al	H2a
+CDM, dummy (non=1,cdm=2)	cdm	UNFCCC	6	Go-betw	H3a
+Foreign direct investment (net inflows (% of GDP), new investment inflows less disinvestment) divided by GDP (positive fdi =2, negative fdi=1)	fdi	WDI	7	extern al	H4
+ %Main export partners (competitor) with RPS/FIT	comfit	CIA Factbook	8	extern al	H5a
% of competitors with CDM	compcdm	create	10	extern al	H6a
+% of competitor with FDI	compfdi		11	extern al	H7a
+ Regional difference in mean renewable electricity share of FIT and nonFIT (Total Renewable Electricity Net Generation (Billion Kilowatthours)/Total Electricity Net Generation (Billion Kilowatthours)*100	regelshare_fit .nf	EIA	12	Extern al	H8

Table 5 continued: Variables operationalization	Abbreviation	Sources	#	Actor	H_a
+ World difference in mean renewable electricity share of FIT and nonFIT	regelshare_fit.nf	EIA	12	External	H9
+Regional difference in mean CO_2 emissions (metric tons per capita) of fit & nonfat countries	regfit_co2.nonfit	Created-WDI	13	External	H10
+world difference in mean CO_2	wfit_co2_nonfit	Created-WDI	13	External	H11
+ Regional difference in mean GDP growth (annual %) of FIT and nonFIT countries	regfit_gdpg.nonfit	Created-WDI	14	External	H12
+ World Difference in mean GDP growth	wfit_gdpg_nonfit	Created-WDI	14	External	H13
+% of neighboring states with FIT	nei_fit	CIA fact book created	16	External	H14a
+% of countries with the same colonizer having FIT, countries without a colony coded 0	Commoncolony_fit	CEPII, created	17	External	H15
+ % countries with common language with FIT	coml_FIT	CEPII, created	20	External	H16
+Cartagena Protocol on Biosafety, dummy	cartagena	IEAD	22	Go-betw	H17
+Kyoto Protocol from the United Nations Framework Convention on Climate Change, dummy	kyoto	IEAD	21	Go-Betw	H18
+CO_2 emissions (metric tons per capita)	Co2em	WDI	13	Extern	C
+Global oil price	goilpr	EIA	24	Go-	C
+GDP per capita (Current US$)	gdppc	WDI	25	interna	C
+Population	popul	WDI	26	interna	C
Government Orientation, -right(2), center (3), +left(4)	govorient	WBDPI	27	internal	C
System (presidential(2),	system	WBDPI	28	interna	C
-Crude Oil Proved Reserves (Billion	oilres	EIA	29	interna	C
+wind =Total Resource Area (km^2) at 50m, Classes 3-7	wind	Data Catalogue	30	internal	C
+solar= total potential solar energy per year MWh/year	solar	Data Catalogue	31	internal	C

Table 6 Controls not Included Because of Missing Data

Controls missing data	Abbreviation	Missing	Source	% missing
+Energy import, net % of energy use	eimport	748	WDI	26
-Fossil fuel energy consumption (% of total)	ffecpt	721	WDI	25
Energy use (kg of oil equivalent per capita) eupc	eupc	670	WDI	24
GDP per unit of energy use (PPP % per kg of oil equivalent	gdppueu	721	WDI	25
-Oil rents (% of GDP)	oilgdp	665	WDI	23
+education (the % of gross secondary school enrollment)	seconsgross	765	WDI	27
+School enrollment, secondary (% net)	seconsnet	1727	WDI	61
+Unemployment, total % of total labor force	unem	1309	WDI	46
Net ODA received (% of gni)	odapgni	831	WDI	29
Energy Intensity - Total Primary Energy Consumption per Dollar of GDP (Btu per	einten	682	EIA	24
Target percent of final energy from Renewable				0
Share of heavy industry as % of GDP(paper products+ nonmetallicindustry + basic metal industry)/gdp for each year			dataoecd	
Restructured electricity product market regulation (PMR) in the electricity sector			dataoecd	
Renewable energy, Total, % of total energy generation			dataoecd	
Renewable Energy Sources Govt R&D in Million NC (nominal)			IEA	
Renewable Energy Sources Total RD&D in Million USD (2013 prices and PPP)			IEA	
International solar energy society (unknown year of chapter)			sustainabledevelopment.un.	
+biomass resources				
+hydro resources				

Figure 1 Total number of countries with FIT and RPS Policies 1990-2013



About 39 percent out of 196 countries in the world have adopted FIT. Only 13 percent (about 25) have adopted RPS. Some of these countries have dropped the policies and the data about the years of adoption for some of these countries are unavailable. There are a few countries that have adopted both RPS and FIT.

Table 7 Frequency Table

Variables	FIT	Percent FIT	RPS	Percent RPS
EU member	25	36	5	33
Former colonizer with RPS	18	26	3	20
Former colonizer with FIT	38	55	6	40
CDM	19	28	4	27
Foreign direct investment	62	90	13	87
Kyoto Protocol	68	99	15	100
Cartagena Protocol	65	94	11	73
Government Orientation - right	18	26	6	40
Center	8	12	3	20
Left	20	29	4	27
Other	22	32	2	13
Presidential	26	38	4	27
Parliamentary	42	61	11	73

Table 7 shows frequency distribution of FIT and RPS countries and other variables. Almost all FIT and RPS countries have membership in multilateral agreements (Kyoto, Cartagena, and Montreal Protocols). About 90 percent of FIT and 87 percent of RPS countries are recipients of foreign direct investment. In addition, 55 percent of FIT and 40 percent of RPS countries had former colonizers with FIT. Around 61 percent of FIT and 73 percent of RPS countries have parliamentary governments.

Table 8 presents the frequency and percent of each variable. There are 28 European Union members. High percentages of countries are members of multilateral agreements (Kyoto 99 percent, Cartagena 83 percent) and are the recipients of foreign direct investment. About 57 percent and 42 percent are presidential and parliamentary governments. Around 38 percent and 8 percent of countries have FIT and RPS policies. Governments of the right, center and left are respectively 18, 8, and 28 percent of the countries. In addition, about 23 percent of the countries

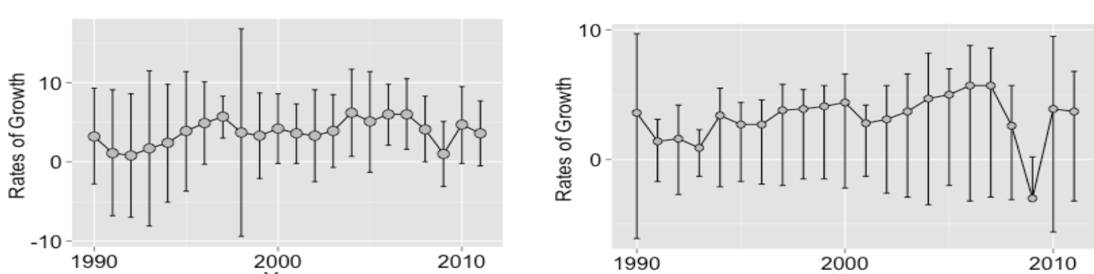
Table 8 Frequency Distribution of Variables

Variables	Frequency	Percent
EU membership	28	16
Former colonizer RPS	60	33
Former colonizer FIT	129	72
CDM	42	23
Foreign direct investment	165	92
Kyoto Protocol	179	99
Cartagena Protocol	150	83
Government Orientation - right	32	18
Center	15	8
Left	51	28
Other	82	46
Presidential	103	57
Parliamentary	75	42
FIT	69	38
RPS	15	8

have CDM. Around 33 percent and 72 percent have former colonizer with RPS and FIT respectively.

Figure 2 shows the average rate of growth and dispersion of FIT and Non-FIT countries. FIT countries have lower rates of growth than Non-FIT countries. This information is only

Figure 2 Average Rates of Growth & Dispersion under FIT/ Non-FIT 1990-2011



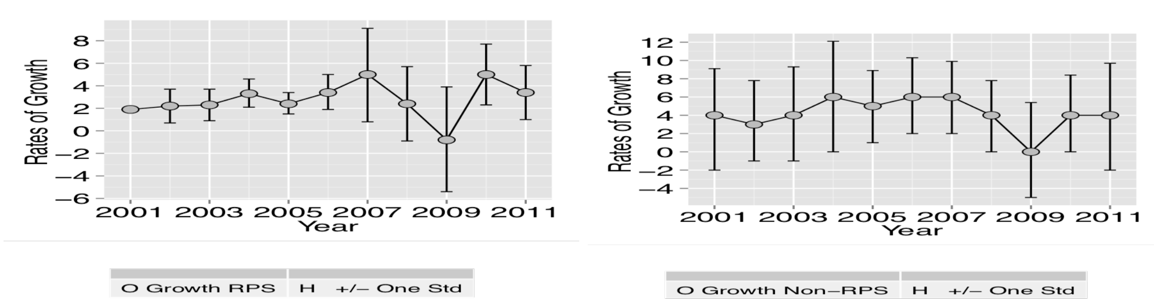
descriptive and only shows correlations. The data cannot inform about the direction of causality and association between growth and FIT adoption. Figure 2 also shows that FIT countries were hit harder by the 2008 recessions. Their growth rates have declined dramatically. The figure also reveals that the FIT countries had lower consistency and higher growth variation than those countries without FIT policies.

Figure 3 and Table 9 show the average rate of growth and dispersion of RPS and non-RPS countries. RPS countries have lower rates of growth than non-RPS countries. This

Table 9 RPS/non-RPS Descriptive Statistics

	RPS			Non-RPS		
Variable	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Growth	-0.8	3	5	4	0	6
Renewable Energy	19	10	27	43	41	45
CO_2	9	7	12	4.8	4.6	5

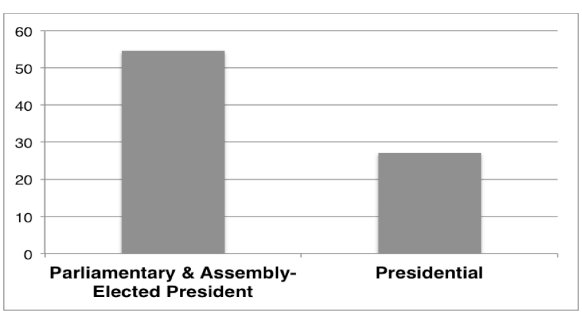
Figure 3 Average Rates of Growth & Dispersion under RPS/non-RPS 1998-2011

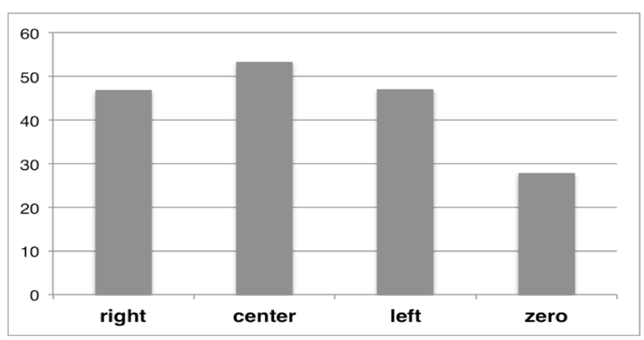


information is only descriptive and only shows correlations. The data cannot inform about the direction of causality in association between growth and RPS adoption. Figure 3 also shows that RPS countries were hit harder in the 2008 recessions. Their growth rates have declined dramatically. The figure also reveals that the non-RPS countries had lower consistency and higher growth variation than those countries with RPS policies. There has been an increase in variation in growth during 2007-2009 and since then it has decreased. Average growth in non-RPS countries is greater than RPS countries except in 2010.

Figure 4 shows the distribution of FIT adoption based on government orientation and system in the year of adoption. In Figure 4 government orientation represents countries that do not fall under right and left categories based on their platform on economic issues or there is no information available. The center category represents those countries where the ruling party is centrist (example social-liberal context where private enterprises are advocated). The categorization is based on Database of Political Institutions of the World Bank.

Figure 4 Percent of Countries with FIT Based on Orientation/ System of Government



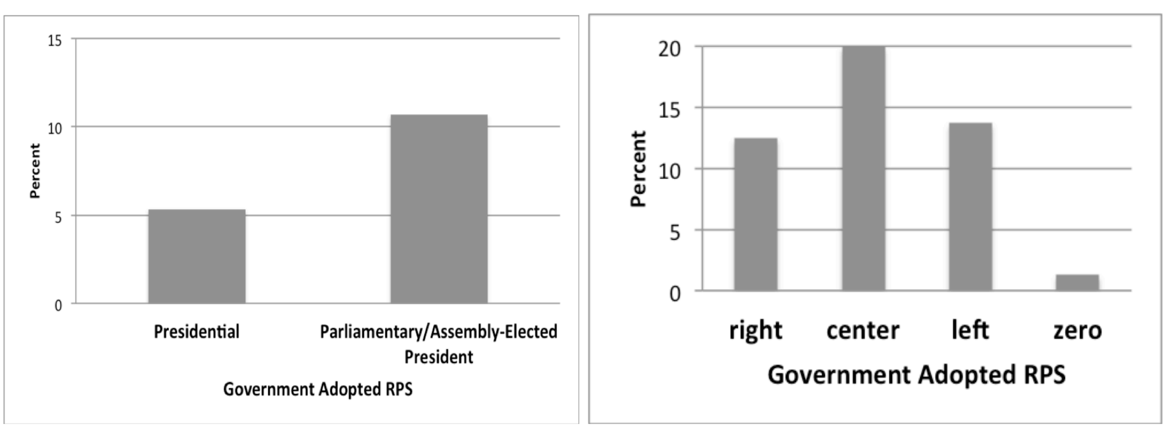


FIT seems more popular among parliamentary than presidential system of governments. About 55 percent of parliamentary governments and only 27 percent of presidential system of government adopted FIT. However, there is not much difference in the distribution of FIT based on government orientation in the year of adoption. About 47 percent of right- and left-oriented governments adopted FIT. Left-, right- and center-oriented governments adopted 35, 22 and 12 percent of FIT policies respectively. Parliamentary and presidential governments adopted 59 and 41 percent of RPS respectively.

The percent of parliamentary-system governments that adopted RPS is double that of the presidential system of governments. About 11 percent of parliamentary and five percent presidential governments adopted RPS. There is not much difference between the right- and left-oriented governments in terms of RPS adoption.

The percentage of centrist governments which adopted RPS is the highest. About 14, 12 and 20 percent of RPS policies are adopted by left-, right- and center-oriented governments

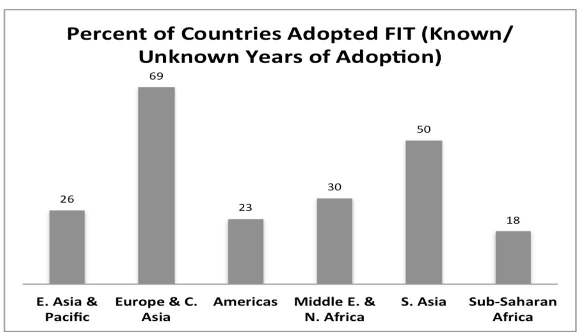
Figure 5 Percent of Countries with RPS Based on System/Government Orientation

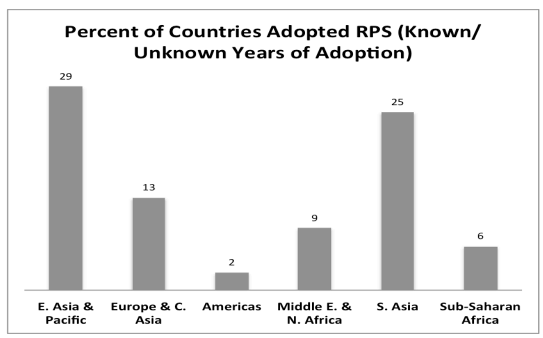


respectively. Parliamentary and presidential governments adopted 11 and 6 percent of RPS policies respectively.

RPS adoption is most popular in Asia. Figure 6 shows that the highest percentage of countries that adopted RPS are in East Asia and the Pacific followed by South Asia. The percentage of countries that adopted RPS in East Asia and Pacific, South Asia and Europe and Central Asia are 29, 25 and 13 percent respectively. Around 49 percent of FIT policies are adopted in Europe and Central Asia. East Asia/ Pacific and America each has adopted 13 percent of all FIT adoptions. Sub-Saharan Africa has adopted 12 percent of FIT policies.

Figure 6 Percent of Countries with FIT/RPS in Each Region





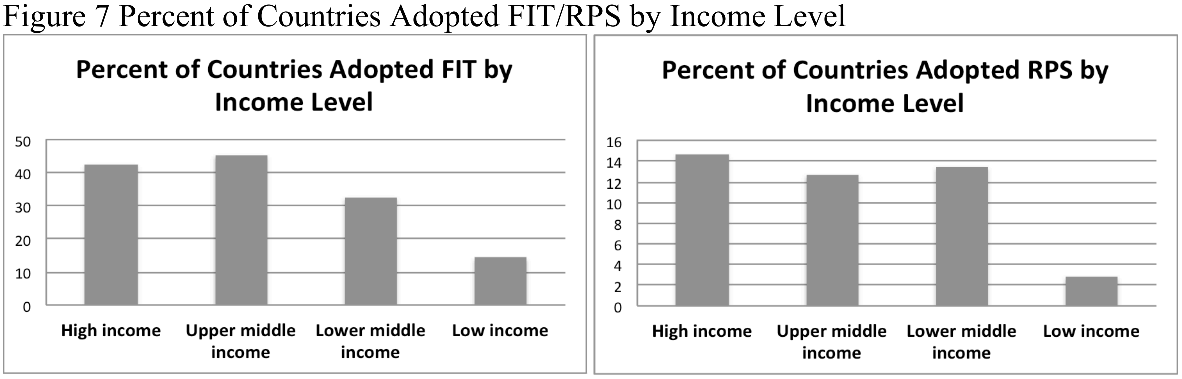
On the other hand, FIT is most popular in Europe and Central Asia. Figure 6 shows percentage of countries in each region that adopted FIT. The percentage of countries that adopted FIT in Europe and Central Asia, South Asia, Middle East and North Africa and East Asia and Pacific are 69, 50, 30 and 26 percent respectively. East Asia and the Pacific is on the top of the list in terms of percentage of RPS policies adoption while America is in the bottom of the list.

East Asia/Pacific, Europe/Central Asia, Sub-Saharan Africa, South Asia, and Middle East/North Africa have adopted 40, 28, 12, 8,8 and 4 percent respectively.

Figure 7 shows that the percent of high- and middle-income countries which have adopted FIT and RPS are higher than low-income countries. The percent of high income, upper-middle income, lower-middle income and low income countries that adopted FIT are 43, 45, 33 and 14 respectively. In addition, the highest percentage of FIT policies are adopted by high income countries. High income, upper middle income, lower middle income and low-income countries adopted 38, 33, 22 and 7 percent of FIT policies respectively. Around 76 countries adopted FIT policies. Some of these countries have dropped the policies and the data about the years of adoption for some of these countries are unavailable.

The percent of high income, upper-middle income, lower-middle income and low-income countries that adopted RPS are 15, 13, 13 and 3 respectively. In addition, high-income countries have adopted the highest percentage of RPS policies. While there is around a 10-percent gap between upper and lower middle-income countries in the adoption of FIT, it is the same in terms of RPS policies. High income, upper middle income, lower middle income and low-income

Figure 7 Percent of Countries Adopted FIT/RPS by Income Level



countries adopted 40, 28, 28 and 4 percent of RPS policies respectively.

CONCLUSION

This chapter lays out the research design. A mixed statistical method of pooled random-effects logistic regression and event history will be used to analyze the data and test the hypotheses. These two methods will allow for robustness check whether the variables behave consistently across specifications within pooled logit models and within event history models and across pooled logit models and event history models. To complement the statistical models by making it possible to model how actors receive information and update their preferences, agent-based model will be developed. This chapter also discussed the sources and operationalization of the data. In the next chapter author presents the results of statistical analysis of four specifications of event history and four specifications of random-effects pooled logit regression.

Using the findings of previous studies, an agent-based model of diffusion will be built. Because an agent-based model provides a micro level analysis of the interactions between the crucial actors in the diffusion of policies, it is a useful method for theory and hypothesis generation, especially when empirical data about actor preferences are scarce. The next chapter will discuss the development, experimentation with and analysis of the agent-based model.

AGENT-BASED MODEL

The previous chapter presented hypotheses, operational measures, and the research methodology. In the next chapter, a random effects regression analysis will test the hypothesis using large sample data. An event history analysis also will seek to explain the effects on timing of diffusion. One advantage of statistical models is that they allow observing correlation of regularities. However, they do not permit direct observation of how states change their preferences and make decisions. Agent-based models can close this gap by making it possible to model how actors receive information and update their preferences. “Agent based models can be used to develop models based on agents making decisions with simple strategies that can explain the observed behavior in experiments” (Poteete, Janssen, and Ostrom 2010 ,178).

Conventional theories of collective action claim that actors make decisions based on rational utility maximization. However, empirical findings have challenge this assumption. These findings show different outcomes in how individuals manage collective action. “The findings suggest the importance of communication, trust, and reciprocity, normative considerations, interactions among multiple types of actors, and the cognitive challenges presented by complex ecological systems” (Poteete, Janssen, and Ostrom 2010 ,194). Agent-based models use agents with heterogenous attributes and preferences to explain outcomes. This justifies the use of agent-based modeling to study collective action and how individuals or agents act collectively to manage collective action problems in a sustainable way.

This chapter's agent-based model of policy diffusion adopts and builds upon Ring’s □□□=□□,□,□ to represent three parameters of theoretical interest to him: hierarchy, neighborhood and identity. He hypothesizes norm adoption is a function of these three factors.

Based on theories of policy adoption, policy diffusion is influenced or the result of interaction of three sets of actors: external actors, internal actors and "go-betweens" or intermediators. In this chapter's extension of Ring's model, other nation-states that have already adopted the policy are the external actors. An internal actor is represented by nation-states adopting the policy and the people in those nation-states. Go-betweens are intergovernmental organizations.

This chapter presents agent-based model by discussing the simulated environment and agents. Then it discusses the rules for interaction for each mechanism. It displays the initialization of the model with plots. Finally, it provides the run results and conclusions.

An agent-based model (ABM) is a computer simulation that represents people as "agents" or autonomous objects that execute algorithms written by the modeler. In an ABM, agents interact with other agents and with the environment. The interaction rules guide agents' interaction. In this chapter's model of policy diffusion, agents signal each other about a policy choice i. At each step of the simulation run, two agents, a receiver and a sender, are activated. The sender sends a signal to the receiver agent. When an agent receives a signal, it evaluates the benefits and costs of adoption and then updates its policy choice accordingly. An agent that sends the signal is the sender and the agent that updates its policy choice is the receiver. The study builds the model in NetLogo, a free and widely used integrated development environment for agent-based models (Wilensky 1999).

THE ENVIRONMENT AND AGENTS

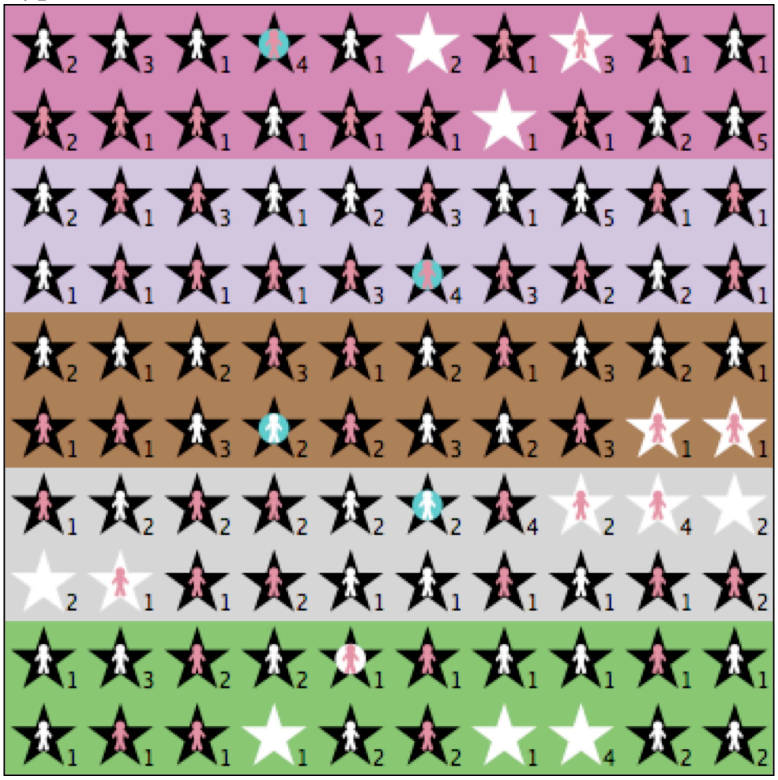
The model represents a world with five "regions". In this respect, the model represents a spatially explicit world in which policy diffusion occurs among geographically positioned agents. For ease of visualization, the model shades each region a different color. The model includes 20 nation-states and 20 internal actors, one per patch in each region. Within each region, there is one intergovernmental organization; all the nation-states in the region are members of the organization, analogous to a regional trading arrangement or governance organization such as the Organization of American States.

The model uses three "breeds" or types of agents: intergovernmental organizations (the NetLogo code uses the primitive "IGOs"), internal actors ("i_actors") and nation states ("nation_states"). The nation-states, i_actors and IGOs have star, people and circles shapes to facilitate visualization of the simulated social system. The "world" consists of one hundred nation-states and one hundred internal actors. There are five intergovernmental organizations. Each actor in the model either is committed (i=1) or not committed (i=0) to a policy: although the choice is nominal in the model, for purposes of this study the nominal choice represents the mitigation of carbon dioxide emissions. If the agent is an IGO or I_actor, the agent is committed to and prefers carbon dioxide mitigation. If a nation-state, the nation-state already has the policy. Agents that have committed to the policy will have white colors.

Internal Actors initialization

Below are the variables associated with internal actors. Internal actors are people-shaped with pink color except the ones that have adopted the policy, i.e. those with value i=1. The ones committed to the mitigation of carbon emissions are colored white.

Figure 8 Agent Types



The number of committed internal actors (i=1) is set through a user-interface slider called "person=1". The slider permits the researcher to conduct quasi-experiments that assess the effect of the number of internal actors on policy diffusion. These actors are colored white.

Each internal actor has a reelection value between 0 and 1. The reelection parameter shows whether policy makers who had adopted policy *i* were reelected. If the value is less than the value of slider "reelection=1", reelection gets a value of 1, otherwise 0. The slider permits the researcher to conduct quasi-experiments to assess the effect of the prospects for reelection on policy diffusion.

Each internal actor has a competitiveness value between 0 and 1. Competitiveness represents whether policy i is competitive. If the value is less than the slider "competitiveness=1", the competitiveness value is set at 1, otherwise 0.

Initialization of IGO actors

The variables for IGOs agents and their attributes are as follows: The initial number of IGOs committed to the policy (*i*=1) is set through a user-interface slider called "IGO=1". By allowing the initial number of committed IGO agents to vary, the ABM permits quasi-experimentation to assess the effect of initial adoption on policy diffusion.

Each IGO has nation-states as members. The nation-states that are located in the same simulated region as the IGOs are their members. If more than fifty percent of its members have value of *i*=1, the receiver nation-states gets a value of 1. At each step of the simulation run, two agents, a receiver and a sender are activated. One agent, which is the sender, sends a signal to the receiver. Based on the signal received, the receiver nation-state makes a decision on whether to adopt policy *i* or keep the status quo.

Initialization of nation-state agents

The model provides nation-state agents with several properties. The initial number of nation-states that have adopted the policy (*i*=1) is set through sliders "probability-i=1". At initialization, each nation-state agent draws a random number from a uniform distribution bounded by 0 and 1. If the drawn value is less than the probability-i=1 threshold, the nation-state agent becomes an initial adopter (i.e. its value of *i* takes a value of 1). Otherwise the nation-state is not an adopter (*i*=0). This formulation allows the ABM to conduct quasi-experiments to assess whether the number of initial-adopter nation-states affects the speed of policy diffusion.

Each nation-state has a utility value. This initial utility is set by drawing a number from a normal distribution with a mean of 2.5 and a standard deviation of 1. The benefit of the policy π to a given country i is the difference between utility of the sender (u_s) and the utility of receiver (u_r):

$$\pi_i = u_s - u_r$$

Each state has a benefit of compliance c and cost for non-compliance c' with the policy choice i. These values of the compliance and non-compliance variables are drawn from a normal distribution with a mean of 2.5 and a standard deviation of 1. This permits the model to calculate the costs of non-compliance C as:

$$C = c_r' - c_r$$

Figure 9 Competitors

The model tests whether the distribution of power in the international system affects the likelihood and speed of policy diffusion. To do so, at initialization the model distributes power among nation-states using three different distributions. The Poisson Distribution represents a hegemonic distribution: a single great power and many lesser states. The Normal Distribution represents a distribution of power more analogous to a multipolar world: many middle powers with a few large and small powers. Finally, the uniform distribution represents a perfectly multipolar world: each state has power equal to every other state. This formulation of the ABM allows the study to examine policy diffusion in different "worlds". The researcher chooses the power distribution using a chooser in the model's user interface.

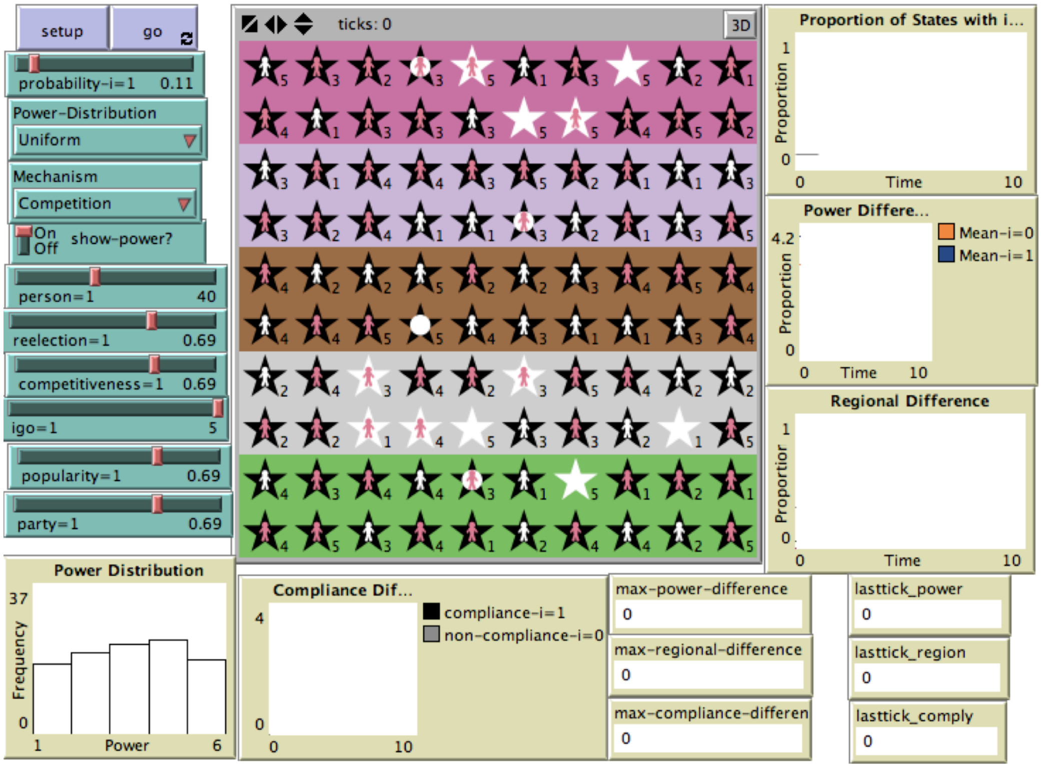
The *ruling-p* parameter represents whether the ruling party of a nation-state is a majority in the legislature and supports policy *i* (1) or not (0). For example, leftist parties are more likely to support mitigation of carbon emissions than rightist parties. This formulation allows the model to simulate domestic politics and their effect on policy adoption. At initialization, the *ruling-p* parameter draws a random value from a uniform distribution bounded by zero and 1. If the random value is less than a threshold value set by the party=1 slider, the nation-state gets a value of 1, otherwise it takes the value of 0.

Each nation state has five competitors. The competitors are selected randomly at initialization. If more than fifty percent of their competitors have adopted the policy (that is, i=1), the receiver nation-state adopts the policy.

AGENTS' INITIALIZATION

All the agents have a dependence value, which is drawn randomly from a normal distribution with a mean of 2.5 and a standard deviation of 1. The literature shows that powerful countries and multilateral organizations shape policies of countries that are structurally dependent on them. The dependence parameter examines the effect of how countries' dependence affects their policy choices.

Figure 10 Initialization



At initialization, the model assigns to each agent a "popularity". Each agent draws a random number from a uniform distribution bounded by zero and 1, and compares the draw to a threshold set by a model slider labeled "popularity=1". If the randomly drawn value is less than the slider "popularity=1", the agent receives a popularity value of 1; otherwise it receives a value of 0. Some policies receive greater public support than others. This parameter examines how popularity of a policy among general public affect its adoption.

MODEL EXECUTION: TO ACTIVATE A DYAD

To enact communication between agents, at run time the ABM will choose a dyad of agents, one a sender of its policy choice and the other a receiver. The runtime procedure proceeds as follows. One of the patches will set its color red and one of the agents will set its color green, yellow or sky blue. The nation-state in the red color patch will become a receiver and one of the other color agents will become a sender. If the color of the patch is sky blue, a nation-state will be the sender. If there is an IGO on the patch, it will turn green and the IGO will be the sender. If the color of patch is yellow, a domestic actor (i_actor) is the sender of the signal.

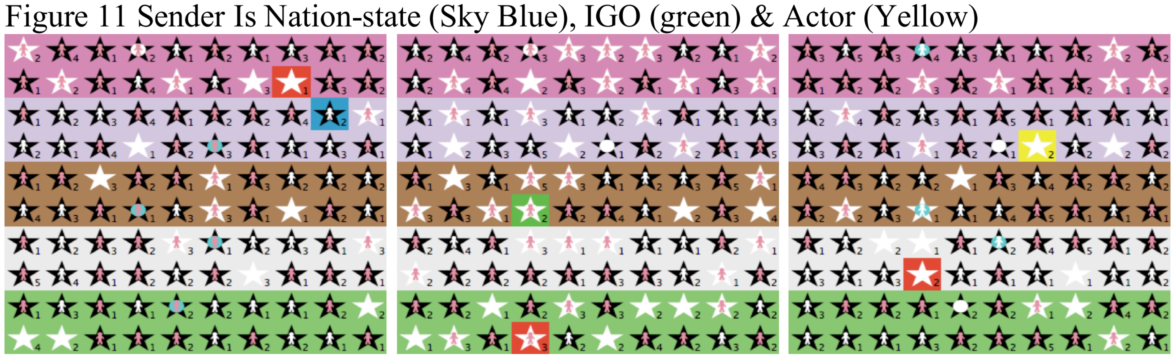
FACTORS THAT AFFECT THE RATE AT WHICH DIFFUSION OCCURS

The agent-based model incorporates algorithms that simulate the four mechanisms of policy diffusion: coercion, competition, emulation, and learning.

Variables for the Coercion Mechanism

Adopting Ring's (2014) model, the ABM in this study test for three different distributions of power. The power distributions (Poisson, Uniform, Normal) represent hypothetical assumptions about hierarchy in the global system. In the Poisson distribution, there are many

Figure 11 Sender Is Nation-state (Sky Blue), IGO (green) & Actor (Yellow)



more weak actors than there are strong actors. This distribution indicates a high level of inequality in the global system. There are a few powerful actors, some middle level and a large number of weak actors. In the uniformly distributed global system, the assumption is that all states have equal levels of power. The third assumption is that there are more middle-level actors with a few powerful and a few weak actors. This type of distribution is represented by the normal distribution. While some distributions might be more realistic than others, this implementation allows for testing whether the model's findings are robust to various assumptions about the power distribution in the international system.

In the ABM, coercion is a top-down approach in which powerful actors affect the policy preferences of weaker actors. By contrast, competition, learning and emulation are bottom-up approaches. For this reason, one would expect policy diffusion by coercion to occur more quickly in a Poisson (hegemonic) world than in the normal or uniform distributions of power.

$$H_s > H_R \Rightarrow \text{"top-down"}$$

$$Hs - H_R \leq 1 \Rightarrow \text{"bottom up"}$$

International organizations and national governments in a federal system may use coercive strategies through grants and aid requirements; pre-emptive laws; sanctions; or military force (Graham, et al. 2013). Membership in similar regional or multilateral organizations, preferential trade agreements (PTAs), and military alliances can be used to examine their effect on policy outcomes when coercion is involved. To test for the use of carrots and sticks as tools of policy change, the study uses "costs" of compliance and non-compliance. "[S]tudies linking policy diffusion to soft coercion should show that the policy ideas actively promoted by strong countries are more likely to be put into practice in weaker countries structurally or situationally dependent on them" (Simmons, Dobbin, and Garrett 2006, 791). The dependency variable

1. Power distribution (Poisson, Uniform, Normal) pick one
2. Dependence (random-normal 2.5 1)
3. dependency = dependence-s – dependence-r
4. Compliance (random-normal 2.5 1)
5. non-compliance (random-normal 2.5 1)
6. cost = non-compliance-r – compliance-r
7. popularity=1 (slider 0 1)
8. popularity: (random-float 0 1) if greater than popularity=1, get value of 1 otherwise 0
9. popularity-iactor : sender is i-actor with popularity=1

examines the effect of how strong states promote policy ideas in weaker countries that are structurally or situationally dependent on them.

The model also examines the role of domestic actors in the shaping of nation-states' policy choices:

> The preferences of policy makers may be based on individual opinions and experiences or may be induced by the desires of the electorate, interest groups or others. Such preferences often affect the range of policy choices that policy makers consider, and therefore preferences influence the likelihood of any particular policy spreading from one government to the next. (Graham, etal 2013, p.685)

The model also examines the role of domestic actors in the shaping of nation-states' policy choices. In this study, the variable *i* represents the preferences of policy makers and intergovernmental organization. The popularity-iactor variable simulates whether a policy is more popular than a threshold among internal actors, who may influence the policy makers to change the policy.

Variables for the Competition Mechanism

To simulate mechanisms of competition, the ABM uses operational measures derived from previous empirical studies of competition and policy diffusion. The literature provides various measures of competition, most of which derive from trade relationships among nation-states. Stadelmann and Castro (2014) use membership in a common economic and regional block, trade openness, and countries with similar economic structure as proxies for competition. Baccini, Lenzi, and Thurner (2013) define competitors as a state's main trade partners. Prakash and Potoski (2006) use a state's main export market or partner(s) to identify a nation-state's competitors. Saikawa (2013) suggests that adoption by an importing country puts pressure on the exporting country to adopt the policy as well. Adoption by the exporting country gives it a competitive advantage. "Simmons and Elkins (2004) found that a country is more likely to liberalize its international economic policies following similar reform among its competitors, defined as countries with which it shares similar trade relationships" (Gilardi 2016, p.10). Policies diffuse from external actors to internal actors when they are competitors or trading partners (Berry and Berry 2007). In addition, in the competition mechanism the most important relationships among actors are horizontal rather than vertical (Simmons, Dobbin, and Garrett 2006). External and internal actors who compete are more likely to have similar economic structures (Stadelmann and Castro 2014). Hierarchy examines the similarity of countries' economic structure. This study's ABM defines a nation-state's competitors as its trade partners.

The trade partners are chosen randomly at initialization of the simulation. At run time, the model does not explicitly model a trading relationship; rather, by treating actual processes of trade as exogenous to the model, the ABM allows the researcher to focus on the *fact* of an interdependent relationship rather than volumes of trade. This allows it to test how the behavior of a country's trade partners affect its policy adoption.

Variables for the Emulation Mechanism

As Gilardi (2016) argues, intergovernmental organizations facilitate policy diffusion through the socialization of its members—that is, through the construction of regulative norms that identify "proper" behavior and roles for nation-states. The difference from the coercion mechanism is that intergovernmental organizations' socialization does not influence its members through material incentives or sanctions. For example, Stadelmann and Castro (2014) argue that the international climate regime and the emission targets of transition countries under the Kyoto Protocol are not strict enough to force countries into action. In this study's implementation, joint membership in a multilateral organizations will be used as a proxy to examine policy diffusion through socialization. In the emulation mechanism, as go-betweens international organization can facilitate socialization by establishing information facilities, organizing conferences and recommending best practices (Graham, Shipan, and Volden 2013). NGOs, policy professionals, and academics among others can influence governments to adopt policies (Simmons, Dobbin, and Garrett 2006).

MacGarvie (2005) uses geographic proximity as a proxy for communication barriers between two countries, and measures the distance between the capitals of two countries. In this study's ABM, geographic proximity, which reduces communication and cultural barriers, is used

1. neighbors: nation states in the same region
2. party=1 (slider 0 1)*
3. ruling-p (random-float 1) if less than slider “party=1”, gets value of 1 otherwise 0. Policy makers’ preferences are based on desire of policy advocates.
4. p-r: receiver with ruling-p = 1
5. my-members : igos members are nation states in the same region as the igo
6. member_i : mean (i) of igo members (my-members)
7. mem_i : sender igo with more than 50 percent of its members with (i)

to measures similarities among actors or nation-states. Those in closer geographic proximity communicate and socialize more often.

Variables for the Learning Mechanism

Policy makers learn from earlier adopters about the consequences, benefits and costs of policy adoption. The policy consequence is the success of the policy elsewhere. Berry and Berry (2007) argue that states emulate each other because they learn from each other; they adopt policies they perceive as successful elsewhere. One political consequence is reelection to office. Policy makers imitate a policy if elsewhere voters reelected those who enacted the policy (Gilardi 2010). Assuming it is a democracy, electorates influence policy makers’ preferences through elections. In the simulation, every adopter is given a binary variable of reelected/not reelected. In the model, “learning” occurs when a receiver checks two variables of a sender: whether or not it adopted the policy, and whether or not its reelection value is 1. A receiver is more likely to adopt (“learn”) if both of the sender’s variables are equal to 1

1. utility (random-normal 2.5 1)
2. reelection=1 (slider 0 1)*
3. reelection (random-float 1) if greater than "reelection=1" slider, reelection gets value of 1 (reelection of those who adopted the policy earlier) otherwise 0.
4. reelection-s: sender is an i-actor with reelection=1 and i=1

INTERACTION

One advantage of agent-based modeling is that the researcher can use quasi-experimental techniques to measure interactive effects among model parameters. That is, by explicitly manipulating parameter values, the ABM researcher can determine whether parameter interactions enhance, mitigate, or have no effect on the systemic behavior of interest. This study tests for the following interactions effects.

The Coercion Mechanism

As in the real world, in the model nation-states exercise coercion through both power differentials and asymmetric interdependence. When the sender is a nation-state that has adopted the policy (that is, with *i*=1), the receiver will also adopt the policy (set its *i*-value to 1) if two conditions are satisfied: the sender has power greater than the power of receiver (hierarchy > 0), and dependence of receiver is greater than the dependence of sender (dependency > 0). Actors other than states can also use coercive mechanisms. When the sender is an IGO that has adopted the policy, the receiver will set its *i*-value to 1 if the cost of non-compliance is greater than or equal to the compliance cost (cost >= 0). Finally, when the sender is an i-actor with *i*=1 (*i*=1 illustrates that the internal actor's policy choice is i) and its popularity is greater than the threshold popularity=1, the receiver will set is *i*-value to 1. The popularity=1 is a slider in the interface and its value is set before running the model.

The Competition Mechanism

"Competition" among agents in the model reflects both differences in relative power and the policy choices of competing states. When the sender is a nation-state with *i*=1, hierarchy <= 1 and fifty percent or more of the receiver's competitors have i=1, the receiver will set its *i*-value to 1. The competitors have symmetric power. Their power relation is horizontal rather than vertical.

When the sender is an i-actor with *i*=1 and competitiveness has a value less than the threshold (competitiveness = 1), the receiver will adopt the policy (that is, set its *i*-value to 1). Competitiveness represents that this policy *i* is competitive relative to other policies. For example, currently because of low prices of conventional energy prices, the renewables can not compete with conventional energy.

The Emulation Mechanism

When the sender is a nation-state with *i*=1, hierarchy <= 1 and the receiver and sender are in the same region, the receiver will set its *i* value to 1. The sender and receivers have relatively equal power. There is not large power difference between them.

When the sender is an IGO with *i*=1 and fifty percent or more of IGO members adopted the policy, the receiver will set its *i* value to 1. The receiver will adopt the policy if fifty percent or more of the members of the organization it is member to adopted the policy.

Table 10 Interaction Rules

		Mechanism of Diffusion			
		Coercion	Competition	Emulation	Learning
Signaler is. . .	State	i = 1 hierarchy > 0 Dependence-r >dependence-s	i = 1 hierarchy <= abs 1 compet_i >= 0.5	i = 1 hierarchy <= abs 1 Ns=Nr	i = 1 benefit >0 hierarchy <= abs 1
	IGO	(i = 1 noncompliance-r >=compliance cost-r		i =1 mem_i = 1	i =1
	Internal Actor	i = 1 popularity =1	i = 1 competitiveness =1	i= 1 ruling-r =1	i= 1 reelection-s = 1

When the sender is an *i*-actor with *i*=1 and the ruling-p has a value of 1 (less than the threshold party=1) the receiver will set its *i* value to 1. The ruling-p parameter gets a value a binary value of 0 or 1. When the ruling party has a majority in the parliament and supports policy i, it gets a value of 1. If the ruling party does not have a majority in the parliament it gets a value of 0. When ruling party has control of legislature of a nation-state, it can adopt its policy choice easier than when ruling party is not a majority.

The Learning Mechanism

The adopting nation-state is seeking for a solution to its policy problem. It looks at others' policy choices actively for a successful policy. When the sender is an adopter nation-state, hierarchy <= 1 and the utility of the sender is greater than or equal to the utility of receiver (benefit >= 0) the receiver will set its *i* value to 1. If policy *i* increases the utility of the receiver, the receiver will adopt policy *i*.

When the sender is an IGO with *i*=1, the receiver will set its *i* value to 1. IGO's preferred policy choice is *i*, the receiver nation-state learns about the policy *i* through information provided by the IGO.

Nation-states learn not only about the policy consequences, but also about the political consequences of a policy. The policy makers look at how policy adoption affected the reelection of policy makers in other nation-states. When they see that policy adoption did not cost them their office, they become more confident about the political consequence of the policy adoption. When the sender is an *i*-actor with *i*=1 and the reelection of sender has a value of 1, the receiver will set is *i* value to 1.

PLOTS

The results of one simulation run are presented in figures four through eight. For this simulation, the model parameters were arbitrarily set at probability-i=1 (0.11); person=1 (40); reelection=1 (0.69); competitiveness=1 (0.69); IGO=1 (5); popularity=1 (0.69); party=1 (0.69); and power distribution = Poisson. The plot titled "Proportion of States with i=1" shows the percent of nation-states with policy *i* at each time tick. The multiple lines in figure 9 "Regional Difference" shows the percent of nation-states in each region with policy *i*. Figure 10 "Power Difference" illustrates the average power of nation-states with and without policy *i*. Figure 11 "Compliance Difference" shows the mean compliance of nation states with policy *i* and mean non-compliance of nation-states without policy *i*.

Figure 12 Non-Convergence the Receiver Nation-state (Red Patch) Not Turning White

Figure 13 Convergence: The Receiver Nation-state (Red Patch) Turned White

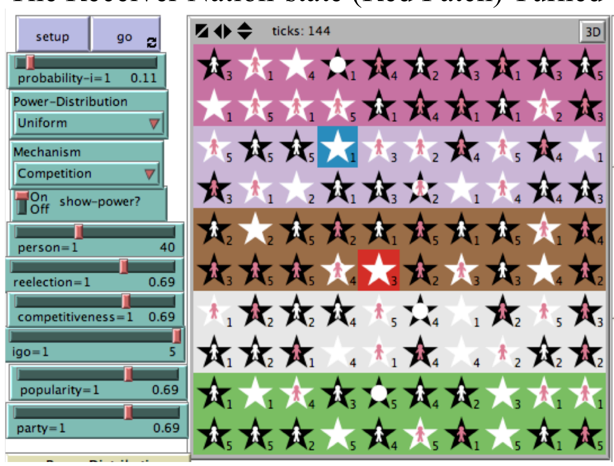


Figure 14 Left to Right Emulation, Learning & Competition

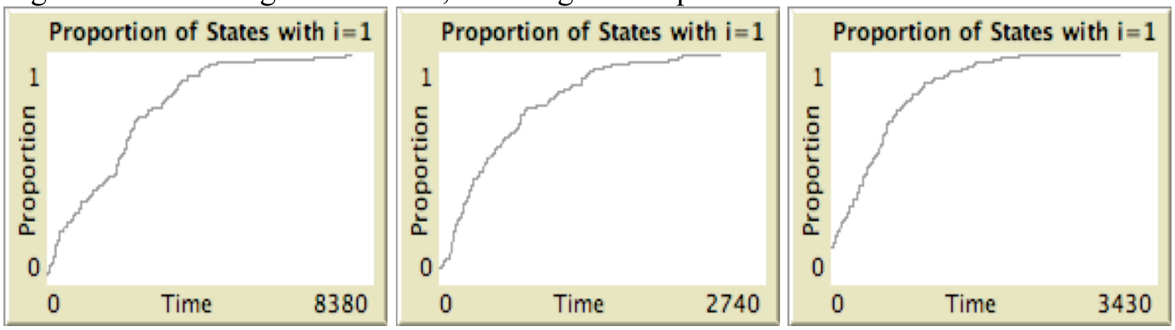


Figure 15 Coercion: Poisson, Uniform, Normal

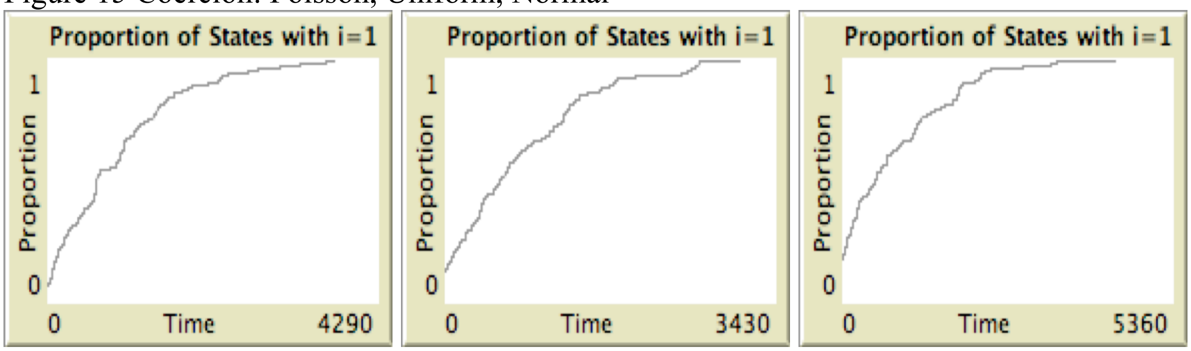


Figure 16 Competition Normal, Uniform, Poisson

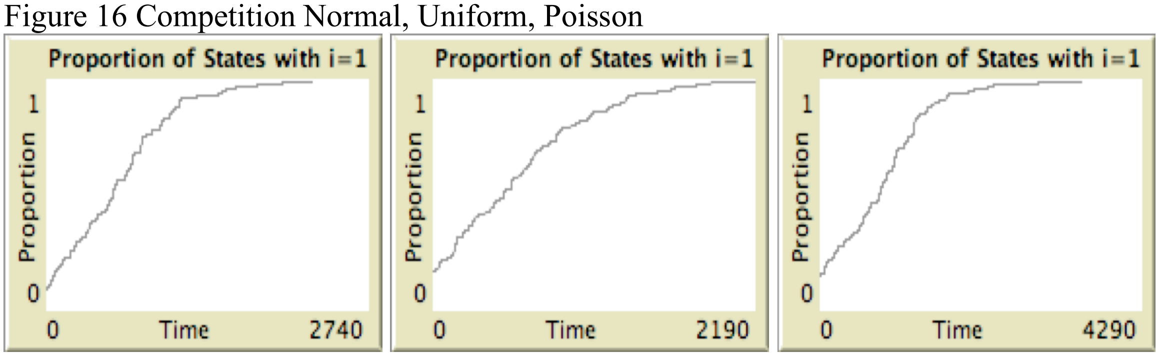


Figure 17 Emulation, Normal, Uniform, Poisson

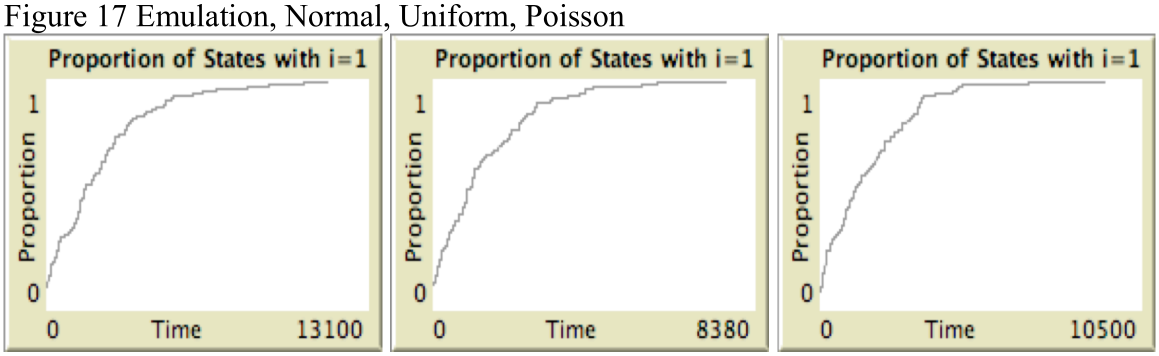


Figure 18 Learning Normal, Uniform, Poisson

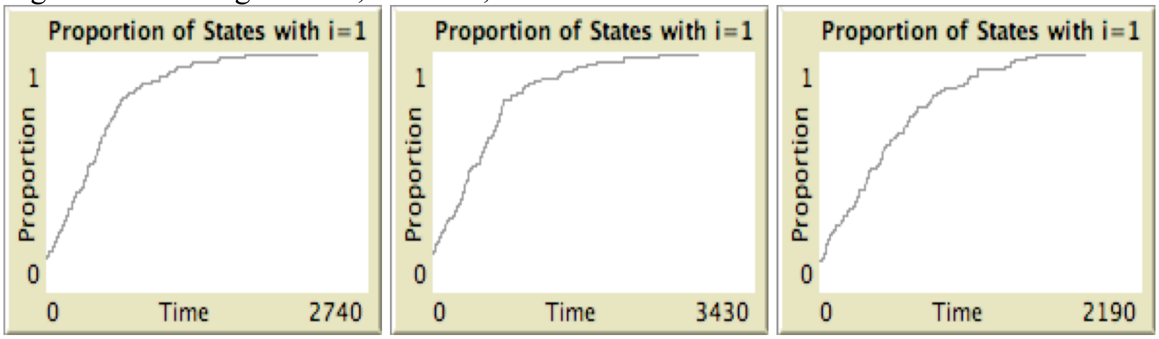


Figure 19 Learning Poisson Regional Difference

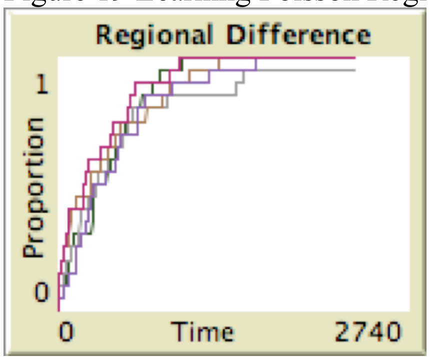


Figure 20 Learning Poisson Power Difference

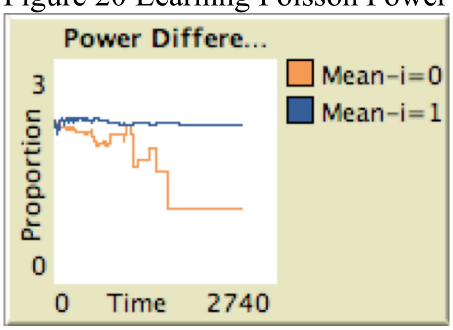
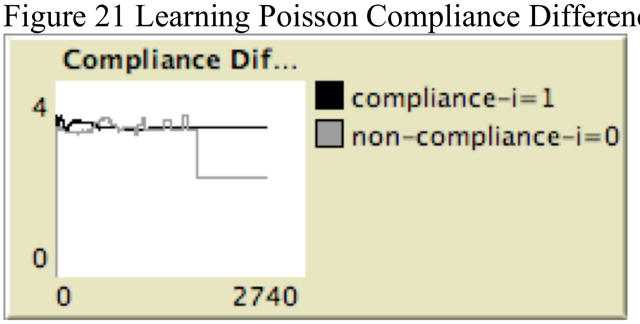


Figure 21 Learning Poisson Compliance Difference



TYPICAL RUN FOR EACH MECHANISM

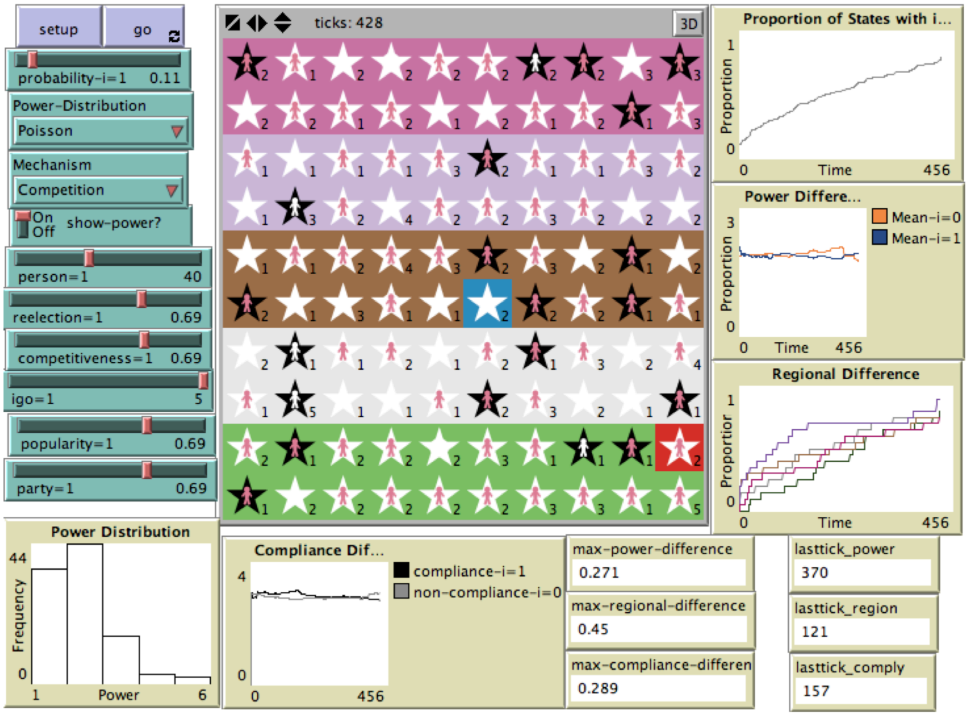
For an initial evaluation of the model, I ran the simulation for each hypothesized mechanism of diffusion, allowing the simulations to run until all nation-states had adopted the policy (i.e. full diffusion was complete). The following four figures show a typical run for each mechanism. The simulations use the same main parameters and the parameters specific to each mechanism as specified in the previous section. For the simulation of the competition mechanism, the simulated community of states converge on full policy adoption. Competition has a typical S-curve. Hence the process is not linear. The early stages of diffusion are slow and in the end stages there are a few holdouts who take a while to adopt. The regional differences are small. The maximum regional difference of the proportion of nation states with and without the policy is 35 percent. There is a 35 percent difference between the region with the highest and that with the lowest number of adopters. That difference is in the earlier steps of the run. The maximum power difference of nation-states with and without *i* is close to equal. The highest difference is 0.125. The maximum compliance cost difference of adopters and non-adopters is 0.67. Mostly the compliance cost for adopters and non-adopters is close to equal. This difference is in the second quarter of the run time.

For emulation, there is full diffusion of the policy. The rate of adoption in the later steps of the run time becomes very flat. In the later stages of diffusion, there are a few holdouts that take a long time before full diffusion. For the emulation mechanism, full diffusion of the policy takes longer than competition and coercion, but it approximates the time to full diffusion for the learning mechanism. The maximum power difference is one, which is close to the end of second quarter of simulation run time. The maximum difference in compliance costs is 0.79. The difference in compliance is calculated subtracting the mean compliance cost of nation-states with *i* from mean non-compliance cost of nation-states without *i*. The compliance cost ranges from 1 to 5. In a simulation run when this difference is the highest, that value is recorded. The maximum regional difference of proportion of nation-state with and without *i* is 0.45, which is in the earlier steps of simulation run. It suggests that in the emulation mechanism a policy first diffuses within regions before diffusing across regions.

For the coercion mechanism, there is full diffusion of the policy. The maximum power difference is 0.43. This difference is a relatively small value. Maximum power difference is calculated subtracting mean power value of countries without i from mean power value of countries with i. When this value is the highest in a simulation run, it is recorded. Power value ranges from 1 to 5. The proportion of nation states with *i* in each region is approximately equal except in the earlier stage of the process. The maximum regional difference of states with and without *i* is 0.35, which is in the earlier stages of the run. In the simulation of the coercion mechanism, policies diffuse within regions in the earlier stages of the process. The maximum difference in compliance and non-compliance costs is 0.40.

For the learning mechanism, there is full diffusion of the policy. Under this mechanism, the simulation takes longer to converge on full policy diffusion than under either coercion and

Figure 22 Competition Mechanism. Top to Bottom Run Time 428, 561, 792



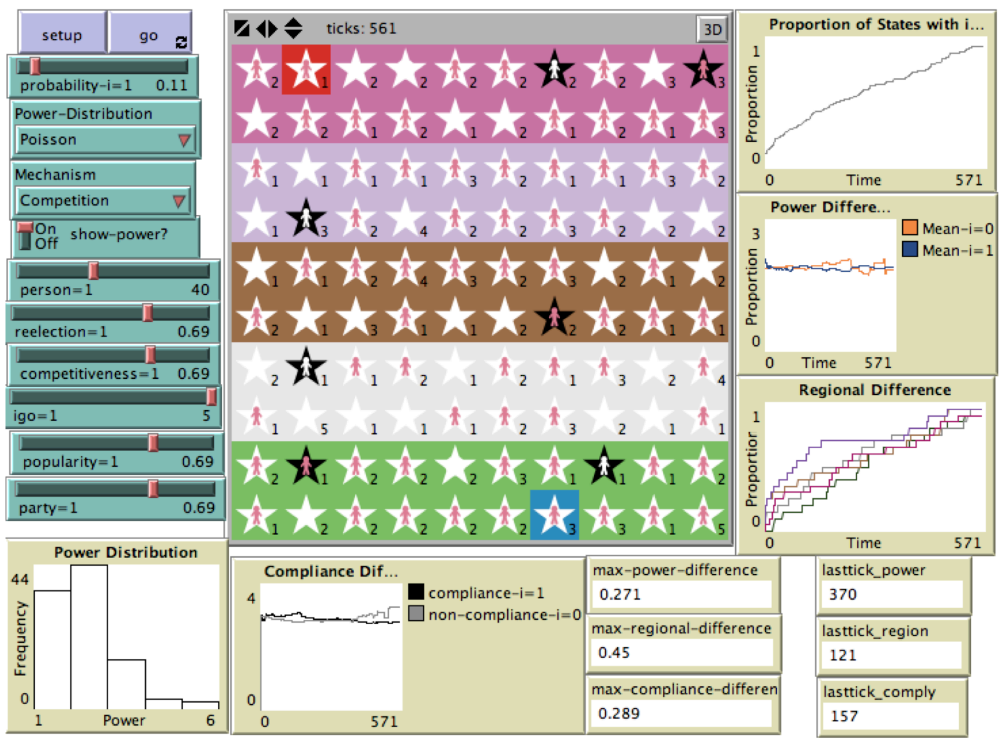
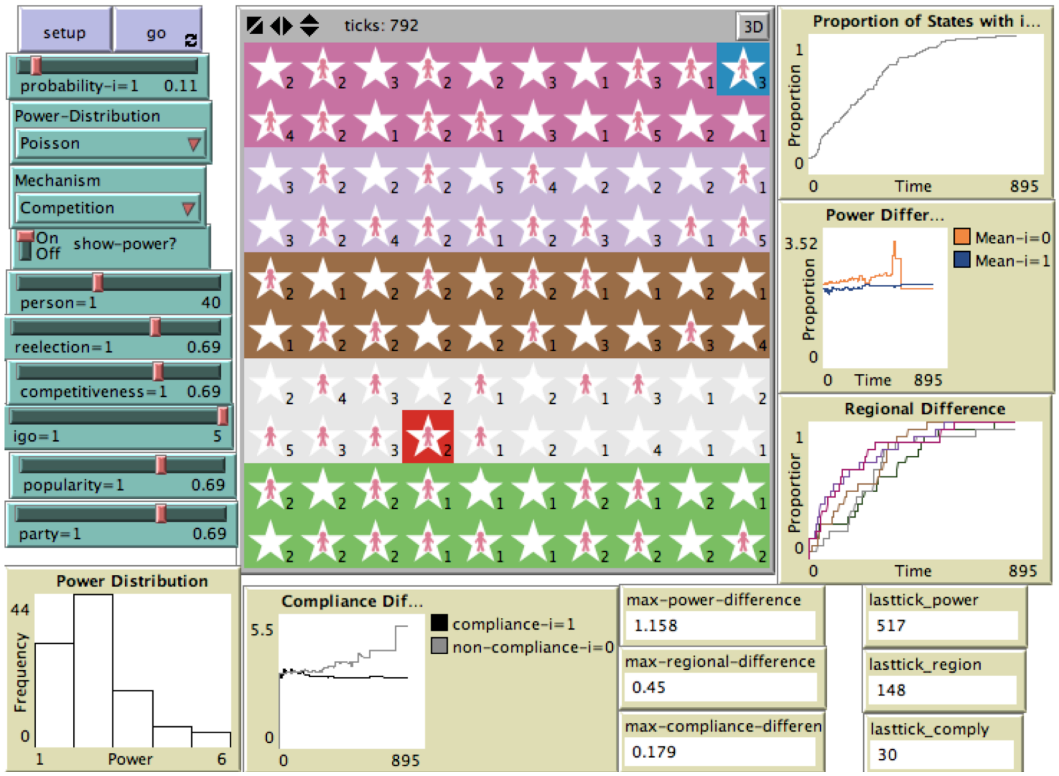


Figure 22 Continued



competition mechanisms. The maximum power difference is approximately equal. The maximum regional differences of the proportion of states with *i* is 0.40, which is in the earlier steps of the run. Diffusion through learning occurs within regions before it occurs between regions. The maximum compliance difference is also small. It happens at earlier steps of the run.

Figure 23 Emulation Mechanism. Top to Bottom Run Time 260, 792, 2594

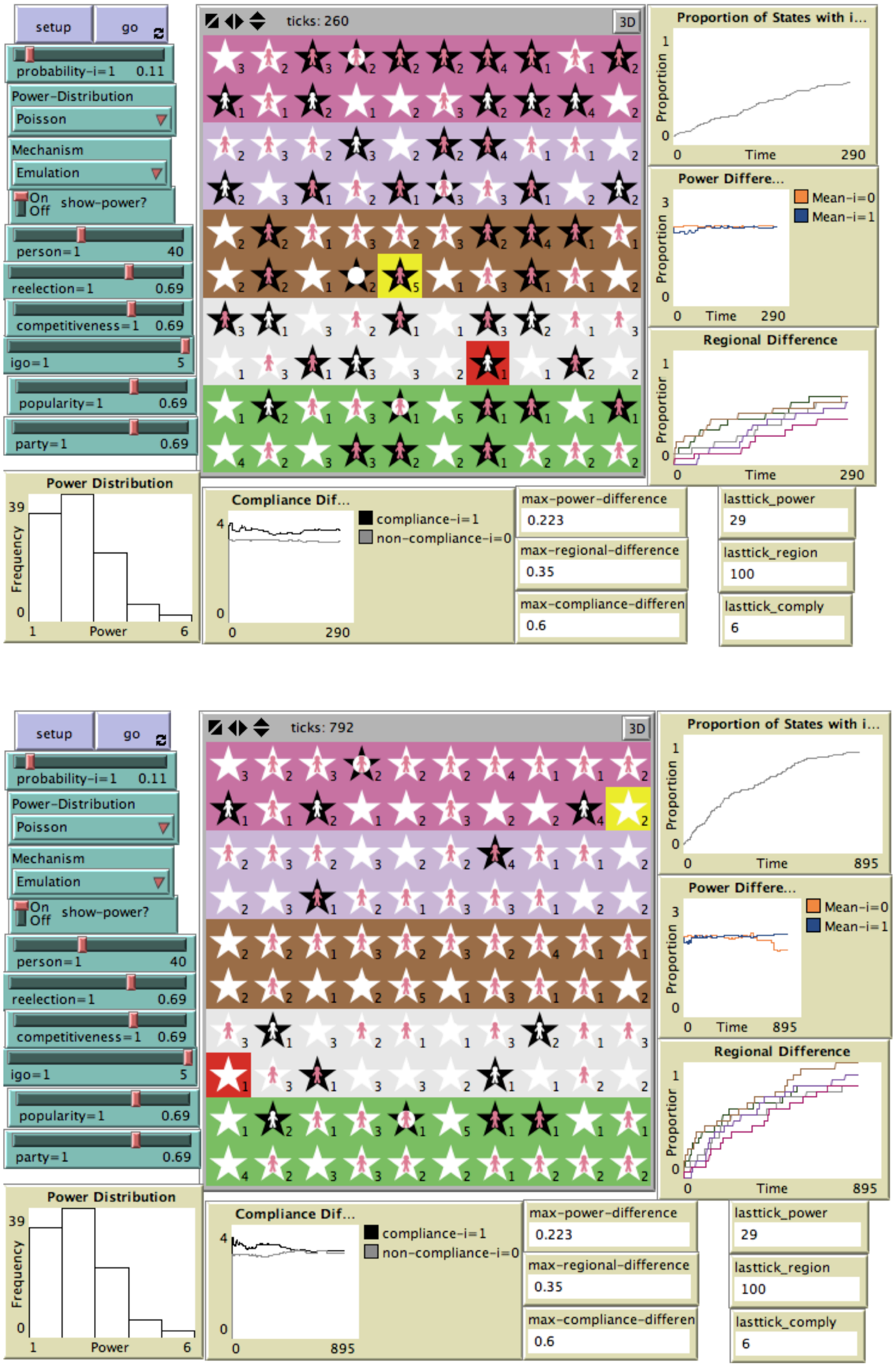


Figure 23 Continued

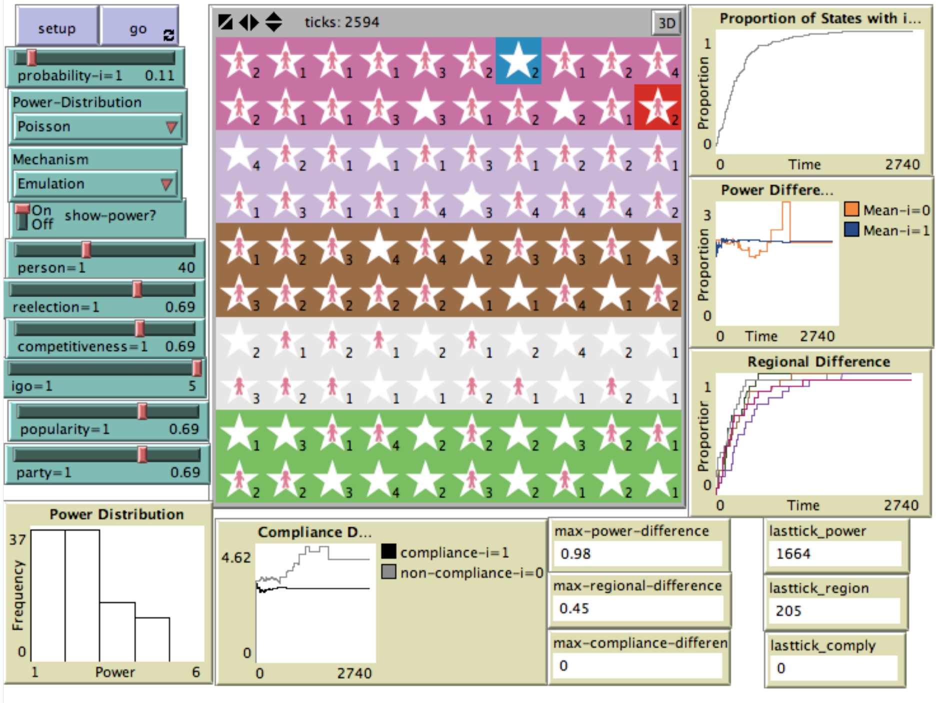


Figure 24 Coercion Mechanism Top to Bottom Run Time 313, 587, 1445

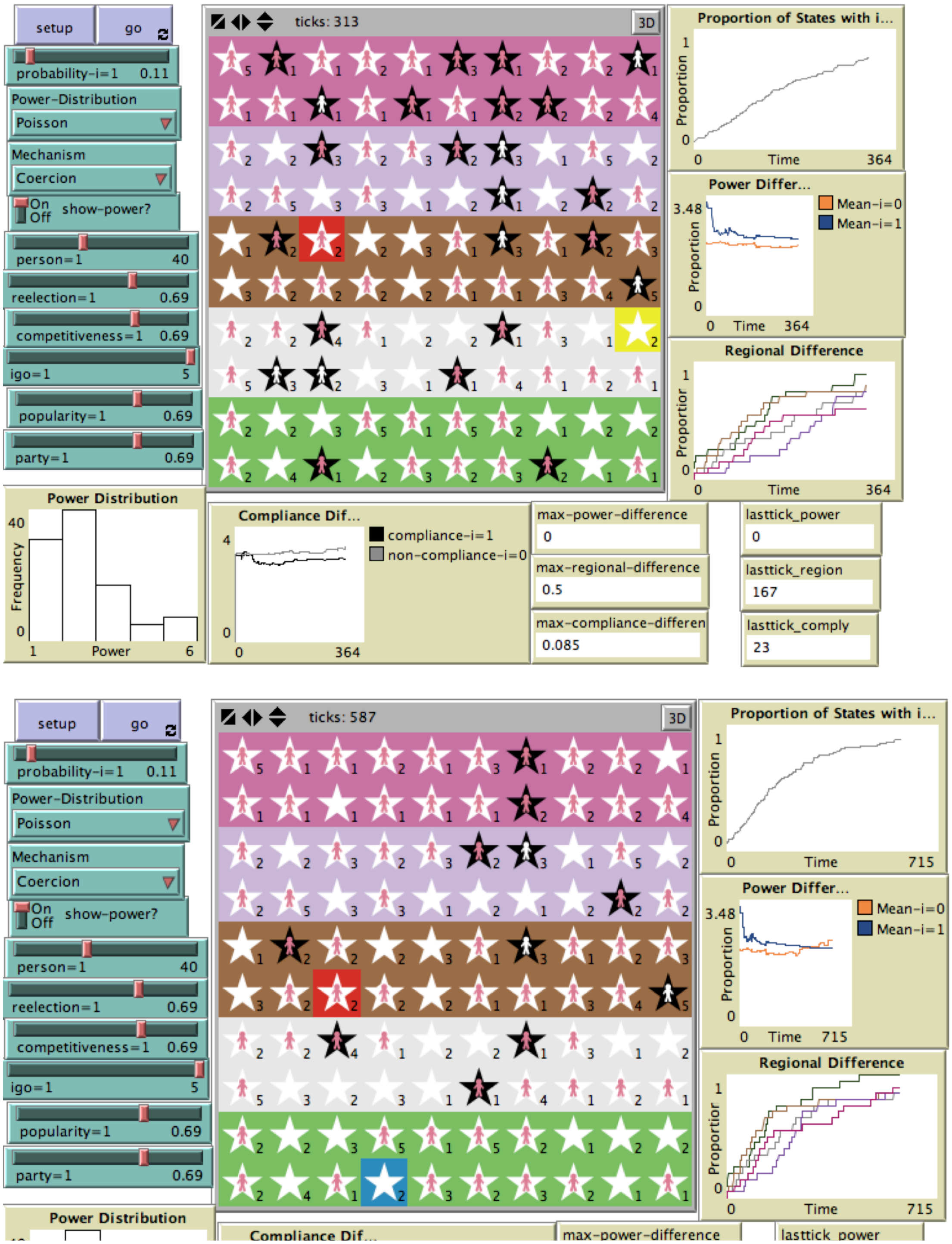


Figure 24 Continued

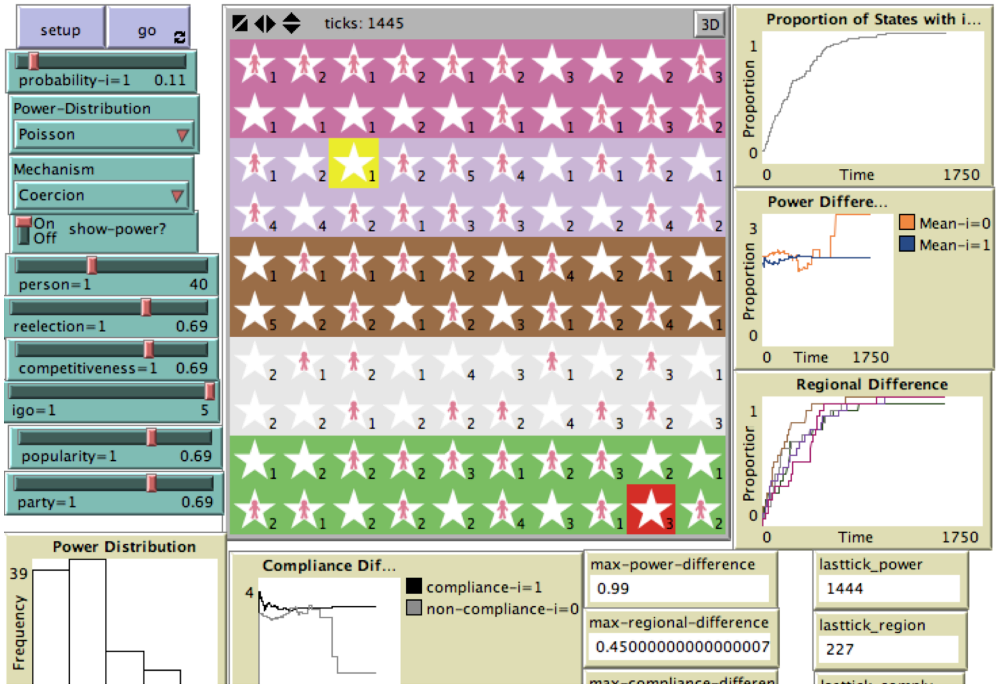
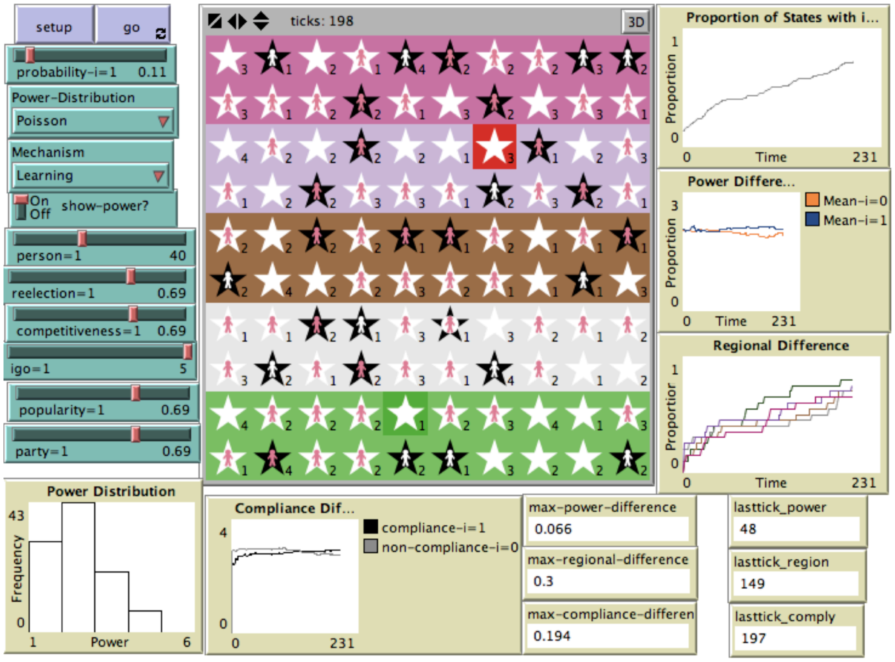


Figure 25 Learning Mechanism Top to Bottom Run Time 198, 394, 1086



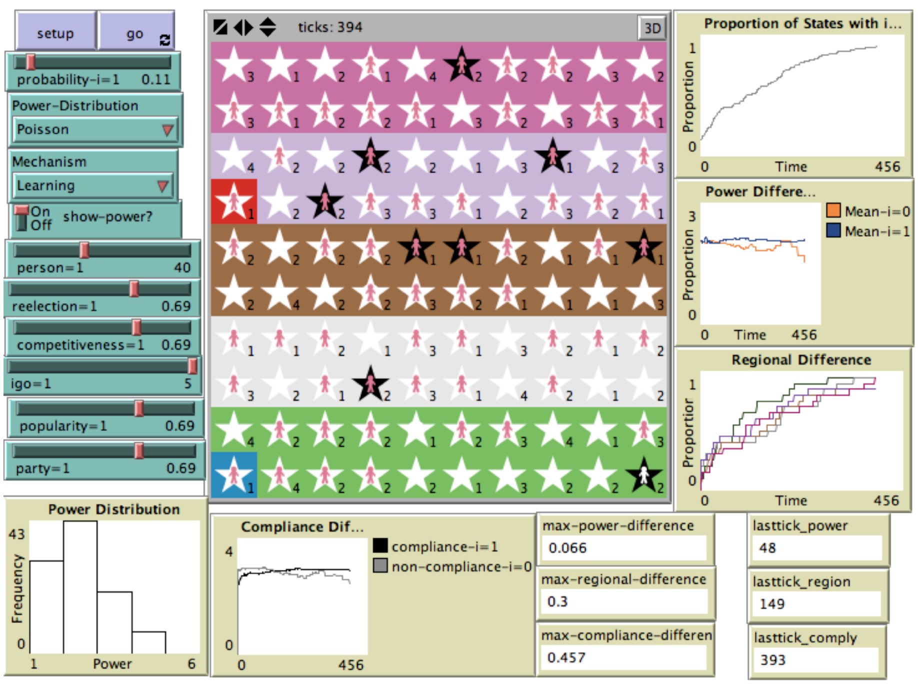
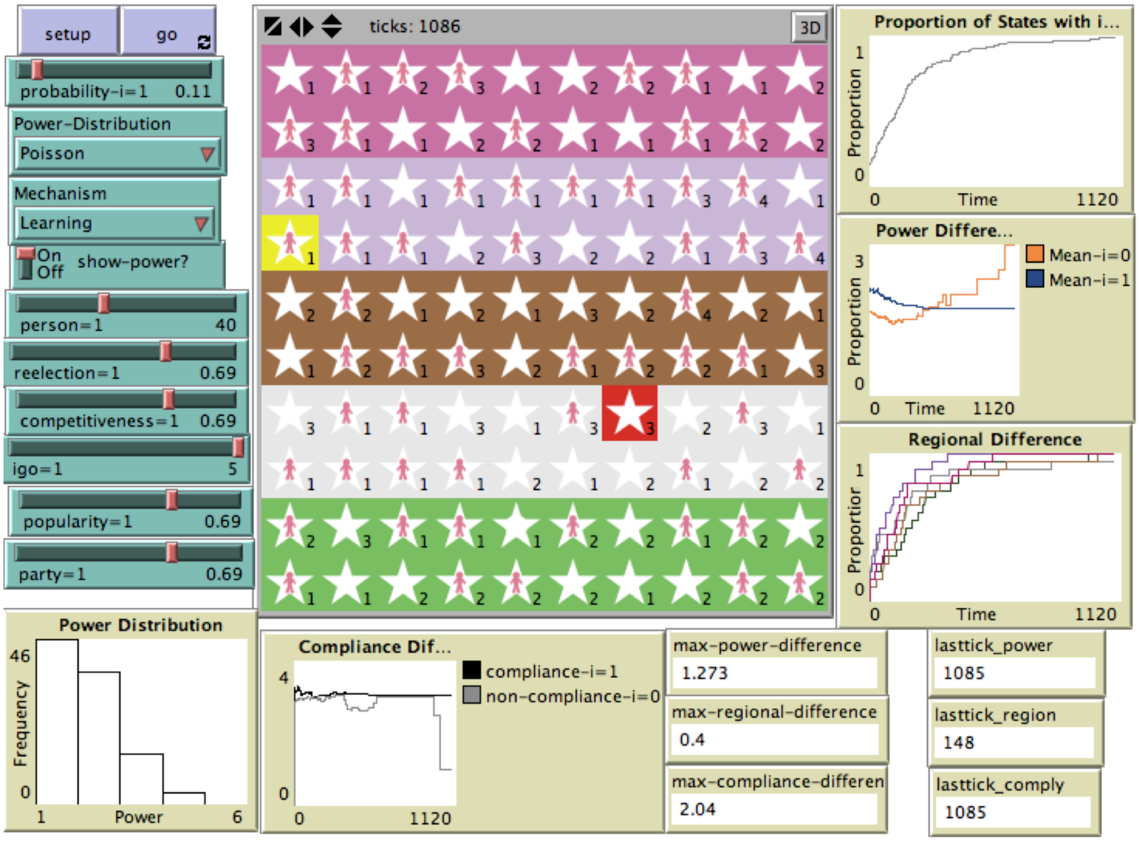


Figure 25 Continued



STATISTICAL ANALYSIS OF SIMULATED DATA

To examine the effect of each factor on the diffusion of policies, each diffusion mechanism is simulated 100 times. For each run, the experiment measured seven dimensions of the emergence of policy diffusion:

1. the time until full diffusion as measured by the number of steps in the run;
2. the largest power difference between states within a run;
3. the largest difference between regions in the proportion of adopters;
4. the largest difference in compliance and noncompliance costs within a run;
5. the last step at which the power difference was greater or less than zero;
6. the last step at which the difference in compliance-noncompliance costs was greater than or less than zero; and
7. the last step at which regional differences are greater or less than zero.

The maximum power difference is the maximum average power difference between adopter and non-adopter nation-states in each simulation run. The maximum compliance difference is the maximum difference of average compliance of adopter and non-adopter nation states. The maximum regional difference is the maximum difference among regions in the proportion of adopter to total nation-states in the region in each simulation run. “Last tick power” is the last step in simulated time at which occurs the maximum average power difference between adopter and non-adopter nation-states. “Last tick comply” is the last step in time at which occurs the maximum average compliance difference between adopter and non-adopter nation states. “Last tick region” is the last step in time at which occurs the maximum difference among regions in the difference in proportion of adopter nation-states.

The results of these 400 simulation runs are compiled into a dataset. The unit of observation is simulated step in time, for a total n = 19,179. The data is used to run regression tests that examine the partial effects of model parameters on the seven measures of policy convergence listed above. The parameters of theoretical interest are the initial probability of adoption (probability-i=1); the four diffusion mechanisms (learning, emulation, coercion and competition); the number of initial internal actors (person=1); the distribution of power among nation-states (Poisson, uniform, normal); and the initial number of IGOs committed to the policy (IGO=1). The analysis specifies a full regression that includes all model parameters, as well as several more parsimonious specifications that include only a subset of the estimators. By comparing the full and parsimonious specifications, one can examine the consistency of the estimates. Such consistency would suggest that the theoretical findings are insensitive to choices of model specification, thus increasing our confidence in the inferences we draw. Tables 29-35 present the results of the regression analysis.

The number of initial adopters; the four diffusion mechanisms; the number of internal actors; the number of initial IGOs; and the distribution of power all consistently affect the rate of time to full adoption. The variable "probability–i=1" is significant in all five specifications with a consistent, negative sign. The negative coefficient implies that this parameter reduces the time to policy adoption; as expected, the more initial adopters of the policy, the faster the diffusion of the policy will be. The variable "local actor" is statistically significant in three of the specifications with a consistent negative sign. As expected, as the number of people committed to carbon mitigation increases, the time to full policy diffusion decreases. The number of initial IGOs supporting adoption is statistically significant in three of the specifications with consistent negative sign. As expected, as the number of IGOs committed to carbon mitigation increases, the time to full adoption decreases.

Interestingly, the adoption rate is faster in a Poisson distribution of power than in a state system characterized by the normal distribution. The adoption rate expedites with a few large powers compared to a system with more middle powers and fewer weaker and stronger states. In a uniform system, the rate of adoption is lower than a system with normal distribution of power. This is an interesting finding: whereas a uniformity of state power may create a “balance” of strategic stability, the ABM suggests that in such a world policy diffusion will occur more slowly.

In the simulations that use the learning and competition mechanisms, the rate of adoption is faster than in those that use the coercion mechanism. Conversely, adoption takes longer through emulation than coercion. These results suggest that learning and competition are more effective mechanisms of policy diffusion than is coercion, ceteris paribus.

Because three parameters—of the number of the initial adopters, the number of internal actors, and the number of IGOs—are all measured on a scale of 0 to 1, one can directly compare the magnitude of each parameter’s effects. The magnitude of effect of number of initial state adopters is the highest on rate of adoption. The IGO parameter has a higher magnitude of effect than the person variable. Interestingly, while IGO has a statistically significant effect on the rate of adoption in when learning or emulation is the mechanisms of diffusion, it shows no such effect on the rate of adoption when competition or coercion is the mechanism.

Unsurprisingly, the initial distribution of power among nation-states influences the maximum power difference between adopters and non-adopters. As table 12 illustrates, the initial Poisson distribution is statistically significant in four of the regression specifications with a consistently positive sign, indicating a larger emergent power difference on average. The uniform distribution of power is significant in all five of the specifications with a consistently positive direction of effect. For the maximum power difference dependent variable, the initial probability of adoption (probability-i=1) is only significant in the coercion specification. The person and IGO parameters are not significant in any of the specifications, suggesting perhaps unsurprisingly that these parameter have no effect of the emergent power differences between adopters and non-adopters. Interestingly, learning, emulation and competition each have a significantly positive effect on the maximum power distribution. The reelection, competitiveness and party parameters are statistically significant and have a positive effect on maximum power difference. An increase in the number of reelection of policy makers who had adopted the policies increases the probability of power difference. An increase in the number of the ruling parties that support policy *i*, increases the power difference. An increase in the popularity of policy *i* has negative effect on maximum power difference. An increase in the popularity of policy *i* among internal actors increases the probability of power differences. An increase in the competitiveness of policy *i* increases the likelihood of power difference.

As shown in Table 13, for the maximum difference among regions in the proportion of adopters, the probability of initial adoption is significant in all five of the specifications with consistent positive direction of effect. This is a bit surprising because the probability of initial adoption is the same for all regions at the time of initiation. The Poisson, uniform and IGO parameters are significant only in one of the specifications. The party parameter is significant in the simulations of the emulation mechanism with a negative direction of effect. Only emulation is significant with a positive effect. Popularity, reelection, and competitiveness show no meaningful effect on the emergent regional differences in the proportion of states adopting the policy.

Table 14 shows that for the measure of the size of differences in compliance costs, the probability of initial adoption (probability-i) is significant in two of the regression specifications: the parsimonious specification of only the coercion mechanisms (column 3 i) and the full specification. In both specifications, the direction of effect is negative, suggesting the greater probability of initial adoption reduces the differences in compliance costs. The IGO variable is significant in only one specification, but in a surprising way: in the specification of the coercion mechanism, the IGO variable has a positive direction of effect, suggesting that the greater the number of IGOs supporting a policy, the greater the emergent differences in compliance costs. Learning, emulation, competition and popularity are statistically significant with a negative direction of effect, contributing to a reduction in differences in compliance costs. Reelection, competitiveness, party, person, Poisson, and uniform show no significant effects in any of the specifications.

Table 16 illustrates that for the dependent variable that measures the last step at which the power difference is greater or less than zero, the probability of initial adoption (probability-i) is statistically significant in all five specifications with consistent negative direction of effect. This suggests that along with the time to full policy diffusion, a larger of number of initial adopters also reduces the time at which power differences remain between adopters and non-adopters. The Poisson distribution of power is significant only in the parsimonious specification of the competition mechanism (Table 16 column 6), with a positive direction of effect. The uniform distribution of power is significant only in the competition specification with a negative direction of effect. The IGO parameter is significant in three specifications: the full, coercion and emulation specifications, each time with a negative coefficient indicating a reduction in the time to the elimination of power differences between adopters and non-adopters. Competitiveness, reelection, popularity, learning, emulation and competition are significant with negative directions of effect in competition, learning, coercion and in full specification respectively, all reducing the time to the elimination of power differences. The person parameter is not significant in any of the specifications.

As shown in Table 17, for the dependent variable that measures the last step at which differences in compliance costs were nonzero, the probability of initial adoption (probability-i) is statistically significant in all five specifications with a consistently negative direction of effect. This illustrates that the larger the number of initial adopters, the quicker the differences in compliance costs disappear. The IGO parameter is significant in three specifications: the full, learning and emulation specifications with consistently negative directions of effect. This suggests that IGOs resolve differences in compliance costs: the larger the number of IGOs advocating for a policy, the quicker compliance cost differences converge to zero. The uniform, Poisson and person parameters are significant only in the parsimonious competition specification, with positive, negative and negative signs respectively. The competitiveness (competition specification), party (emulation specification), reelection (learning), popularity (coercion), competition and learning (full) parameters are statistically significant with negative direction of effect. Emulation is significant with a positive direction of effect in full specification.

For the dependent variable that measures the last step at which regional differences in adoption exist, the probability of initial adoption (probability-i) is significant in all the specifications with a consistently negative direction of effect. Once again, as shown in table 15 the number of initial adopters significantly reduces the time to policy diffusion, measured in this case as the time at which regional differences in policy adoption disappear. The uniform and IGO parameters are significant in two of the specifications, the full specification and the parsimonious emulation specification. The person parameter is significant only in the competition specification with a negative direction of effect. The party (emulation specification), competitiveness (competition), reelection (learning), popularity (coercion), competition and learning (full specification) parameters are statistically significant with negative directions of effect. Emulation is significant with a positive direction of effect in full specification. The Poisson distribution of power shows no meaningful effect in any of the specifications.

Table 11 Time to Full Diffusion

Time to Full Diffusion										
	Full		Coercion		Learning		Competition		Emulation	
Intercept	3251.8	***	4948.9	***	2141.4	***	1795.4	***	6272.9	***
	(37.65)		(77.70)		(29.00)		(21.89)		(75.95)	
probability-i=1	-1604.8	***	-1377.2	***	-694.5	***	-775.1	***	-2574.5	***
	(34.74)		(78.19)		(27.47)		(20.65)		(58.77)	
Learning	-1142.6	***								
	(22.0546)									
Emulation	1042.6	***								
	(22.2273)									
Competition	-1294.6	***								
	(22.03)									
popularity=1			-4273.1	***						
			(61.32)							
reelection.1					-1285.3	***				
					(27.47)					
competitiveness.1							-923.8	***		
							(21.18)			
party.1									-2530.8	***
									(65.68)	
person=1	-1.4	*	-3.2	*	-0.2		-0.9	*	-1.5	
	(0.71)		(1.42)		(0.50)		(0.38)		(1.52)	
Poisson	-78.7	***	7.0		-42.7	**	-79.8	***	-198.2	***
	(19.09)		(38.30)		(13.47)		(10.12)		(41.03)	
Uniform	86.5	***	6.1		40.0	**	75.1	***	224.9	***
	(19.08)		(38.30)		(13.43)		(10.12)		(41.03)	
igo=1	-55.1	***	-15.2		-20.2	***	-0.03		-185.3	***
	(5.20)		(10.43)		(3.66)		(2.75)		(11.17)	
Adjusted R-squared		0.49								
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05										

Table 12 Maximum Power Difference

	DV= max-power-difference									
	Full		Coercion		Learning		Competition		Emulation	
Intercept	1.00	***	1.22	***	0.48	***	0.35	***	0.38	***
	(0.02)		(0.05)		(0.05)		(0.04)		(0.04)	
probability-i=1	-0.02		-0.19	***	0.03		-0.01		0.03	
	(0.02)		(0.05)		(0.04)		(0.04)		(0.03)	
Learning	-0.49	***								
	(0.01)									
Emulation	-0.54	***								
	(0.01)									
Competition	-0.59	***								
	(0.01)									
popularity=1			-0.41	***						
			(0.04)							
reelection.1					0.04					
					(0.04)					
competitiveness.1							0.15	***		
							(0.04)			
party.1									0.16	***
									(0.03)	
person=1	0.0002		-0.0004		0.001		-0.0002		0.001	
	(0.0004)		(0.001)		(0.001)		(0.001)		(0.001)	
Poisson	0.06	***	0.06	*	0.05	*	0.12	***	0.02	
	(0.01)		(0.02)		(0.02)		(0.02)		(0.02)	
Uniform	0.21	***	0.44	***	0.14	***	0.11	***	0.14	***
	(0.01)		(0.02)		(0.02)		(0.02)		(0.02)	
igo=1	0.002		-0.001		-0.0002		0.003		0.01	
	(0.003)		(0.01)		(0.01)		(0.01)		(0.01)	

Adjusted R-squared 0.16

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05

Table 13 Maximum Regional Difference

	DV=max-regional-difference									
	Full		Coercion		Learning		Competition		Emulation	
Intercept	0.43	***	0.43	***	0.43	***	0.41	***	0.46	***
	(0.00)		(0.01)		(0.01)		(0.01)		(0.01)	
probability-i=1	-0.20	***	-0.20	***	-0.20	***	-0.19	***	-0.21	***
	(0.003)		(0.01)		(0.01)		(0.01)		(0.004)	
Learning	-0.003									
	(0.002)									
Emulation	0.004	*								
	(0.002)									
Competition	-0.002									
	(0.002)									
popularity=1			-0.0003							
			(0.004)							
reelection.1					-0.01					
					(0.01)					
competitiveness.1							-0.01			
							(0.01)			
party.1									-0.05	***
									(0.005)	
person=1	-0.00005		-0.00020		-0.00003		0.00004		-0.00002	
	(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)	
Poisson	0.003	*	0.002		-0.001		0.005		0.005	
	(0.001)		(0.003)		(0.003)		(0.003)		(0.003)	
Uniform	0.001		0.001		-0.002		0.007	*	-0.002	
	(0.001)		(0.003)		(0.003)		(0.003)		(0.003)	
igo=1	0.00003		0.0001		0.001		0.000		-0.002	*
	(0.0004)		(0.001)		(0.001)		(0.001)		(0.001)	

Adjusted R-squared 0.25

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05

Table 14 Maximum Compliance Difference

	DV= max-compliance-difference								
	Full		Coercion		Learning		Competition		Emulation
Intercept	0.83	***	0.99	***	0.61	***	0.67	***	0.68
	(0.02)		(0.04)		(0.04)		(0.04)		(0.03)
probability-i=1	-0.09	***	-0.23	***	-0.02		-0.01		-0.10
	(0.02)		(0.04)		(0.04)		(0.04)		(0.03)
Learning	-0.17	***							
	(0.01)								
Emulation	-0.16	***							
	(0.01)								
Competition	-0.17	***							
	(0.01)								
popularity=1			-0.27	***					
			(0.03)						
reelection.1					0.05				
					(0.04)				
competitiveness.1							-0.06		
							(0.04)		
party.1									0.01
									(0.03)
person=1	-0.0002		-0.001		0.001		-0.001		0.0002
	0.0004		0.001		0.001		0.001		0.001
Poisson	0.002		0.01		-0.02		-0.01		0.02
	(0.01)		(0.02)		(0.02)		(0.02)		(0.02)
Uniform	-0.01		-0.02		-0.02		0.01		-0.02
	(0.01)		(0.02)		(0.02)		(0.02)		(0.02)
igo=1	0.001		0.01	*	-0.01		0.004		-0.005
	0.003		(0.01)		(0.01)		(0.01)		(0.01)

Adjusted R-squared 0.02
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05

Table 15 Last Step Maximum Region

	DV=max-regional-difference									
	Full		Coercion		Learning		Competition		Emulation	
Intercept	0.43	***	0.43	***	0.43	***	0.41	***	0.46	***
	(0.00)		(0.01)		(0.01)		(0.01)		(0.01)	
probability-i=1	-0.20	***	-0.20	***	-0.20	***	-0.19	***	-0.21	***
	(0.003)		(0.01)		(0.01)		(0.01)		(0.004)	
Learning	-0.003									
	(0.002)									
Emulation	0.004	*								
	(0.002)									
Competition	-0.002									
	(0.002)									
popularity=1			-0.0003							
			(0.004)							
reelection.1					-0.01					
					(0.01)					
competitiveness.1							-0.01			
							(0.01)			
party.1									-0.05	***
									(0.005)	
person=1	-0.00005		-0.00020		-0.00003		0.00004		-0.00002	
	(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)	
Poisson	0.003	*	0.002		-0.001		0.005		0.005	
	(0.001)		(0.003)		(0.003)		(0.003)		(0.003)	
Uniform	0.001		0.001		-0.002		0.007	*	-0.002	
	(0.001)		(0.003)		(0.003)		(0.003)		(0.003)	
igo=1	0.00003		0.0001		0.001		0.000		-0.002	*
	(0.0004)		(0.001)		(0.001)		(0.001)		(0.001)	
Adjusted R-squared 0.25										
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05										

Table 16 Last Step Maximum Power Difference

DV= lasttick_power										
	Full		Coercion		Learning		Competition		Emulation	
Intercept	1863.0	***	3501.4	***	940.2	***	614.3	***	1931.3	***
	(34.62)		(75.81)		(36.71)		(26.17)		(88.49)	
probability-i=1	-689.4	***	-1154.2	***	-347.4	***	-340.6	***	-801.0	***
	(31.95)		(76.29)		(34.77)		(24.69)		(68.47)	
Learning	-998.8	***								
	(20.28)									
Emulation	-356.7	***								
	(20.44)									
Competition	-1133.0	***								
	(20.26)									
popularity=1			-2918.4	***						
			(59.83)							
reelection.1					-559.1	***				
					(34.77)					
competitiveness.1							-237.0	***		
							(25.32)			
party.1									-885.3	***
									(76.53)	
person=1	0.0		-2.5		0.2		-0.2		2.3	
	(0.65)		(1.39)		(0.63)		(0.45)		(1.77)	
Poisson	6.9		-55.8		-13.5		67.3	***	29.9	
	(17.56)		(37.37)		(17.05)		(12.09)		(47.80)	
Uniform	-2.8		65.3		-13.2		-25.3	*	-37.8	
	(17.54)		(37.37)		(17.00)		(12.09)		(47.80)	
igo=1	-13.3	**	-24.2	*	-3.1		0.9		-27.0	*
	(4.78)		(10.17)		(4.64)		(3.29)		(13.01)	
Adjusted R-squared 0.20										
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05										

Table 17 Last Step Maximum Compliance Difference

	DV= lasttick_comply									
	Full		Coercion		Learning		Competition		Emulation	
Intercept	2088.5	***	3436.6	***	1108.3	***	1093.2	***	3565.0	***
	(38.75)		(83.95)		(36.26)		(29.46)		(99.66)	
probability-i=1	-1078.8	***	-1232.8	***	-404.5	***	-541.7	***	-1599.0	***
	(35.76)		(84.48)		(34.34)		(27.79)		(77.11)	
Learning	-861.7	***								
	(22.70)									
Emulation	236.4	***								
	(22.88)									
Competition	-905.1	***								
	(22.68)									
popularity=1			-2944.4	***						
			(66.26)							
reelection.1					-618.7	***				
					(34.34)					
competitiveness.1							-564.2	***		
							(28.51)			
party.1									-1784.0	***
									(86.19)	
person=1	-0.7		-2.2		0.5		-1.0	*	0.1	
	(0.73)		(1.54)		(0.62)		(0.51)		(2.00)	
Poisson	-6.1		37.2		-16.3		-38.9	**	-6.7	
	(19.65)		(41.39)		(16.84)		(13.62)		(53.83)	
Uniform	34.3		-28.6		20.5		49.4	***	95.9	
	(19.64)		(41.39)		(16.79)		(13.62)		(53.83)	
igo=1	-32.1	***	-6.0		-13.4	**	1.2		-110.0	***
	(5.35)		(11.26)		(4.58)		(3.71)		(14.65)	
Adjusted R-squared 0.22										
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05										

CONCLUSION

This chapter presented the agent-based model, the results of simulation and the regression analysis of data generated from the ABM. The analysis examined several measures of policy diffusion including the time to full diffusion; the average power of adopters and non-adopters; the proportion of adopters in each region; the average difference in compliance cost of adopters and non-adopters; the time of the maximum power difference between adopters and non-adopters; the time of the maximum compliance difference between adopters and non-adopters; and the time of the maximum regional difference of proportion of adopters were analyzed.

The analysis found that the number of initial adopters, commitment of the people and the influence of intergovernmental organizations expedite the process of policy diffusion. An international system with large number of weak states and small number of super powers (Poisson distribution of power) accelerates the time to full adoption. A perfectly multipolar international system (uniform distribution of power) slows the time to full diffusion. Learning and competition lead to faster diffusion; coercion takes more time to diffuse policy; and emulation is consistently the slowest diffusion mechanism.

Diffusion through coercion tends to increase power differences between adopters and non-adopters while learning, emulation and competition tends to decrease it. In the coercion mechanism, the weaker states adopt the policies through suasion. However, the more powerful ones are less likely to be influenced by the superpowers. Therefore, the power of non-adopters is greater. In learning, emulation and competition the more powerful and less powerful ones are equally likely to adopt the policy in the early stage of diffusion because the difference between power of non-adopters and adopters is lower than in coercion. In coercion there are some powerful holdouts up to later stages in the diffusion process. It suggests that the earlier powerful adopters indirectly influence the powerful holdouts by first influencing the weaker nation states dependent on them. The powerful hold outs eventually converge their policies. For example, during the Cold War. The United States and the Soviet Union could first influence the weaker states reliant on them. There were some relatively powerful nation states, which were neutral and did not side with neither the United States nor the Soviet Union. However, with the fall of the Soviet Union more countries liberalized their economies, which eventually led the more powerful holdouts to also liberalize their economies. The highest power difference is in the initial stages of diffusion process in learning, emulation and competition. The Poisson and uniform distributions of power increase the average power difference between adopters and non-adopters. The number of initial adopters decreases power difference. Likewise, the number of initial adopters is negatively associated with regional differences. With an increase in the number of initial adopters, there is a decrease in regional difference. There is a higher regional difference in emulation than coercion.

The difference in compliance costs between adopters and non-adopters is lower in learning, emulation and competition than in the coercion. The cost is higher for the adopters in coercion than in learning, emulation and competition. However, as the number of initial adopters increases, the cost decreases for the adopters in coercion and in the full specifications. The number of IGOs and the difference in compliance cost of adopters and non-adopters are positively associated. With an increase in the number of IGOs, the costs increase for the adopters in the coercion specification. The number of initial adopters and the difference in compliance costs have a negative association.

With an increase in the number of initial adopters, powerful and weak nation-states are equally likely to adopt the policies. The persistence of maximum power differences is negatively associated with the number of initial adopters. When the number of initial adopters increases, maximum power difference between adopters and non-adopters decreases. This suggests that if a few nation-states adopt a policy, they are the powerful ones and they lead less powerful countries. However, when a policy is adopted by a large number of nation-states initially, there are both powerful and less powerful nation-states among them. In emulation, learning and competition power difference between adopters and non-adopters is small. In coercion the power difference between adopters and non-adopters is large. It is negatively associated with learning, emulation and competition. With an increase in the number of IGOs, power difference between adopters and non-adopters decrease. In the full regression specification and the coercion specification, the persistence of maximum power differences is negatively associated with the number of IGOs. In a more equal international system, the difference between the power of adopters and non-adopters decreases. The uniform power distribution is negatively associated with it in the competition specification. When there are only very few powerful states, the power difference between adopters and non-adopters is larger. It is positively associated with the Poisson power distribution in the competition specification.

Table 18 Diffusion of Kyoto Protocol by Region

Kyoto Protocol Membership by Region				
Regions	1994	1997	2004	2011
East Asia & Pacific	12	19	19	19
Europe & Central Asia	25	38	46	47
Latin America & Caribbean	12	24	26	26
Middle East & North Africa	4	18	17	18
North America	2	2	2	2
South Asia	6	7	8	8
Sub-Saharan Africa	13	27	33	34

The persistence of maximum differences in compliance costs is negatively associated with the initial number of adopters. Interestingly, it is negatively associated with learning and competition and positively associated with emulation, suggesting that emulation adds to long-term differences in compliance costs. In learning and competition the highest cost difference between adopters and non-adopters is early in the diffusion process; however, it is in the later stage of diffusion process in emulation. Since difference in cost is generated from subtracting cost of adopters from cost of non-adopters, whenever the cost closely equal on adopters and non-adopters the difference is low. In competition and learning the cost is more equal on adopters and non-adopters. The persistence of these costs is negatively associated with internal actors' commitment to the policy in the competition model. It also is negatively associated with the number of IGOs in the full regression specification as well as the more parsimonious learning and emulation specifications. It is positively associated with the uniform distribution of power in competition. It is negatively associated with the Poisson distribution of power in the competition specification.

The differences in regional differences decrease in the later stages of diffusion process in every mechanism. The persistence of maximum regional differences associates negatively with the number of initial adopters. Regional difference decreases when the number of initial adopters increases. Countries from every region adopt the policy when there is a large number of initial adopters. With a few number of initial adopters, the regional differences increase. The policy diffuses within region first before diffusing between regions. As Table 18 illustrates the example of membership of Kyoto. The Kyoto Protocol, which has a large number of initial adopters and members from each region, has low regional difference in terms of proportion of adopters from

Table 19 FIT Diffusion Regional Variation

FIT Adoption by Region				
Regions	1978	1994	2004	2011
East Asia & Pacific	0	0	2	10
Europe & Central Asia	0	7	20	36
Latin America & Caribbean	0	0	2	4
Middle East & North Africa	0	0	2	7
North America	1	1	1	1
South Asia	0	1	2	3
Sub-Saharan Africa	0	0	0	8

each region. The proportional increase in number of adopters in each region is proportional to the number of initial adopters from each region.

The competition and learning mechanisms are negatively associated with regional differences while emulation is positively associated. In emulation, the highest regional differences occur in the later stages of the diffusion process. However, in learning and competition the highest regional differences occur in the earlier stage of the diffusion process. In the emulation and full specifications, the highest regional difference is likely to occur in the initial stage of diffusion process when the number of IGOs increases. In competition and learning policies diffuse between regions, but in emulation the policies diffuse within regions before diffusing between regions. Table 19 illustrates the regional variation of FIT diffusion. Through the emulation mechanism with a few initial adopters, the policy has initially diffused within Europe and Central Asia before diffusing to other regions.

The number of people committed to the policy is negatively associated with it in the competition specification. The uniform power distribution is positively associated with it in the full and emulation specifications. The number of IGOs is negatively associated with it in the full and emulation specifications. An increase in the number of IGOs committed to the policy decreases regional differences in emulation and full specifications. With an increase in the number of IGOs, the cost on adopters is the highest in the initial stages of adoption in emulation, full and learning specifications.

The next chapter will present the results of statistical analysis. The findings show that diffusion of renewable energy policies has occurred mainly through emulation and coercion mechanisms. The variables EU membership, common language, CDM and FDI are positively associated with the policies' diffusions.

STATISTICAL RESULTS

The previous chapter presented the agent-based model, the results of simulation and the regression analysis of data generated from the ABM. The analysis examined several measures of policy diffusion including the time to full diffusion; the average power of adopters and non-adopters; the proportion of adopters in each region; the average difference in compliance cost of adopters and non-adopters; the time of the maximum power difference between adopters and non-adopters; the time of the maximum compliance difference between adopters and non-adopters; and the time of the maximum regional difference of proportion of adopters were analyzed.

The analysis found that the number of initial adopters, commitment of the people and the influence of intergovernmental organizations expedite the process of policy diffusion. An international system with a large number of weak states and a small number of super powers (Poisson distribution of power) accelerates the time to full adoption. A perfectly multipolar international system (uniform distribution of power) slows the time to full diffusion. Learning and competition mechanisms lead to faster diffusion; coercion takes more time to diffuse policy; and emulation is consistently the slowest diffusion mechanism.

This chapter presents the results of statistical tests of the four diffusion theses. To examine the robustness of these statistical findings, the research uses several model specifications that interrogates the consistency of estimates across different statistical assumptions. The variables are tested in eight specifications, four random effect logistic regressions and four event history models. In brief, there is a robust finding of support for the emulation and suasion mechanisms of policy diffusion, but little support for learning and competition. Estimates that behave consistently increase the confidence when making references. In the following two sections, the results of random effect logistic regression models and event history models are discussed. First, four models of random effect logistic regression for FIT and RPS are presented. Then, four event history models for RPS and FIT are discussed. The findings of eight models are then compared to test for consistency of the estimates.

The independent variables are divided into four categories: suasion, emulation, competition, and learning. Each independent variable will be examined under four specifications: pooled random-effects logistic regression models that are fully specified; pooled random-effects logistic regression that are parsimonious specifications for each mechanism; fully specified event history models; and parsimonious event history models for each mechanism. The full models include all the independent variables and the controls, and the parsimonious models for each mechanism include only the independent variables for the given mechanism and all the controls.

RANDOM EFFECTS LOGISTIC REGRESSION MODELS

Table 20 shows the results of random effect logistic regression models for the FIT dependent variable, that is, whether (1) or not (0) a state adopts FIT. The full model includes the independent variables for all four mechanisms of diffusion and the controls. The suasion model only includes the variables for the suasion mechanism and the controls. And for each mechanism there is a separate model that includes all the control variables.

Two of the four variables (EU membership, and FDI) of the suasion model are significant in both the full and the parsimonious models and their directions of effects are as hypothesized, that is, positively associated with the adoption of FIT. In the competition model only one of the three independent variables is significant, but none of them is significant in the full model.

Competitors' adoption of FIT in the competition model is significant with the expected positive direction of effect. The direction of effect of a competitor's FIT is inconsistent across the two models. In the emulation model, two of the five independent variables (common language and common colonial history) are statistically significant with the expected positive direction of effect. However, only one common language is significant in both the emulation and the full model with a positive direction of effect. Two of the six independent variables (the difference in the share of renewable energy and CO_2 share of FIT and Non-FIT countries within each region) are significant in both the learning and full models with a negative direction of effect. Control variables including time, system, CO_2 emissions, solar and wind are statistically significant and consistent in five, four, two, two and two models respectively.

Table 21 shows the results of random effect logistic regression models for RPS. The full model includes all the variables and the controls. The suasion model only includes the variables for the suasion mechanism and the controls. For each mechanism there is a separate parsimonious model that includes all the control variables.

One of the four independent variables (EU membership) of the suasion model is significant in both the full and the suasion models, and the direction of effect is positive as hypothesized. CDM is significant only in the full model with a positive direction of effect. None of the three independent variables of the competition mechanism is significant in either the full model or in the competition model. In the emulation model, three of the four independent variables (the percent of common language countries with RPS, the percent of states with a common colonial history with RPS) are statistically significant with expected positive direction of effect in both the full and emulation models. Neighbors' adoption of RPS is statistically significant with a negative direction of effect in both logit models. Only in the full model, the

Cartagena agreement is statistically significant with a negative direction of effect. (The Kyoto variable is omitted from the RPS logit models because there is no variation in Kyoto adoption in the sample after adoption of RPS. All countries with RPS are members of Kyoto.)

Two of the six independent variables for learning (the difference in the share of renewable energy of RPS and Non-RPS countries within each region, and the difference in the GDP growth of RPS and Non-RPS countries in the world) are statistically significant. For both variables he direction of effect is positive in the full model. None of the learning variables are statistically significant in the parsimonious learning model. In the full model, the difference in the GDP growth of RPS and Non-RPS countries in the world is significant and the direction of effect is negative.

Control variables including adoption of wind energy; adoption of solar energy; CO_2 emissions; oil reserves; population size; type of government; and a time variable (to control for serial correlation) are statistically significant and consistent in three, five, three, one, two, one and four models. The direction of effect for wind and centrist government is negative and the rest of them have a positive direction of effect. Wind is significant and positively associated in the emulation, suasion and competition models. Solar is significant with a positive direction of effect in all the five models. CO_2 emission is significant and positively associated in the suasion, competition and learning models. The measure of oil reserves is significant with a positive direction of effect only in the full model. Population is significant in the full and emulation models. The measure of centrist governments is significant with a negative direction of effect only in the learning model. Time is significant and positively associated in all four of the models except emulation model.

Table 10 FIT Models, Random-Effects Logit

Variable	Full	Suasion	Competition	Emulation	Learning
FDI	5.08	2.92*	-	-	-
EU membership	15.17***	13.75***	-	-	-
CDM	1.63	0.15	-	-	-
colonizer_ RPS/FIT	-0.76	0.54	-	-	-
Neighbors	-0.03	-	-	-0.01	-
Cartagena	0.5	-	-	1.03	-
Kyoto	5.48	-	-	2.68	-
Common colonial history	10.10*	-	-	5.62	-
Common language	0.42***	-	-	0.37***	-
Competitors' RPS/FIT	-3.34	-	4.65*	-	-
Competitors' CDM	1.97	-	1.17	-	-
Competitors' FDI	0.38	-	0.79	-	-
Regional renewables share	-0.10*	-	-	-	-0.06*
Regional CO_2 emission	-0.79**	-	-	-	-0.42*
Regional GDP growth	-0.25	-	-	-	-0.23
World CO_2 emission	0.59	-	-	-	-0.06
World GDP growth	0.18	-	-	-	0.28
World renewables share	0.02	-	-	-	-0.01
wind	0	0.00***	0	0	0.00***
solar	0.00*	0	0	0.00**	0
CO_2emission	0	0.00*	0.00***	0	0
GDPG	0	0	0	0	0
oilreserve	0.01	0	0	0	0
globaloilprice	0	0	0.01	0.01	0
GDPPC	0	0	0	0	0
Population	0	0	0	0	0
System	1.36	4.57***	8.34***	3.01*	8.84***
Government type	-	-	-	-	-
3	-1.34	0.06	-0.55	-0.89	-0.45
4	0.41	1.18	0.49	0.13	1.38
_cons	-1387.02*	-3161.70***	-3571.40***	-1021.18**	-3365.87***
_cons	4.88***	5.30***	5.84***	4.81***	5.59***
N	3117	3117	3310	3310	3310
ll	-134.47	-270.4	-284.39	-155.88	-285.85
time	0.66*	1.55***	1.76***	0.49**	1.66***

Signif. codes: * p<.05; ** p<.01; *** p<.001

Table 21 RPS Models Random-Effects Logit

Variable	Full	Suasion	Competition	Emulation	Learning
FDI	8.38	1.67	-	-	-
EU membership	46.17**	10.73***	-	-	-
CDM	23.79**	5.92	-	-	-
colonizer_ RPS/FIT	-6.1	-0.2	-	-	-
Neighbors	-0.96*	-	-	-0.66*	-
Cartagena	-19.06*	-	-	-0.51	-
Kyoto	(omitted)	-	-	(omitted)	-
Common colonial history	258.93***	-	-	128.59***	-
Common language	1.34***	-	-	1.87***	-
Competitors' RPS/FIT	-6.25	-	-7.01	-	-
Competitors' CDM	-5.77	-	1.64	-	-
Competitors' FDI	20.72	-	1.22	-	-
Regional renewables share	-0.86*	-	-	-	-0.06
Regional CO_2 emission	-1.5	-	-	-	0.13
Regional GDP growth	1.76	-	-	-	0.5
World CO_2 emission	-2.59	-	-	-	-0.66
World GDP growth	-7.93*	-	-	-	-1.39
World renewables share	-1.36	-	-	-	0.01
wind	0	-0.00*	-0.00**	-0.00**	0
solar	0.00***	0.00***	0.00***	0.00***	0.00***
CO_2emission	0	0.00**	0.00*	0	0.01***
GDPG	0	0	0	0	0
oilreserve	0.03*	0	0	0.02	0
globaloilprice	0.01	0.02	0.03	0.03	0.03
GDPPC	0	0	0	-0.01**	0
Population	0.01**	0	0	0.01*	0
System	0.87	2.64	5.6	1.71	5.33
Government type	-	-	-	-	-
3	-5.4	-2.62	-2.36	-11.94*	-6.83*
4	-3.02	-2.1	-1.53	-2.48	-2.61
_cons	-8918.34*	-3421.56***	-4036.29***	-3039.89*	-5042.03***
_cons	5.01***	5.37***	5.36***	6.16***	6.11***
N	1888	3117	3310	2522	1956
ll	-17.87	-72.95	-76.75	-27.72	-71.44
time	4.35*	1.67***	1.99***	1.48*	2.48***

legend: * p<.05; ** p<.01; *** p<.001

EVENT HISTORY MODELS

Pooled logistic regression models help explain whether diffusion mechanisms explain *why* states adopt FIT and/or RPS. They do not explain, however, *when* states adopt these policies. To help understanding the timing of adoption, and whether diffusion mechanisms explain this timing, one can use an event history model (sometimes called a hazard model). Table 22 presents the estimates for the event history models. As in the pooled logistic regression models, the analysis uses both a full model specification that includes all four diffusion mechanisms plus controls; and parsimonious specifications that test each diffusion mechanism separately while controlling for rival factors. These specifications allow the analysis to assess the consistency of the estimates under different specifications and assumptions; those estimates that behave consistently increase the confidences in the inferences one may draw.

In both the full and suasion FIT event history models, two of the suasion variables (EU membership and FDI) are statistically significant with a positive direction of effect. A positive direction of effect in event history models speeds up the diffusion process. In both the full and emulation FIT event history models, one of the emulation variables (a common language with adopters) is statistically significant with a positive direction of effect. None of the competition variables is significant. None of the emulation models is significant in either the full or parsimonious emulation models. However, the difference in CO_2 between regions with FIT and non-FIT is significant with a negative direction of effect in the full model of FIT adoption. The difference in GDP growth of FIT and non-FIT countries of the world is statistically significant in the learning event history model with a positive direction of effect.

The controls for CO_2 emissions, the global price of oil, and system (coded 2 presidential, 3 parliamentary) are statistically significant in three, four, and three models respectively. CO_2

emissions is statistically significant in the suasion, competition, and emulation event history models of FIT with a positive direction of effect. The global oil price is significant with a negative direction of effect (as expected) in all the event history models except the parsimonious competition model. FIT diffuses faster in parliamentary system of government than in presidential system. System (coded 2 presidential, 3 parliamentary) is significant with a positive direction of effect in the suasion, competition and learning event history models for FIT adoption.

In the full event history model for RPS adoption, EU membership, CDM, FDI, average difference in CO_2 emissions within regions of countries with and without RPS, average difference in GDP growth within regions of countries with and without RPS, common former adopted the policy, common language and Kyoto are statistically significant. As expected the direction of effects of EU membership, CDM, FDI, average difference in GDP growth within regions of countries with and without RPS, percentage of countries with common former colonizer adopted RPS, common language and Kyoto Protocols are positive. However, average difference in CO_2 emissions within regions of countries with and without RPS has a negative direction of effect. Therefore, hypothesis 1, 3, 4, 10, 12, 15, 16 and 18 are accepted.

Table 22 FIT Models: Event History (Estimates as Betas)

Variable	Full	Suasion	Competition	Emulation	Learning
FDI	13.88***	14.56***	-	-	-
EU membership	0.98**	1.10**	-	-	-
CDM	0.61	0.7	-	-	-
Colonizer_RPS/FIT	-0.44	0.22	-	-	-
Neighbors	-0.01	-	-	-0.01	-
Cartagena	0.5	-	-	0.38	-
Kyoto	-1.38	-	-	-1.21	-
Common colonial history	0.44	-	-	-0.27	-
Common language	0.05***	-	-	0.05***	-
Competitors' RPS/FIT	-0.83	-	-0.21	-	-
Competitors' CDM	0.06	-	0.62	-	-
Competitors' FDI	1.78	-	1.14	-	-
Regional renewables share	0.01	-	-	-	0.01
Regional CO_2 emissions	-0.14*	-	-	-	-0.08
Regional GDP growth_	0.08	-	-	-	-0.01
World CO_2 emission	0.63	-	-	-	0.46
World GDP growth	0.14	-	-	-	0.25*
World renewables share	-0.02	-	-	-	-0.02
wind	0	0	0	0	0
solar	0	0	0	0	0
CO_2emission	0	0.00***	0.00***	0	0.00***
GDPG	0	0	0	0	0
oilreserve	0	0	0	0	0
globaloilprice	-0.05*	-0.02*	-0.02	-0.03**	-0.03*
GDPPC	0	0	0	0	0
Population	0	0	0	0	0
System	0.42	0.90**	0.98**	0.36	1.02**
Government type 3	0.21	0.21	0.05	0.37	0.1
Government type 4	0.48	0.16	0.06	0.35	0.19
_cons	-7919.88**	-3355.27***	-3259.51***	-3309.68***	-6278.40**
_cons	6.94***	6.08***	6.06***	6.08***	6.72***
N	2662	2662	2847	2847	2847
ll	303.11	217.54	215.19	293.71	222.05

legend: * p<.05; ** p<.01; *** p<.001

Table 23 RPS Models: Event History (Estimates as Betas)

Variable	Full	Suasion	Competition	Emulation	Learning
FDI	14.11***	14.17***	-	-	-
EU membership	9.31*	1.96	-	-	-
CDM	2.49**	2.60***	-	-	-
Colonizer_RPS/FIT	-1.18	-0.57	-	-	-
Neighbors	-0.05	-	-	-0.03	-
Cartagena	-6.56	-	-	-2.13**	-
Kyoto	9.03*	-	-	15.83***	-
Common colonial history	14.97***	-	-	11.09***	-
Common language	0.12**	-	-	0.07***	-
Competitors' RPS/FIT	-10.77	-	-1.49	-	-
Competitors' CDM	2.13	-	0.77	-	-
Competitors' FDI	4.06	-	0.11	-	-
Regional renewables share	-0.07	-		-	-0.02
Regional CO_2 emission	0.42*	-		-	0.02
Regional GDP growth	0.74**	-		-	0.2
World CO_2 emission	-0.37	-		-	0.06
World GDP growth	-0.71	-		-	-0.14
World renewables share	-0.3	-		-	0.06
wind	-0.00*	0	-0.00*	0	0
solar	0	0	0.00**	0	0
CO_2emission	0	0	0	0.00*	0
GDPG	0	0	0	0	0
oilreserve	0.01*	0.00*	0	0	0.00*
globaloilprice	0.12***	-0.02	0	0.04	0.02
GDPPC	-0.00**	0	0	0	0
population	0	0	0	0	0
system	3.65*	0.98	1.32	2.02	1.11
Government type	0.09	-	-	-	-
Gov 3		-1.09	-1.43	-0.1	-1.43
Gov 4		-0.59	-0.58	0.78	-0.56
_cons	-9219.77	-3510.93*	-4036.51*	-690.18	-707.85
_cons	7.09***	6.12***	6.27***	4.44	4.52
N	1832	3046	3239	3239	1885
ll	81.45	43.78	37.04	66.26	39.59

legend: * $p<.05$; ** $p<.01$; *** $p<.001$

In the RPS event history full specification the controls wind power, oil reserves, the global price of oil, GDP per capita and system (presidential coded 2, parliamentary coded 3) are statistically significant. While wind power and GDP per capita have a negative direction of effect (that is, they slow the process of policy diffusion), oil reserves, the global price of oil and system (presidential coded 2, parliamentary coded 3) have positive direction of effect (that is, they speed up the process of policy diffusion). In the RPS event history suasion model FDI and CDM are statistically significant. As expected both have a positive effect on RPS adoption. In the suasion event history specification only the control oil reserve is statistically significant with a positive direction of effect.

In the RPS event history competition model, none of the independent variables is significant. Only the controls for wind and solar power are statistically significant with negative and positive effects respectively. In the RPS event history emulation model, Cartagena, Kyoto, common former colonizer, common language and the control for CO_2 emissions are statically significant. Kyoto, common former colonizer and common language and CO_2 emissions as expected are positively associated with RPS adoption in the emulation model. Contrary to expectation, Cartagena has a negative effect. In the RPS event history model for the learning mechanism, none of the independent variable is statistically significant. Only the control, oil reserves, as expected has a statistically significant and positive effect.

HYPOTHESIS EXAMINATION UNDER FOUR SPECIFICATIONS OF FIT MODELS

Each independent variable is examined in four models (two event history and two random effects logistic regression models). There are parsimonious models for each mechanism that include the independent variables of a given variable and all the controls. There are full models that include all the variables in the four mechanisms and the controls. This estimation approach allows one to compare the effect of a hypothesized variable under different modeling assumptions.

For the models of the suasion mechanism of policy diffusion, wo out of four variables are statistically significant and two of them are not statistically significant in any of the FIT models. EU membership and FDI in four and three models respectively. CDM and adoption of FIT by a former colonizer are not statistically significant in any of the FIT models. Therefore, hypothesis two and three are rejected.

EU membership is statistically significant in all four of FIT models (FIT-full event history, FIT-suasion event history, FIT-suasion random-effect logistic regression and FIT-suasion random-effect logistic regression). EU membership has a consistent positive direction of effect as expected in hypothesis one. This consistency in significance and direction of effect allows one to accept hypothesis one.

Table 24 FIT Suasion Models

		Total	Event history		Random-effects Logit	
Hypothesis	Variables	Significant	Full	Suasion	Full	Suasion
1	EU-Membership	4	✔	✔	✔	✔
2	Colonizer-FIT/RPS	0	✖	✖	✖	✖
3	CDM	0	✖	✖	✖	✖
4	FDI	3	✔	✔	✖	✔
Codes: Significant ✔, Not significant ✖						

FDI is statistically significant in three of the four FIT models (FIT-full event history, FIT-suasion event history and FIT-suasion random-effect logistic regression). FDI has a consistent positive direction of effect as expected in hypothesis four. Therefore, hypothesis four is accepted in FIT-full event history, FIT-suasion event history and FIT-suasion random-effect logistic regression.

In the FIT emulation models, two out of six variables are statistically significant. Adoption by a country with common language is significant in all four of the FIT models. Common colonizer is only significant in the full pooled random effects logistic regression model; therefore, hypothesis 15 is accepted. Common colonizer has a positive direction of effect as expected in hypothesis 15. Common language is statistically significant and has a consistent positive direction of effect in all four of the models. Therefore, hypothesis 16 is accepted.

Table 25 FIT Emulation Models

		Total	Event history		Random-effects Logit	
Hypothesis	Variables	Significant	Full	Emulation	Full	Emulation
14	Neighbors	0	✖	✖	✖	✖
15	Common colonial history	1	✖	✖	✓	✖
16	Common language	4	✓	✓	✓	✓
17	Cartagena	0	✖	✖	✖	✖
18	Kyoto	0	✖	✖	✖	✖

Codes: Significant ✓, Not significant ✖

Table 26 FIT Competition Models

		Total	Event history		Random-effects Logit	
Hypothesis	Variables	Significant	Full	Competition	Full	Competition
5	Competitors' RPS/FIT	1	✖	✖	✖	✓
6	Competitors' CDM	0	✖	✖	✖	✖
7	Competitors' FDI	0	✖	✖	✖	✖

Codes: Significant ✓, Not significant ✖

In Table 26, which compares the estimations across four specifications of the FIT-emulation models, only competitor's FIT adoption is statistically significant. Only in one model is competitor's FIT adoption statistically significant and the direction of effect is positive as expected in hypothesis 5. Based on the competition random-effects logistic regression model, hypothesis 5 is rejected because of omitted variable bias; there is not a lot of confidence in that variable. However, it is not consistent and not significant in the full models.

Three of the variables are statistically significant in at least in one of the learning FIT models. Three of the variables, average difference in GDP growth of countries with and without FIT within regions, Average difference in CO_2 emissions of countries with and without FIT in the world and average difference in the renewable energy share of countries with and without FIT in the world are not statistically significant in any of the models. Therefore, hypotheses 9, 11 and 12 are rejected. Average difference in renewable energy share within regions of countries with and without FIT is statically significant in two of the logit models, but not in any of the event history models. The direction of effect is consistent and negative in both logit models. However, the hypothesis stated an expectation of a positive direction of effect. According to the logit models' results, then, hypothesis eight is accepted. Average difference in CO_2 emissions within regions of countries with and without FIT is statistically significant in three of the models.

The direction of effect is consistent and negative in all three of the models. Hypothesis 10 is accepted. Average difference in GDP growth of countries with and without FIT in the world is only significant with a positive direction of effect as expected in learning event history model. Therefore, hypothesis 13 is rejected because of omitted variable bias; there is not a lot of confidence in that variable. However, it is not consistent and not significant in the full models.

In terms of the strength of the mechanisms that may explain FIT diffusion, there is strong support for suasion and to a lesser degree strong support for emulation. For learning and competition there is moderate and weak support respectively. Suasion and emulation each have one variable that are significant in all four models. The suasion mechanism's hypothesis 1, EU membership, and emulation mechanism's hypothesis 16, common language, are statistically

Table 27 FIT Learning Models

		Total Significant	Event history		Random-effects Logit	
Hypothesis	Variables		Full	Learning	Full	Learning
8	Regional renewables share	2	✖	✖	✓	✓
9	World renewables share	0	✖	✖	✖	✖
10	Regional CO_2 emission	3	✓	✖	✓	✓
11	World CO_2 emission	0	✖	✖	✖	✖
12	Regional GDP growth	0	✖	✖	✖	✖
13	World GDP growth	1	✖	✓	✖	✖

Codes: Significant ✓, Not significant ✖

significant with positive direction of effect in all four of the models. Suasion mechanism's hypothesis four, FDI, is statistically significant with consistent positive effect in three of the models. Learning mechanism's hypothesis 10, Average difference in CO_2 emissions within regions of countries with and without FIT, is statistically significant with negative direction of effect in three of the models.

Table 28 FIT Models

Hypothesis	Variables	Total Significant	Event history		Random-effects Logit	
			Full	Parsimonious	Full	Parsimonious
Suasion						
1	EU-Membership	4	✓	✓	✓	✓
2	Colonizer-FIT	0	✖	✖	✖	✖
3	CDM	0	✖	✖	✖	✖
4	FDI	3	✓	✓	✖	✓
Competition						
5	Competitors' RPS/FIT	1	✖	✖	✖	✓
6	Competitors' CDM	0	✖	✖	✖	✖
7	Competitors' FDI	0	✖	✖	✖	✖
Learning						
8	Regional renewables share	2	✖	✖	✓	✓
9	World renewables share	0	✖	✖	✖	✖
10	Regional CO_2 emission	3	✓	✖	✓	✓
11	World CO_2 emission	0	✖	✖	✖	✖
12	Regional GDP growth	0	✖	✖	✖	✖
13	World GDP growth	1	✖	✓	✖	✖
Emulation						
14	Neighbors	0	✖	✖	✖	✖
15	Common colonial history	1	✖	✖	✓	✖
16	Common language	4	✓	✓	✓	✓
17	Cartagena	0	✖	✖	✖	✖
18	Kyoto	0	✖	✖	✖	✖

Codes: Significant ✓, Not significant ✖

Table 29 RPS Suasion Models

		Total	Event history		Random-effects Logit	
Hypothesis	Variables	Significant	Full	Suasion	Full	Suasion
1	EU-Membership	3	✔	✖	✔	✔
2	Colonizer-RPS	0	✖	✖	✖	✖
3	CDM	3	✔	✔	✔	✖
4	FDI	2	✔	✔	✖	✖

Codes: Significant ✔, Not significant ✖

There is the strongest support for EU membership and common language in four models. There is moderate support for FDI and Average difference in CO2 emissions within regions of countries with and without FIT in three models. There is weak support for Average difference in renewable energy share within regions of countries with and without FIT in two logit models. There is very weak support (one model only) for common colony, competitors' FIT, average difference in GDP growth of countries with and without FIT in the world in full logit, parsimonious logit, and parsimonious event history models respectively. In fit models there is no support for colonizer-FIT, CDM, neighbors' FIT, Cartagena, Kyoto, competitors' CDM, competitors' FDI, average difference in GDP growth of countries with and without FIT within regions, Average difference in CO2 emissions of countries with and without FIT in the world and average difference in the renewable energy share of countries with and without FIT in the world.

Table 30 RPS Emulation Models

		Total	Event history		Random-effects Logit	
Hypothesis	Variables	Significant	Full	Emulation	Full	Emulation
14	Neighbors	1 (-)	✖	✖	✓	✓
15	Common colonial history	4	✓	✓	✓	✓
16	Common language	4	✓	✓	✓	✓
17	Cartagena	2 (-)	✖	✓	✓	✖
18	Kyoto	2	✓	✓	✖	✖

Codes: Significant ✓, Not significant ✖

HYPOTHESIS EXAMINATION UNDER FOUR SPECIFICATIONS OF RPS MODELS

Overall there is moderate support for the suasion mechanism in the RPS models. There is moderate support (significant in three of the models) for EU membership and CDM. There is weak support for FDI, which is statistically significant in only one of the models. There is no support for a colonizer's adoption of RPS.

Hypothesis 1, EU membership, is statistically significant with the expected direction of effect (positive) in the full event history model, random-effects logit full and suasion models. Therefore, Hypothesis 1 is accepted. Hypothesis 3, CDM, is statistically significant with expected (positive) direction of effect in three models: the full event history, parsimonious suasion, and random-effect logit full models. Therefore, hypothesis 3 is accepted. FDI is statistically significant with positive direction of effect in two event history models.

There is strong support for the emulation mechanism in explaining diffusion of RPS. Competitors' RPS and common language are statistically significant with expected direction of effect (positive) in all four models. Therefore, hypothesis 15 and 16 are accepted. Cartagena is statistically significant in the event history emulation and logit full models. Hypothesis 17 is accepted; however, not with a positive, but instead a negative direction of effect.

Being signatory to Kyoto Protocols is statistically significant in two event history models with positive direction of effect. Therefore, hypothesis 18 is accepted. Hypothesis 14, neirps is statistically significant in the logit full and parsimonious models. Hypothesis 14 is accepted; however, the direction of effect is negative.

There is no support for the competition mechanism in explaining the diffusion of RPS. None of the competition variables are statistically significant. Therefore, hypotheses five, six and seven are rejected.

Table 31 RPS Competition Models

		Total	Event history		Random-effects Logit	
Hypothesis	Variables	Significant	Full	Competition	Full	Competition
5	Competitors' RPS/FIT	0	✖	✖	✖	✓
6	Competitors' CDM	0	✖	✖	✖	✖
7	Competitors' FDI	0	✖	✖	✖	✖
Codes: Significant ✓, Not significant ✖						

There is very weak support for the learning mechanism in explaining RPS diffusion. None of the learning variables are significant in both the event history and logit models. Hypothesis 10 and 12, average difference in CO_2 emissions of countries with and without RPS within regions and average difference in GDP growth of countries with and without RPS within

Table 32 FIT Learning Models

		Total Significant	Event history		Random-effects Logit	
Hypothesis	Variables		Full	Learning	Full	Learning
8	Regional renewables share	1 -	✖	✖	✓	✖
9	World renewables share	0	✖	✖	✖	✖
10	Regional CO_2 emission	1	✓	✖	✖	✖
11	World CO_2 emission	0	✖	✖	✖	✖
12	Regional GDP growth	1	✓	✖	✖	✖
13	World GDP growth	1 -	✖	✖	✓	✖

Codes: Significant ✓, Not significant ✖

regions are only statistically significant in event history full models. Hypothesis 10 and 12 are accepted. Hypothesis 8, average difference in the renewable energy share of countries with and without RPS within regions and hypothesis 13, average difference in the GDP growth of countries with and without RPS in the world, are statistically significant in the full logit models. Hypothesis 8 and 13 are accepted; however, their directions of effects are negative. Hypothesis 9, average difference in the renewable energy share of countries with and without RPS in the world and 11, average difference in CO2 emissions of countries with and without RPS in the world are rejected.

Emulation, suasion learning and competition mechanisms are strong, moderate, very weak and without support respectively in terms of explaining RPS diffusion. Two variables of the suasion mechanism are statistically significant. The suasion mechanism's hypothesis 15, common former colonizer, and hypothesis 16, common language, are statistically significant with a positive direction in all four RPS models. Two variables of the suasion models—hypothesis 1 about EU membership and hypothesis 3 about CDM—are statistically significant in three of the models. The learning mechanism's hypothesis 8,10,12 and 13 are significant in one of the models. None of the competition mechanism's variables, hypothesis 5 through 7, is statistically significant.

The strongest support is for hypothesis 15 common former colonizer, and hypothesis 16, common language, in four models. There is moderate support for EU membership and CDM, which are statistically significant in three models. There is weak support for FDI, which is statistically significant, in two logit models. There is very weak support for average difference in the renewable energy share of countries with and without RPS within regions, average difference in CO_2 emissions of countries with and without RPS within regions, average difference in GDP growth of countries with and without RPS within regions, average difference in the GDP growth of countries with and without RPS in the world, which are only significant in one of the models, full logit, full event history, full event history and full logit models respectively. In the RPS models, there is no support for former colonizer, competitor's CDM, competitor's FDI, competitor's RPS, average difference in CO_2 emissions of countries with and without RPS in the world, average difference in the renewable energy share of countries with and without RPS in the world.

COMPARISON: RESULTS OF FIT AND RPS MODELS

There are eight models in total for RPS and FIT. In order to check for robustness a comparison is made across all eight models. The findings for emulation and suasion are robust in both RPS and FIT. The emulation variable of sharing a common language (hypothesis 16) is statistically significant with a positive direction of effect in all eight models. The emulation variable of sharing a common colonial history (hypothesis 15) is statistically significant with a positive direction of effect in all four RPS models, but there is no consistent finding for it in the FIT models. There is a robust finding for EU membership (hypothesis 1) in both RPS and FIT models. There is a robust finding for EU membership (hypothesis 1) in both RPS and FIT models. EU membership is statistically significant with a positive direction of effect in three and four models RPS and FIT respectively. There is robust finding for CDM (hypothesis 3) in RPS models but not in FIT models. There is a robust finding for FDI (hypothesis 2) in the FIT models, but not in the RPS models. There is no significant finding for the colonizer variable (hypothesis 2), which is not significant in any of the models.

There are robust findings for learning in the FIT models, but not in the RPS models. In FIT models, there is a robust finding for the learning variable, the average difference in CO_2 emissions within region of countries that adopted the policy and those that have not, but not in RPS models. It is statistically significant in three of the FIT models with a negative direction of effect. There is a robust finding that the competition mechanism is not a predictor of RPS and FIT diffusion.

Table 33 RPS Models

Hypothesis	Variables	Total Significant	Event history		Random-effects Logit	
			Full	Parsimonious	Full	Parsimonious
Suasion						
1	EU-Membership	3	✓	✖	✓	✓
2	Colonizer-RPS	0	✖	✖	✖	✖
3	CDM	3	✓	✓	✓	✖
4	FDI	2	✓	✓	✖	✖
Competition						
5	Competitors' RPS/FIT	0	✖	✖	✖	✖
6	Competitors' CDM	0	✖	✖	✖	✖
7	Competitors' FDI	0	✖	✖	✖	✖
Learning						
8	Regional renewables share	1 -	✖	✖	✓	✖
9	World renewables share	0	✖	✖	✖	✖
10	Regional CO_2 emission	1	✓	✖	✖	✖
11	World CO_2 emission	0	✖	✖	✖	✖
12	Regional GDP growth	1	✓	✖	✖	✖
13	World GDP growth	1 -	✖	✖	✓	✖
Emulation						
14	Neighbors	2 (-)	✖	✖	✓	✓
15	Common colonial history	4	✓	✓	✓	✓
16	Common language	4	✓	✓	✓	✓
17	Cartagena	2 (-)	✖	✓	✓	✖
18	Kyoto	2	✓	✓	Omitted	Omitted

Codes: Significant ✓, Not significant ✖

The results of eight specifications presented in this chapter show robust findings of support for emulation and suasion, but little support for learning and competition. In the emulation mechanism, there is a robust finding for common language. In the suasion model there is a robust finding of support for EU membership. In addition, there is a robust finding that competition is not the driver of RPS and FIT diffusion. The findings for the learning mechanism in diffusion of RPS are not robust. However, there is a robust finding for learning variable, average difference in CO_2 emissions within regions of countries with and without FIT, in the FIT learning models.

PROBABILITY PROFILES OF FIT AND RPS MODELS

Probability profiles are generated to show the magnitude of effect of the independent variables on the dependent variable. While the results of regression and event history models show the direction of effect and statistically significance of the variables, they do not show the magnitude of effect on the dependent variable. Probability profiles allow the calculation of the effect of values of a given independent variable on the dependent variable. For example, it allows the separate calculation of effect of each value of a dummy variable, EU membership, with a value of zero and one on RPS adoption. Therefore, in order to find out which factor has the greatest effect on the probability of adoption, probability profiles are calculated for the statistically significant variables.

The probability profiles for the pooled logit full RPS model, pooled logit full FIT model, event history full RPS model, and event history full FIT model are presented in the next four tables. In the pooled logit full RPS and FIT models, EU membership has the greatest effect. In the probability profile of event history full FIT model, FDI has the greatest effect.

Table 34 Comparison FIT and RPS Models

Hypothesis	Variables	RPS Models Significant	FIT Models Significant	Total significant
Suasion				
1	EU-Membership	3	4	7
2	Colonizer-RPS/fit	0	0	0
3	CDM	3	0	3
4	FDI	2	3	5
Competition				
5	Competitors' rps/fit	0	1	1
6	Competitors' CDM	0	0	0
7	Competitors' FDI	0	0	0
Learning				
8	Regional renewables share	1 -	-2	-3
9	World renewables share	0	0	0
10	Regional CO_2 emission	1	-3	(+1, -3)=4
11	World CO_2 emission	0	0	0
12	Regional GDP growth	1	0	1
13	World GDP growth	1 -	1	(-1, +1)=2
Emulation				
14	Neighbors	2 (-)	0	-2
15	Common colonial history	4	1	5
16	Common language	4	4	8
17	Cartagena	2 (-)	0	-2
18	Kyoto	2	0	2

Pooled logit RPS probability profiles show that EU membership has the highest magnitude of effect on RPS adoption. The probability of RPS adoption in the pooled logit full RPS model for positive FDI is .029 and the probability of RPS adoption for negative FDI is .03. There is one tenth of a percent (0.001) difference between probabilities of RPS adoption in countries with positive FDI and negative FDI.

The probability of RPS adoption for non-EU member is 0.03 and for EU member it is .05. Hence, the probability of RPS adoption is two percent higher for EU members. The probability of adoption for non-CDM countries is .03 and for CDM countries it is 0.035. There is half a percent increase in the probability of adoption for countries with CDM. The probability of adoption for a Cartagena member is 0.03 and 0.035 for non-members. There is half a percent decrease in the probability of adoption for Cartagena members.

Pooled logit probability profiles for full FIT model show that once again EU membership has the greatest magnitude of effect on FIT adoption. The probability of FIT adoption for non-EU member is 0.11 and for EU member it is .28. Hence, the probability of FIT adoption is 17 percent higher for EU members. The probability of FIT adoption in a pooled logit full FIT model

Table 35 Pooled Logit Probability Profiles Full RPS Model

Variables		Predictive Margins	Delta-method Std. Err.	z	P>z	[95% Conf.	Interval]
FDI							
	1	0.028	0.0025025	11.32	0	0.0234172	0.0332267
	2	0.0298	0.0013549	21.97	0	0.0271092	0.0324204
EU membership							
	1	0.03	0.0066993	4.1	0	0.0143413	0.0406021
	2	0.05	0.0154067	3.26	0.001	0.0199668	0.08036
CDM							
	1	0.0276	0.0016587	16.62	0	0.0243241	0.0308262
	2	0.0347	0.0046233	7.51	0	0.0256748	0.0437978
Cartagena							
	1	0.0354879	0.0062065	5.72	0	0.0233233	0.0476524
	2	0.0297563	0.0013585	21.9	0	0.0270937	0.0324188
N		1861					
Model VCE:		OIM					
Expression: Pr(rps=1 assuming u_i=0), predict(pu0)							

Table 36 Pooled Logit Probability Profiles Full FIT Model

	Margin	Delta-method Std. Err.	z	P>z	[95% Conf.	Interval]
FDI						
1	0.1088369	0.023838	4.57	0	0.0621153	0.1555586
2	0.1281259	0.0043609	29.38	0	0.1195787	0.1366732
EU membership						
1	0.1051216	0.0034141	30.79	0	0.0984301	0.111813
2	0.2753785	0.041415	6.65	0	0.1942065	0.3565504
CDM						
1	0.1271293	0.0043747	29.06	0	0.1185551	0.1357034
2	0.1324374	0.0067815	19.53	0	0.1191459	0.1457288
N	3117					
Model VCE: OIM						
Expression: Pr(fit=1 assuming u_i=0), predict(pu0)						

for a net positive inflow of FDI is .13 and the probability of FIT adoption for negative FDI is .11. Positive FDI has a 2 percent higher probability of FIT adoption than non-FDI countries. The probability of adoption for non-CDM countries is .127 and for CDM countries it is 0.132. There is half a percent increase in the probability of adoption for countries with CDM.

The probability profile for the full specification of the event history FIT model predicts that half of countries with negative FDI will adopt FIT by 2033, holding other variables constant at their mean values. The median adoption time for positive FDI is 2008. The median time of adoption for EU members is 2008 and the median time of adoption for non-EU member is 2010. The median time of adoption of CDM is 2009 and it is 2010 for non-CDM countries.

Table 37 Full FIT Model: Event History Probability Profile

	Margin	Delta-method Std. Err.	z	P>z	[95% Conf.	Interval]
FDI						
1	2033.011	9.666722 210.31		0	2014.065	2051.958
2	2008.459	1.909871 1051.62		0	2004.715	2012.202
EU membership						
1	2009.962	2.366367 849.39		0	2005.324	2014.6
2	2008.07	2.013965 997.07		0	2004.123	2012.018
CDM						
1	2009.924	2.368373 848.65		0	2005.282	2014.566
2	2008.747	2.129958 943.09		0	2004.573	2012.922
N 2662						
Model VCE: Robust						
Expression: Predicted median _t, predict()						

The probability profiles for the full specification of the pooled logit RPS model, pooled logit full FIT model and event history full FIT model were presented in four tables. The variable, EU membership, has the greatest effect in the pooled logit full RPS and FIT models. The variable, FDI, has the greatest effect in the probability profile of event history full FIT model.

CONCLUSION

The statistical estimates provide robust support for the emulation and suasion mechanisms but not much support for learning and competition mechanisms. In the emulation models hypothesis 16, common language, is significant with a consistently positive direction of effect in all eight of the models. In the suasion models, hypothesis 1 about EU membership is significant in seven models. There are robust findings that the competition mechanism is not the driver of RPS and FIT diffusion. Competition variables, competitor's CDM and competitor's FDI, are not significant in any of the models. There is no robust finding for learning in diffusion of RPS. However, there is a robust finding for Average difference in CO_2 emissions within regions of countries with and without FIT, which is statistically significant in three FIT models with a negative direction of effect. In addition, the factors EU membership and FDI have the highest magnitude of effect.

The next chapter discusses the theoretical findings and conclusions of the study. There are robust findings of support for emulation and suasion mechanisms, but there is little support for learning. The statistical findings show that diffusion of RPS and FIT are not through competition mechanism.

CONCLUSIONS AND THEORETICAL FINDINGS

The diffusion of RPS and FIT are more likely to have occurred through emulation and suasion than through learning or competition. There are robust statistical findings for emulation and suasion, but there is little support for competition in the diffusion of RPS and FIT policies. This is consistent with empirical data since currently renewable energy sources cannot compete with conventional sources of energy. Currently, the prices of conventional sources of energy is lower than renewable sources of energy. Using renewables do not give competitive advantage to either producers or consumers. There is also a robust finding of support for learning in the diffusion of FIT, but not in RPS diffusion. Countries are seeking a solution that mitigates carbon emissions, diversifies their energy needs, and improves their energy security.

The following eighteen hypotheses are tested using event history and random-effects logistic regression specifications. The findings show robust support for hypothesis 1, 3, 15 and 16 in the RPS models. There is robust support for hypothesis 1, 4 and 16 in FIT models. Therefore, these hypotheses are accepted and the remainder of them are rejected.

Coercion Hypotheses

H1a Countries that are members of the European Union are more likely to adopt renewable energy policies than non-EU states. (Accepted for both FIT and RPS)

H2a Countries for which their former colonizers adopted RPS/FIT are more likely to adopt them. (Rejected)

H3a Countries with CDM projects are more likely to adopt RPS/FIT than countries without them. (Accepted for RPS)

$_{H4a}$ Countries with high levels of FDI are more likely to adopt FIT/RPS than countries with lower levels of FDI. (Accepted for FIT).

Competition Hypotheses

$_{H5a}$ Countries are more likely to adopt FIT/RPS if their main export partner(s) (competitor) adopted them. (Rejected)

$_{H6a}$ Countries are more likely to adopt FIT/RPS if their competitors with CDM have adopted these policies. (Rejected)

$_{H7a}$ Countries are more likely to adopt RPS/FIT if their competitors with positive FDI, foreign direct investment net inflows as a percentage of GDP, (new investment inflows less disinvestment divided by GDP) adopted them. (Rejected)

Learning Hypotheses

$_{H8a}$ In comparing countries, those in regions with a high share of renewable energy are more likely to adopt FIT/RPS than those in regions with a low share of renewable energy. (Rejected)

$_{H9a}$ In comparing countries of the world, the average share of renewable energy is higher in countries with FIT/RPS than countries without them. (Rejected)

$_{H10a}$In comparing countries, those in regions with lower average carbon emissions are more likely to adopt FIT/RPS that those in regions with high average carbon emissions. (Rejected)

$_{H11a}$ In comparing countries of the world, the average carbon emissions are lower in countries with FIT/RPS than countries without them. (Rejected)

$_{H12a}$ In comparing countries, those in regions with higher average economic growth are more likely to adopt FIT/RPS than those in regions with lower average economic growth. (Rejected)

$_{H13a}$ In comparing countries of the world, the average economic growth is higher in countries with FIT/RPS than countries without them. (Rejected)

Emulation Hypotheses

$_{H14a}$ States with a higher percentage of neighbors with renewable energy policies are more likely to adopt renewable energy policy than states with a lower percentage of neighbors with renewable energy policies. (Rejected)

$_{H15a}$ States that share a common colonizer with countries that have a higher percentage of FIT/RPS adoption are more likely to adopt RPS/FIT than states which share a common colonizer with countries that have a lower percentage of RPS/FIT adoption. (Accepted for RPS)

$_{H16a}$States that share a common language with countries that have a higher percentage of FIT/RPS adoption are more likely to adopt RPS/FIT than states which share a common language with countries that have a lower percentage of RPS/FIT adoption. (Accepted for both RPS and FIT).

$_{H17a}$ Countries that are signatories to the Cartagena multilateral environmental agreement are more likely to adopt renewable energy policies than states which are non-signatories. (Rejected)

$_{H18a}$ Countries that are signatories to the Kyoto multilateral environmental agreement are more likely to adopt renewable energy policies than non-signatories. (Rejected)

Countries that are members of European Union and receive foreign direct investment are more likely to adopt FIT. The statistical analysis shows that the probability of FIT adoption is 17 percent higher among EU members than non-members. Countries with positive FDI, Foreign direct investment net inflows (% of GDP) (new investment inflows less disinvestment divided by GDP) have a two percent higher probability of RPS adoption than those without FDI. In addition, FDI and EU membership increase the rate of adoption. Holding other variables at their means, the median time of adoption for EU members is 2008 and it is 2010 for non-EU members. The median time of adoption for FDI countries is 2008 and it is 2033 for non-FDI countries. The indicators of suasion (EU membership and FDI) are statistically significant in all four of the event history models and three of the random effects logistic regression models. These findings suggest that EU membership and FDI increase the incentives for the countries to adopt FIT.

FIT is more likely to diffuse to countries that share a common language, a significant indication of emulation diffusion. As the percentage of policy adopters with common language increases, there is an increase in the adoption of FIT. The percentage of countries with common language is statistically significant with a consistent positive direction of effect in all the statistical models of FIT.

For RPS diffusion, the strongest support is for the emulation mechanism, followed by suasion. There is not much support for competition and learning. For FIT, there is a robust finding for common language. For RPS, in addition to common language, there is a robust finding for common colonial experience as measures of emulation in all four of the statistical models.

CDM and EU membership increase the probability of RPS diffusion. The probability of RPS adoption is two percent higher for EU members than for non-members. There is half a percent increase in the probability of RPS adoption for countries with CDM than for countries without it. As measures of suasion, there are robust and consistent positive findings for EU membership and CDM for RPS diffusion. Each of them is statistically significant in three of the four statistical models. EU membership increases the probability of diffusion of FIT and RPS. In addition, FDI increases the probability and diffusion of FIT. There is no robust finding for FDI in RPS diffusion. CDM, for which there is no robust finding in FIT, is a strong predictor of RPS diffusion.

Agent-based models complement these findings and show that full diffusion through coercion and emulation take longer than competition and learning. In addition, the initial number of adopters; people's commitment to the mitigation of carbon emissions; the number of intergovernmental organizations committed to mitigation; and the Poisson distribution of power in the international system expedite full diffusion. When there are one or two super powers in the international system, the policies diffuse faster than in a multipolar system. This is an interesting finding: whereas a uniformity of state power may create a "balance" of strategic stability, the ABM suggests that in such a world policy diffusion will occur more slowly. Initially adoption of RPS and FIT only started with a single country, and their diffusion through emulation and suasion explains the slow rate of diffusion of these policies.

The maximum power difference between adopters and non-adopters is higher in a Poisson distribution, an international system with one or two super powers than a normal system with many middle powers. Non-adopters have higher power in the Poisson than in the normal distribution of power. In a multipolar world, powerful and less powerful countries are equally likely to adopt, but in a single power world the less powerful ones are more likely to adopt. In addition, the maximum power difference is higher in a uniform system than a normal system. Weaker states are more likely to adopt in a uniform world than a multi-polar world. The number of initial adopters decreases the time to maximum power difference. When there are more initial adopters, the maximum power difference occurs in the earlier times of diffusion process. In other words, there are less powerful ones that adopt the policies in the earlier phase of diffusion process. The maximum power difference between adopters and non-adopters is lower in the learning, emulation and competition mechanisms than in suasion. Powerful and less powerful ones are equally likely to adopt. Since in suasion more powerful countries shape the policies of weaker states dependent on them, the power difference between adopters and non-adopters is higher. In suasion less powerful states are more likely to adopt. In learning, emulation and competition, the maximum power difference occurs in the initial phase of diffusion. In coercion there are more powerful non-adopters in the later stage of diffusion process than in emulation, learning and competition.

The maximum regional difference in proportion of adopters and non-adopters occurs only in diffusion through emulation not in other mechanisms. As the number of initial adopters increase, there is a decrease in the maximum regional difference. However, this difference is more likely to occur in the initial phase of diffusion. In the competition and learning mechanisms, the maximum regional difference occurs in the earlier phase of diffusion. In emulation, the regional difference occurs in the later phase of diffusion.

Maximum compliance cost differences of adopters and non-adopters is lower in competition, learning and emulation than in suasion. There is more equal cost on adopters and non-adopters in learning, emulation and competition. In coercion, the cost is greater on adopters than on non-adopters. In the learning and competition mechanisms, the maximum cost difference is in the earlier phase of diffusion. In emulation, the maximum cost difference is in the later phase of diffusion. With higher number of initial adopters, the maximum compliance cost difference occurs in the earlier phase of diffusion.

AREAS FOR FUTURE RESEARCH

This study moves beyond the state centric approach and, in the agent-based model, examines individuals working as activists and the intergovernmental organizations. One of the study's contributions is that it includes different level of analysis and interactions across them in diffusion process. Contrary to the literature, this study makes clear distinctions between indicators of the four mechanisms. In the literature, the focus is more on whether diffusion has occurred through these mechanisms while indicators overlap across mechanisms. In addition, the use of agent-based modeling allow for understanding the rate of diffusion through each mechanism. The findings show that full diffusion through emulation and coercion take longer than competition and learning. In addition the agent-based model can be adopted to understand other examples of diffusion such as economic liberalization, metric system, fashion, sports and etc.

There are several suggestions for future research. Future research can look at the reversal of adoption. There are countries that have initially adopted the policies, but have dropped later. This can bring new insights on how it can affect the whole process of diffusion.

Another area of future research is to develop measures of learning variables that better capture the effect of policy adoptions on the share of renewables, economic growth and mitigation of carbon emissions. The difference in share of renewables before and after policy adoption would precisely show how much a country’s renewable share grows after adoption of the policies. A regional or world difference could also be calculated considering the difference of before and after adoption. In addition, measuring carbon emissions by dividing it by GDP before and after adoption would show the effect of the policy adoption on mitigation of carbon emissions. Regional and world differences in mean GDP growth before and after adoption would measure the effect of policy adoptions on economic growth.

In addition, instead of using European Union as a control, future research can use taxation rate to understand the role of collectivist and individualistic societies as a determinant of policy diffusion. Do actors that emulate are more likely to learn? Using percentage of renewable energy share as a dependent variable would allow to understand the link between emulation and learning in a statistical model combing the learning and emulation variables. It is expected that in policy diffusion through emulation the share of renewable energy will be low and in policy diffusion through learning the share of renewables will be higher.

BIBLIOGRAPHY

Aklin, Michaël, and Johannes Urpelainen. 2014. "The global spread of environmental ministries: Domestic-international interactions." *International Studies Quarterly* 58 (4):764-780. doi: 10.1111/isqu.12119.

Al-mulali, Usama, Hassan Gholipour Fereidouni, and Janice Y. M. Lee. 2014. "Electricity consumption from renewable and non-renewable sources and economic growth: Evidence from Latin American countries." *Renewable and Sustainable Energy Reviews* 30:290-298. doi: 10.1016/j.rser.2013.10.006.

Apergis, N., and J. E. Payne. 2010. "Renewable energy consumption and economic growth: Evidence from a panel of OECD countries." *Energy Policy* 38 (1):656-660.

Aslani, Alireza, Petri Helo, and Marja Naaranoja. 2014. "Role of renewable energy policies in energy dependency in Finland: System dynamics approach." *Applied Energy* 113 (0):758-765. doi: http://dx.doi.org/10.1016/j.apenergy.2013.08.015.

Axelrod, Robert M. 1984. *The evolution of cooperation*: New York : Basic Books, c1984.

Baccini, L., V. Lenzi, and P. W. Thurner. 2013. "Global energy governance: Trade, infrastructure, and the diffusion of international organizations." *International Interactions* 39 (2):192-216.

Bahgat, Gawdat. 2006. "Europe's energy security: Challenges and opportunities." *International Affairs* 82 (5): 961-975.

Bayülgen, Oksan. Winter 2013. "Two steps forward, one step back how politics dim the lighs on Turkey's renewable energy future." *Perceptions* 18 (4):71-98.

Benecke, Gudrun. 2009. "Greening energy politics in India: Assessing contributions of the clean development mechanism in the wind energy sector." *Conference Papers -- International Studies Association*:1-33.

Berry, Frances Stokes, and Berry. 2007. *Theories of the policy process / edited by Paul Sabatier*: Boulder, Colo. : Westview, c2007.

Berry, Frances Stokes, and William D. Berry. 1990. "State lottery adoptions as policy innovations: An event history analysis." *The American Political Science Review* 84 (2):395-415.

Berry, William D., and Brady Baybeck. 2005. "Using geographic information systems to study interstate competition." *The American Political Science Review* 99 (4):505-519.

Biresselioglu, Mehmet Efe, and Yasemin Zengin Karaibrahimoglu. 2012. "The government orientation and use of renewable energy: Case of Europe." *Renewable Energy* 47:29-37. doi: 10.1016/j.renene.2012.04.006.

Box-Steffensmeier, Janet , and Bradford Jones. 1997. "Time is of the essence: Event history models in political science." *American Journal of Political Science* 14 (4).

Braun, Dietmar, and Fabrizio Gilardi. 2006. "Taking 'galton's problem'seriously towards a theory of policy diffusion." *Journal of Theoretical Politics* 18 (3):298-322.

Bunce, Valerie J., and Sharon L. Wolchik. 2006. "International diffusion and postcommunist electoral revolutions." *Communist and Post-Communist Studies* 39:283-304. doi: 10.1016/j.postcomstud.2006.06.001.

Burns, James R. 1982. "Solar energy and the national energy dilemma: A model for policy evaluation." *Technological Forecasting and Social Change* 21 (3):213-228. doi: http://dx.doi.org/10.1016/0040-1625(82)90051-8.

Carley, Sanya. 2009. "State renewable energy electricity policies: An empirical evaluation of effectiveness." *Energy Policy* 37:3071-3081. doi: 10.1016/j.enpol.2009.03.062.

Chandler, Jess. 2009. "Trendy solutions: Why do states adopt sustainable energy portfolio standards?" *Energy Policy* 37 (8):3274-3281.

Colgan, J. D., R. O. Keohane, and T. Van de Graaf. 2012. "Punctuated equilibrium in the energy regime complex." *Review of International Organizations* 7 (2):117-143.

Cooper, R. N. 1995. "Trading up - consumer and environmental-regulation in a global economy - vogel,d." *Foreign Affairs* 74 (6):119-120.

Covadonga, Meseguer. 2004. "What role for learning? The diffusion of privatisation in OECD and Latin American countries." 299.

Daley, Dorothy M, and James C Garand. 2005. "Horizontal diffusion, vertical diffusion, and internal pressure in state environmental policymaking, 1989-1998." *American Politics Research* 33 (5):615-644.

Dobbin, Frank, Beth Simmons, and Geoffrey Garrett. 2007. "The global diffusion of public policies: Social construction, coercion, competition, or learning?" *Annual Review of Sociology* 33:449.

Elkins, Zachary, and Beth Simmons. 2005. "On waves, clusters, and diffusion: A conceptual framework." *The Annals of the American Academy of Political and Social Science* 598 (1):33-51.

Erdogdu, Erkan. 2013. "Implications of liberalization policies on government support to R&D: Lessons from electricity markets." *Renewable and Sustainable Energy Reviews* 17 (0):110-118. doi: http://dx.doi.org/10.1016/j.rser.2012.09.030.

Eurostat. 2014. Energy.

Finnemore, Martha, and Kathryn Sikkink. 1998. "International norm dynamics and political change." *International Organization* 52 (4):887.

Gallagher, K. S. 2013. "Why & how governments support renewable energy." *DAEDALUS* 142 (1):59-77.

Gallagher, Kelly Sims, Laura Diaz Anadon, Ruud Kempener, and Charlie Wilson. 2011. "Trends in investments in global energy research, development, and demonstration." *Wiley Interdisciplinary Reviews: Climate Change* 2 (3):373-396. doi: 10.1002/wcc.112.

Garrett, G., and B. Weingast. 1993. *Ideas, interests and institutions: constructing the European communities internal market*: Ithaca : Cornell University Press, 1993.

Geller, Armando , and Scott Moss. 2008. "Growing qawm: An evidence-driven declarative model of Afghan power structures " *Advances in Complex Systems* 11 (02):321-335. doi: doi:10.1142/S0219525908001659.

Gilardi, Fabrizio, Katharina Füglister, and Stéphane Luyet. 2009. "Learning from others the diffusion of hospital financing reforms in oecd countries." *Comparative Political Studies* 42 (4):549-573.

Graham, Erin R., Charles R. Shipan, and Craig Volden. 2013. "The diffusion of policy diffusion research in political science." *British Journal of Political Science* 43 (3):673-701. doi: 10.1017/S0007123412000415.

Gray, Virginia. 1973. "Innovation in the states: A diffusion study." *The American Political Science Review* 67 (4):1174-1185.

Grossman, Gene M., and Alan B. Krueger. 1995. "Economic growth and the environment." *The Quarterly Journal of Economics* 110 (2):353-377.

Gruber, Lloyd. 2000. *Ruling the world : Power politics and the rise of supranational institutions* Princeton, N.J. : Princeton University Press, c2000.

Jenner, Steffen, Gabriel Chan, Roll Frankenberger, and Mathias Gabel. 2012. "What drives states to support renewable energy?" *Energy Journal* 33 (2):1-12.

Jenner, Steffen, Lotte Ovaere, and Stephan Schindele. 2013. "The impact of private interest contributions on RPS adoption." *Economics & Politics* 25 (3):411-423. doi: 10.1111/ecpo.12018.

Jervis, Robert. 1997. *System effects : complexity in political and social life*: Princeton, N.J. : Princeton University Press, c1997.

Johnson, P. E. 1999. *Simulation modeling in political science*.

Karch, Andrew. 2007. *Democratic laboratories : Policy diffusion among the american states*. Ann Arbor: University of Michigan Press.

Kelemen, R. D., and E. C. Sibbitt. 2004. "The globalization of American law." *International Organization* 58 (1):103-136.

Kim, D. 2013. "International nongovernmental organizations and the global diffusion of national human rights institutions." *International Organization* 67 (3):505-539.

Kindleberger, Charles Poor. 1986. *The world in depression, 1929-1939*. Vol. 4: Univ of California Press.

Lee, Jae-Seung. 2013. "Towards green energy cooperation in Northeast Asia:Implications from European experiences." *Asia Europe Journal* 11 (3):231-245.

Leichter, Howard M. 1983. "The patterns and origins of policy diffusion: The case of the commonwealth." *Comparative Politics* 15 (2):223-233.

Lyon, Thomas P., and Haitao Yin. 2010. "Why do states adopt renewable portfolio standards?: An empirical investigation." *Energy Journal* 31 (3):133-157.

MacGarvie, M. 2005. "The determinants of international knowledge diffusion as measured by patent citations." *Economics Letters* 87 (1):121-126.

Macy, Michael W., and Robert Willer. 2002. "From factors to actors: Computational sociology and agent-based modeling." *Annual Review of Sociology* 28:143-166.

Marques, António Cardoso, and José Alberto Fuinhas. 2012. "Is renewable energy effective in promoting growth?" *Energy Policy* 46 (0):434-442. doi: http://dx.doi.org/10.1016/j.enpol.2012.04.006.

Matisoff, Daniel C. 2008. "The adoption of state climate change policies and renewable portfolio standards: Regional diffusion or internal determinants?" *Review of Policy Research* 25 (6):527-546. doi: 10.1111/j.1541-1338.2008.00360.x.

Mueller, Dennis C. 2003. *Public choice III*: Cambridge ; New York : Cambridge University Press, 2003. Non-fiction.

Network, Renewable Energy Policy. 2014. Renewables 2014 Global Status Report.

Pfeiffer, Birte, and Peter Mulder. 2013. "Explaining the diffusion of renewable energy technology in developing countries." *Energy Economics* 40:285-296. doi: 10.1016/j.eneco.2013.07.005.

Poteete, Amy R., Marco A. Janssen, and Elinor Ostrom. 2010. *Working Together : Collective Action, the Commons, and Multiple Methods in Practice*. Princeton: Princeton University Press.

Prakash, Aseem, and Matthew Potoski. 2006. "Racing to the bottom? Trade, environmental governance, and iso 14001." *American Journal of Political Science* 50 (2):350-364.

Radaelli, Claudio M. 2000. "Policy transfer in the European Union: institutional isomorphism as a source of legitimacy." *Governance* 13 (1):25-43.

Ring, J. 2014. "The Diffusion of Norms in the International System." Dissertation, The University of Iowa.

Rosenau, James N. 1990. *Turbulence in world politics : a theory of change and continuity*: Princeton, N.J. : Princeton University Press, c1990.

Sadorsky, Perry. 2009. "Renewable energy consumption and income in emerging economies." *Energy Policy* 37 (10):4021-4028. doi: http://dx.doi.org/10.1016/j.enpol.2009.05.003.

Saidur, R., M. R. Islam, N. A. Rahim, and K. H. Solangi. 2010. "A review on global wind energy policy." *Renewable and Sustainable Energy Reviews* 14:1744-1762. doi: 10.1016/j.rser.2010.03.007.

Saikawa, Eri. 2013. "Policy diffusion of emission standards is there a race to the top?" *World Politics* 65 (01):1-33. doi: doi:10.1017/S0043887112000238.

Salim, Ruhul A., and Shuddhasattwa Rafiq. 2012. "Why do some emerging economies proactively accelerate the adoption of renewable energy?" *Energy Economics* 34:1051-1057. doi: 10.1016/j.eneco.2011.08.015.

Saurugger, Sabine. 2013. "Constructivism and public policy approaches in the EU: from ideas to power games." *Journal of European Public Policy* 20 (6):888-906. doi: 10.1080/13501763.2013.781826.

Schreurs, Miranda A. 2012. "The politics of phase-out." *Bulletin of the Atomic Scientists* 68 (6):30. doi: 10.1177/0096340212464359.

Simmons, Beth A., Frank Dobbin, and Geoffrey Garrett. 2006. "Introduction: The international diffusion of liberalism." *International Organization* 60 (4):781.

Solangi, K. H., M. R. Islam, R. Saidur, N. A. Rahim, and H. Fayaz. 2011. "A review on global solar energy policy." *Renewable and Sustainable Energy Reviews* 15:2149-2163. doi: 10.1016/j.rser.2011.01.007.

Stadelmann, Martin, and Paula Castro. 2014. "Climate policy innovation in the South – Domestic and international determinants of renewable energy policies in developing and emerging countries." *Global Environmental Change* 29:413-423. doi: 10.1016/j.gloenvcha.2014.04.011.

TC., Schelling. 1960. *The strategy of conflict*. Cambridge, MA: Harvard University.

Tucker, Justin A, James W Stoutenborough, and R Matthew Beverlin. 2012. "Geographic proximity in the diffusion of concealed weapons permit laws." *Politics & Policy* 40 (6):1081-1105.

U.S. Department of Energy, and Energy Information Administration. 2012. "International energy statistics: Exports of crude oil including lease condensate 2012." accessed 6/15/2015. http://www.eia.gov/beta/international/.

ÜSTÜN, ÇİĞDEM. 2012. "Turkey between environmental protection and energy security: A regional perspective." *Insight Turkey* 14 (2).

Walker, Jack L. 1969. "The diffusion of innovations among the American states." *The American Political Science Review* 63 (3):880-899.

White, P. 2009. "The politics that power clean energy." *Journal of Politics & International Affairs*:10-22.

Wilensky, U. 1999. "Netlogo." http://ccl.northwestern.edu/netlogo/.

Yergin, Daniel. 2011. *The quest : Energy, security and the remaking of the modern world* New York : Penguin Press, 2011.

Yildirim, Ertuğrul, Şenay Saraç, and Alper Aslan. 2012. "Energy consumption and economic growth in the USA: Evidence from renewable energy." *Renewable and Sustainable Energy Reviews* 16:6770-6774. doi: 10.1016/j.rser.2012.09.004.

Zhang, ZhongXiang. 2008. "Asian energy and environmental policy: Promoting growth while preserving the environment." *Energy Policy* 36 (10):3905-3924. doi: http://dx.doi.org/10.1016/j.enpol.2008.07.015.

APPENDICES

A. DATA SOURCES

Variables	r	Data Source
Energy import, net % of energy use	1	Word Bank Development Indicators (WDI)
CO_2 emissions (metric tons per capita)	1	WDI
GDP per capita (Current $US)		WDI
Fossil fuel energy consumption (% of total)	1	WDI
GDP growth (annual %)	1	WDI
GDP per unit of energy use (PPP % per kg of oil equivalent)	1	WDI
Net ODA received (% of central government expense)	1	WDI
Net ODA received (% of GNI)	1	WDI
Population	1	WDI, Stadelmanna & Castroa (2014)
Foreign direct investment, net inflows (% of GDP)	1	WDI, MacGarvie (2005)
FDI dummy created using WDI FDI % of GDP data		WDI
Education (the % of gross secondary school enrollment)	1	WDI, Stadelmanna & Castroa (2014)
School enrollment, secondary (% net)	1	WDI
Unemployment, total % of total labor force	1	WDI, Jenner, Chan, Frankenberger, Gabel 2012
Oil rents (% of GDP)	1	WDI
Government Orientation	1	World Bank Database of Political Institutions http://go.worldbank.org/2EAGGLRZ40
Pump price for gasoline ($US per liter)	1	WDI
Crude Oil in Dollars per Barrel, Products in Dollars per Gallon, WTI - Cushing, Oklahoma		http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm
system2012 execrlc2012	1	DPI2012: http://go.worldbank.org/2EAGGLRZ40
+EU member	1	EU, http://europa.eu/about-eu/countries/index_en.htm
Target final energy percent from Renewable	1	Renewables 2014 Global Status Report OECD Stats, rndata
Kyoto Protocol from the United Nations Framework Convention on Climate Change	1	IEAD, Neumayer (2002) http://iea.uoregon.edu/page.php?query=static&file=download_full_dataset.htm Citation: Data from Ronald B. Mitchell. 2002-2015. *International Environmental Agreements Database Project (Version 2014.3).* http://iea.uoregon.edu/
The Cartagena Protocol on Biosafety	1	IEAD
The Montreal Protocol on Substances that Deplete the Ozone Layer	1	*IEAD*

Crude Oil Proved Reserves (Billion Barrels)	1	EIA http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=57&aid=6&cid=regions&syid=1980&eyid=2014&unit=BB
Energy Intensity - Total Primary Energy Consumption per Dollar of GDP (Btu per Year 2005 U.S. Dollars (Purchasing Power Parities)	1	EIA http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=92&pid=47&aid=2&cid=regions&syid=1980&eyid=2011&unit=BTUPUSDM
Total Renewable Electricity net generation (Billion Kilowatt Hours)	eia	http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=6&pid=29&aid=12
Total Renewable Electricity Net Consumption (Billion Kilowatt Hours)	eia	
+Global Oil Price	eia	
Colonizer effect	cepii	CEPII, Centre d'Etudes Prospectives et d'Informations Internationales (French: Institute for Research on the International Economy) http://www.cepii.fr/CEPII/en/cepii/cepii.asp
+Common colony	cepii	CEPII, Stadelmanna & Castroa (2014)
Common language	cepii	CEPII, MacGarvie (2005)
Cdm	cdm	Percentage of projects by Host Party of all registered projects http://cdm.unfccc.int/Statistics/Public/CDMinsights/index.html
Membership (Central European Free Trade Agreement)	cefta	http://www.cefta.int/ Stadelmanna & Castroa (2014)
% of neighboring states with RPS or FIT		The world factbook, CIA, https://www.cia.gov/library/publications/the-world-factbook/fields/2096.html Jenner, etal (2012), chandler 2009
Renewable Energy Sources Govt R&D in Million NC (nominal)	1	IEA http://wds.iea.org/WDS/TableViewer/tableView.aspx
Renewable Energy Sources Total RD&D in Million USD	1	IEA
Share of heavy industry as percentage of GDP(paper products+ nonmetallicindustry + basic metal industry)/gdp for each year (Smith_Urpelainen 2013)		OECDstatshttp://stats.oecd.org/index.aspx?queryid=90#
Renewable energy, Total, % of total energy generation	1	OECD (2014), Renewable energy

Restructured electricity product market regulation (PMR) in the electricity sector		http://www.oecd.org/dataoecd/47/48/42480328.xls PMR is used by Smith_Urpelainen 2013 Jenner, Chan, Frankenberger & Gabel (2012) Erdogdu (2013) for explanation of the variable
+biomass resources		Stadelmanna & Castroa (2014)
+hydro resources		Stadelmanna & Castroa (2014)
+solar resources		Stadelmanna & Castroa (2014) https://catalog.data.gov/dataset?q=wind+resources+by+class+and+country&sort=score+desc%2C+name+asc&publisher=National+Renewable+Energy+Laboratory&ext_location=&ext_bbox=&ext_prev_extent=-106.80084228515625%2C42.037054301883806%2C-106.15264892578125%2C42.44372793752476
+wind resources		Stadelmanna & Castroa (2014) https://catalog.data.gov/dataset?q=wind+resources+by+class+and+country&s
Export/import partners		http://wits.worldbank.org/CountryProfile/Country/AFG/Year/2010/Summary
Export/import partners (accessed 29 oct 15)		https://www.cia.gov/library/publications/the-world-factbook/fields/2050.html
Growth of electricity consumption		Pfeiffer, Mulder 2013

B. DIFFUSION VARIABLES

Literature Review				
Dependent V	IVs	Sources	Diffusion M	Test
RPS adoption US states	+ economic growth / local environment conditions / preferences effects, ?political ideology, ?private interests, American solar energy association, No oil price	Lyon & Yin, 2010	Control	Proportional odds model (Kiefer, 1988)
RPS adoption in state requirement US states	-higher level of renewable energy development + regulated electricity market/ cost based pricing	Lyon & Yin, 2010	Control	
policy adoption (RPS, FIT) EU	+International solar energy association /ratio of neighbor with policy and the total number of states (nbor) /EU membership (representing EU Directive 2001/77/EC on generation of electricity from renewable energy sources (RES-E). It has been the first binding directive that obliges state legislators to support RES-E +solar potential +unemployment rate -electricity market concentration Electricity price per kwh for private consumers No oil price	Jenner, Chan, Frankenberger & Gabel, 2012	international solar energy association= emulation nbor=learning bc chandler (2009) introduces it as learning effect between US neighbor states EU membership=Coercion bc binding	Proportional hazard model
FIT adoption developing and emerging economies	-domestic energy production /air quality (so2), +biomass resources, +hydro resources, +GDP per capita, +population, /education, +EU member, +Common colony, oil price	Stadelmann & Castro (2014)	EU=Learning/coercion Common Colony= emulation/learning Colonizers= coercion	Logit model, using maximum likelihood techniques
energy & environmental policy Turkey	-economic concern - geopolitical concern +environmental concern	Ustun, 2012	geopolitical concern= competition bc turkey as transit state and having long term energy contract with foreign countries	

Dependent V	IVs	Sources	Diffusion M	Test
financial incentives through tax reduction, grants, concessional loans	-domestic energy production +solar resources +GDP per capita +population /education, +democracy, +EU +Central European Free Trade Agreement (CEFTA), +former colonizer % adopted the policy	Stadelmann & Castro (2014)	EU=Learning/coercion Common Colony= emulation/learning	
re Target adoption	+wind resources, -hydrological resources +population, /education, +EU member, +Lag CDM	Stadelmann & Castro (2014)	EU member=learning, coercion	
Framework policies (strategies, plans, generic law)	+population +Common colony +Global Environmental Facility (GEF) funding +Lag CDM	Stadelmann & Castro (2014)	Common Colony= emulation/learning GEF funding= coercion (financial incentive diffusion)	
Technology knowledge diffusion	+common language geographic distance as proxy for language barrier FDI Import of citing country from cited country telephone call traffic between two country	MacGarvie (2005)	Common language = emulation/ learning geographic distance as proxy for language barrier= emulation/ learning FDI = competition Import of citing country from cited country= competition telephone call traffic between two country= emulation/learning	regression
RPS adoption US states	+ Renewable energy interest groups contribution to state level policy makers -conventional energy interest groups donations to state level policy makers No oil price	Jenner etal., 2013Database of state incentives for renewables and efficiency (DSIRE)	control	Proportional hazard model and probit (for the increase in share of renewables
Renewable energy programs and policies US states	+*air pollutant per capita -*carbon intensive economies (carbon dioxide tons per thousand of real 2000 chained dollars of Gross State Product) -coal and natural gas production +GSP per capita +*number of liberal citizens (0 conservative -100 liberal) +wind capacity +solar generation capacity +% of neighboring states adopted	Matisoff, 2008	neighboring states with RPS= emulation/learning, competition	Cross-sectional analysis to test for internal determinants of policy adoption and event history analysis for diffusion, probit maximum likelihood regression

	RPS			model

C. DIFFUSION MECHANISMS

	Diffusion Processes	
	Coercion/Suasion	**Competition**
External	Stadelmann & Castro 2014=Colonizer Aklin, etal 2014=environmental ministries Simmons, et al. 2006= policies promoted by strong countries to be put into practice in weak countries structurally or situationally dependent on them Schelling 1960= Unilateral policy leadership	Stadelmann & Castro 2014=External and internal actors more likely have similar economic structure, they compete with each other Simmons, etal. 2006= most important relationships are horizontal
Go-betweens	Stadelmann & Castro 2014=EU member Stadelmann & Castro (2014)= Central European Free Trade Agreement (CEFTA) Stadelmann & Castro 2014, Clean development mechanisms through international orgs Saikawa 2013=International development assistance (ODA) Graham, etal. 2013= national policy governments or international organizations in federal system and international organization may use coercive strategies through grants and aid requirements, pre-emptive laws, sanctions or military force	Graham, etal. 2013= national policy governments or international organizations in federal system and international organization “may help restructure competitive environments, such as with the European Union facilitating the reduction of trade barriers or the US Constitution limiting interstate regulation of commerce by the states” (693)
Internal	Simmons, etal. 2006= Weaker countries are structurally or situationally dependent on strong countries that diffuse the policies	Tucker, etal 2012= geographic proximity Berry & Berry 2007= Internal actor compete with external actor when trading partner or3rd party in FDI Dobbin, etal. 2007

	Diffusion Processes	
	Learning	**Emulation**
External	External actor increase the knowledge about policy effectivness. Their policy adoption does not have externality effect on the internal actors or potential adopters. External actors are not actively promoting and shaping policy change in potential adopters	Matisoff, 08= % of neighboring states with RPS Walker 1969= interaction between potential and diffusing countries officials Berry & Berry 2007=Similar cultural and historical connections, common norms drive diffusion Finnemore, etal. 1998=common norms emerge from increased interaction between external and internal actors Graham, etal. 2013=Countries with soft power can appeal to others
Go-betweens	Stadelmann & Castro 2014=EU learning effect on European countries in transition Capacity building projects under development and environmental finance initiatives of international climate policy for developing countries Graham, etal. 2013= national policy governments or international organizations in federal system and international organization can facilitate learning	Jenner, etal (2012)= Intersolar energy association Koppl & Steininger 2012=Renewable energy regime Simmons, etal. 2006= NGOs, policy profesionals, academics influence government to adopt policies Graham, etal 2013=Socialization aims to change preferences of actors, without expecting immediate policy change, but rather would lead to long term policy change Graham, etal. 2013= national policy governments or international organizations in federal system and international organization can facilitate socialization by establishing information centers, conferences recommending best practices
Internal	Internal actor active, external actor passive. Graham, etal. 2013=Policy makers seeking effective public policies, learn from others about the success political viability	Stadelmann & Castro (2014)=Common colonial history Policy makers imitate a policy if else where people reelected those who enacted the policy (Gilardi 2010)

D. DESCRIPTIVE STATISTICS

variable	vars	n	mean	sd	min	max
time	1	3395	2000.48	6.3	1990.0	2011.0
region*	2	3395	3.63	2.1	1.0	7.0
fit	3	3395	0.15	0.4	0.0	1.0
rps	4	3395	0.03	0.2	0.0	1.0
ccode*	5	3395	78.63	45.5	1.0	157.0
wrps_co2	6	3395	4.57	0.7	3.9	12.3
wrps_gdpg	7	3395	3.86	1.8	-0.5	6.5
wfit_co2	8	3395	4.56	1.2	3.7	15.4
wfit_gdpg	9	3395	3.86	1.9	-3.0	6.8
regrps_co2	10	3395	4.63	3.6	0.3	18.8
regrps_gdpg	11	3395	3.83	2.9	-6.7	12.0
regfit_co2	12	3395	4.62	3.6	0.2	20.2
regfit_gdpg	13	3395	3.83	3.0	-7.1	12.0
wind	14	3395	77544.77	388272.9	0.0	3225342.0
solar	15	3395	2041006815.49	4553811811.0	793.7	27373606560.0
fdi	16	3185	0.94	0.2	1.0	2.0
co2em	17	3318	4.61	6.6	0.0	68.5
gdpg	18	3251	3.83	7.4	-64.0	150.0
gdppc	19	3277	8549.78	13946.5	64.8	113738.7
popul	20	3392	37450145.91	134742084.0	96286.0	1344130000.0
eumem	21	3395	0.11	0.3	0.0	1.0
cdm	22	3395	0.07	0.3	0.0	1.0
neifit	23	3395	14.96	26.3	0.0	100.0
neirps	24	3395	1.64	8.6	0.0	100.0
sys	25	3351	1.43	0.5	1.0	2.0
system*	26	3395	3.45	0.7	1.0	4.0
gov	27	1963	2.14	0.9	1.0	3.0
govorient*	28	3395	3.27	1.3	1.0	5.0
oilres	29	3185	7.06	29.3	0.0	266.8
goilpr	30	3395	40.11	26.4	14.4	99.7
kyoto	31	3395	0.75	0.4	0.0	1.0
montreal	32	3395	0.85	0.4	0.0	1.0
cartagena	33	3395	0.29	0.5	0.0	1.0
colonizer_rps	34	3395	0.13	0.3	0.0	1.0
colonizer_fit	35	3395	0.27	0.4	0.0	1.0
colonizercode*	36	3395	8.86	4.5	1.0	16.0
comcrps	37	3395	0.01	0.0	0.0	0.5
comcfit	38	3395	0.08	0.2	0.0	1.0
coml_rps	39	3395	1.87	9.7	0.0	100.0
coml_fit	40	3395	13.72	26.6	0.0	100.0
comprps	41	3395	0.10	0.2	0.0	1.0

compfit	42	3395	0.42	0.3	0.0	1.0
comcdm	43	3395	0.08	0.2	0.0	1.0
income*	44	3395	1.69	0.8	1.0	3.0
comfdi	45	3395	0.91	0.1	0.0	1.0
income.group*	46	3395	3.44	1.3	1.0	5.0
cname.y*	47	3395	78.86	45.6	1.0	157.0
renew_gen*	48	3395	898.33	779.3	1.0	2402.0
elec_gen*	49	3395	1398.92	934.2	1.0	3056.0
elshare*	50	3395	148.41	174.4	1.0	474.0
wrps_elshare	51	3395	35.41	2.8	10.3	38.6
wfit_elshare	52	3395	35.42	3.9	7.9	49.8
rps_elshare	53	3395	35.25	15.0	1.0	57.9
fit_elshare	54	3395	35.25	15.6	0.0	88.0
regrps_elshare.nrps	55	1999	-15.09	15.0	-38.5	21.5
reg_rps_co2.nrps	56	1999	3.98	4.6	-10.9	14.0
reg_rps_gdpg.nrps	57	1999	-1.65	1.7	-5.4	5.3
regelshare_fit.nf	58	3395	-6.73	18.4	-52.8	46.4
regfit_co2.nonfit	59	3395	3.21	4.2	-8.0	15.0
regfit_gdpg.nonfit	60	3395	-0.64	2.7	-8.2	8.0
wfit_co2_nonfit	61	3395	4.32	2.4	1.8	11.6
wfit_gdpg_nonfit	62	3395	-0.95	1.4	-5.0	1.6
wfit_elshare_nonfit	63	3395	-8.13	9.3	-31.2	15.0
wrps_co2_nonrps	64	1999	4.26	1.8	2.0	7.8
wrps_gdpg_nonrps	65	1999	-1.59	1.1	-3.2	0.4
wrps_elshare_nonrps	66	1999	-16.37	3.8	-24.5	-9.3

E. CORRELATIONS

	colonizer_rps	colonizer_fit	comoncolony _rps	comcolonyfit	coml_RPS	coml_FIT	cdm	neighbor_fit	neighbo rps	eumem	Co2em	fdiipc
colonizer_rps	1											
colonizer_fit	-.067**	1										
comncolnyrps	.125**	.252**	1									
comcolonyfit	.138**	.242**	.083**	1								
coml_RPS	.078**	0.028	.318**	-0.017	1							
coml_FIT	0.022	.087**	0.037	.480**	.191**	1						
cdm	.114**	.272**	.176**	.211**	.048*	.152**	1					
neighborfit	0.007	0.018	.074**	.287**	.184**	.405**	.116**	1				
neighborps	.167**	0.004	0.028	.200**	0.031	.155**	.052*	.246**	1			
eumem	-.060**	-.123**	0.031	.143**	.182**	.460**	-.079**	.446**	.162**	1		
Co2em	.069**	-.190**	-0.016	.061**	.050*	.115**	-.063**	.173**	0.03	.252**	1	
fdiipc	.067**	.047*	0.014	.140**	0.003	.122**	0.012	.068**	.055**	.096**	.074**	1
gdpg	.055**	.063**	0.013	.074**	-0.023	-0.011	.065**	-0.014	0.014	-.064**	0.036	.107**
gdppcapita	.081**	-.127**	-0.011	.079**	.235**	.407**	-.056**	.451**	.157**	.495**	.585**	.154**
popul	.091**	-0.035	0.003	0.004	.045*	-0.006	.168**	-0.01	0.029	-.053**	-.071**	-.052**
Kyoto	.223**	.291**	.139**	.259**	.116**	.254**	.159**	.263**	.106**	.107**	0.027	.111**
cartagena	.255**	.300**	.249**	.398**	.223**	.391**	.286**	.307**	.188**	.183**	-0.037	.119**
oilres	0.013	-.052**	-0.02	0.009	-0.024	-.065**	-0.026	-0.008	-0.036	-.067**	.200**	-0.028
Renewbles consumpn	0.005	-0.011	-0.019	-0.03	.127**	.097**	.098**	.262**	-0.015	0.025	.135**	-.042*
goilpr	.355**	.360**	.299**	.485**	.210**	.356**	.375**	.375**	.222**	.106**	-0.002	.132**
system	.097**	-.237**	-.039*	.065**	.111**	.183**	-.104**	.330**	.078**	.348**	.206**	.048*
govorient	-.052**	.083**	.110**	-0.022	0.023	.083**	.043*	.142**	0.039	.174**	0.014	0.019

E. CORRELATIONS Continued

	gdpg	gdppcapita	popul	Kyoto	cartagena	oilres	Renewables consumption	goilpr	system
colonizer_rps									
colonizer_fit									
comncolnyrps									
comcolonyfit									
coml_RPS									
coml_FIT									
cdm									
neighborfit									
neighborps									
eumem									
Co2em									
fdiipc									
gdpg	1								
gdppcapita	-.043*	1							
popul	.047*	-.063**	1						
Kyoto	.141**	.136**	.042*	1					
cartagena	.071**	.157**	.054**	.377**	1				
oilres	.044*	.063**	0.031	-.041*	-.052**	1			
Renewbles consumpn	-.042*	.272**	.286**	.061**	0.021	.150**	1		
goilpr	.102**	.205**	0.026	.415**	.740**	0.008	.038*	1	
system	-.075**	.437**	.091**	0.035	0.013	-.084**	.143**	-0.011	1
govorient	-.077**	.148**	.070**	0.014	-.044*	-.102**	.194**	-0.028	.226**

F. OPERATIONALIZATION

Independent variables operationalization					
	Abbreviation	**Sources**	**#**	**Actor**	**Hypothesis**
RPS dummy	fit	Renewables	1,2	Internal	DV
+EU membership (non=1,2)	eumem	EU	3	Go-betw	H1a
+former colonizer RPS (1,2) without colonizers 0	colonizer_rps	CEPII, created	4	external	H2a
+former colonizer FIT (1,2),	colonizer_fit	CEPII, created	5	external	H2a
+CDM, dummy (non=1,cdm=2)	cdm	UNFCCC	6	Go-betw	H3a
+Foreign direct investment, (positive fdi =2, negative fdi=1)	fdi	WDI	7	external	H4a
+ %Main export partners	comfit	CIA Factbook	8	external	H5a
+ %Main export partners	comrps	CIA Factbook	9		
%Competitor CDM	compcdm	create	10	external	H6a
+%Competitor FDI	compfdi		11	external	H7a
+ Difference in mean renewable electricity share of FIT and nonFIT countries in each region, Total Renewable Electricity Net	regelshare_fit.nf	EIA	12	External	H8a
+Difference in mean renewable electricity share of RPS & nonRPS countries in each region	regrps_elshare.nrps	EIA	12	External	H8a
+ Difference in mean renewable electricity share of FIT and nonFIT countries in world,	wfit_elshare_nonfit	EIA	12	External	H9a
+Difference in mean renewable electricity share of RPS & nonRPS countries in world	wrps_elshare_nonrps	EIA	12	External	H9a
+Difference in mean CO_2 emissions (metric tons per capita) of fit & nonfit countries in each region	regfit_co2.nonfit	Created-WDI	13	External	H10a
+Difference in mean CO_2 emissions (metric tons per capita) of RPS & nonRPS countries in each region	reg_rps_co2.nrps	Created-WDI	13	External	H10a
+Difference in mean CO_2 emissions (metric tons per capita) of fit & nonfit countries in world	wfit_co2_nonfit	Created-WDI	13	External	H11a
+Difference in mean CO_2 emissions (metric tons per capita) of RPS & nonRPS countries in world	wrps_co2_nonrps	Created-WDI	13	External	H11a
Difference in mean GDP growth (annual %) share of RPS & nonRPS countries in each region	reg_rps_gdpg.nrps	Created-WDI	14	External	H12a
+ Difference in GDP growth (annual %) of FIT and nonFIT countries of each region	regfit_gdpg.nonfit	Created-WDI	14	External	H12a

+ Difference in GDP growth (annual %) of FIT and nonFIT countries in world	wfit_gdpg_nonfit	Created-WDI	14	External	H13a
+ Difference in GDP growth (annual %) of RPS and non-RPS countries in world	wfit_gdpg_nonfit	Created-WDI	14	External	H13a
+% of neighboring states with RPS	Nei_rps	created	15	External	H14a
+% of neighboring states with FIT	nei_fit	created	16	External	H14a
+% of countries with the same colonizer having FIT, countries without a colony coded 0	Commoncolony_fit	CEPII, created	17	External	H15a
+ % of countries with the same colonizer having RPS, countries without a colony coded 0	commoncolony_fit	CEPII, created	18		H15a
+ % countries with common language RPS	coml_RPS	CEPII, created	19	External	H16a
+ % countries with common language FIT	coml_FIT	CEPII, created	20	External	H16a
+Cartagena Protocol on Biosafety, dummy	cartagena	IEAD	22	Go-betw	H17a
+Kyoto Protocol from the United Nations Framework Convention on Climate Change,dummy	kyoto	IEAD	21	Go-Betw	H18a
+The Montreal Protocol on Substances that Deplete the Ozone Layer, dummy	montreal	IEAD	23	Go-betw	H19a
+CO_2 emissions (metric tons per capita)	Co2em	WDI	13	External	C(control
+Global oil price	goilpr	EIA	24	Go-betw	C
+GDP per capita (Current US$)	gdppc	WDI	25	internal	C
+Population	popul	WDI	26	internal	C
Government Orientation, -right, center, +left	govorient	WBDPI	27	internal	C
System (presidential, parliamentary)	system	WBDPI	28	internal	C
-Crude Oil Proved Reserves (Billion Barrels)	oilres	EIA	29	internal	C
+wind =Total Resource Area (km^2) at 50m, Classes 3-7	wind	Data Catalogue	30	internal	
+solar= total potential solar energy per year MWh/year	solar	Data Catalogue	31	internal	

G. ABM CODE

Setup

There are three types of actors: igos, nation_states and i_actors. At the setup they are initialized. In addition, competitors are identified for each country. Each country has five competitors. The countries also become members of international organizations. The six measures that will be reported at the end of each run are setup.

In the hypothetical world there are 100 countries. One country is located in each cell. The world is divided into 5 regions. Each country is member of the international organization in their region. There are 100 people. There is one person in each country.

```
;Setup and Initialization of Patches

to setup
  clear-all
  clear-all-plots

  create-igos 5 [ set color yellow ]

  ask patches [initialize-patches]
  ask nation_states [initialize-nation_states]
  ask igos [initialize-igos]
  ask i_actors [initialize-i_actors]
  ask turtles [initialize-turtles]
  setup-competitors
  setup-members

    ;; added code for purposes of measurement in behaviorspace

set max-power-difference power-differ
  set max-compliance-difference compliance-difference
  set max-regional-difference regional-proportion
  set lasttick_power 0
  set lasttick_comply 0
  set lasttick_region 0
```

```
  reset-ticks
end


to initialize-patches
sprout-i_actors 1 ; populate the world with 100 agents with one on each cell
  sprout-nation_states 1

  if pycor < 2 [
              set region 0
              set pcolor 56 ; A shade of green

              ]
if pycor >= 2  [
             set region 1
             set pcolor 8 ; A shade of grey

            ]
if pycor >= 4  [
             set region 2
             set pcolor 35 ; A shade of brown
            ]
if pycor >= 6  [
             set region 3
             set pcolor 118 ; A shade of violet
            ]
if pycor >= 8  [
             set region 4
             set pcolor 127 ; A shade of magenta
            ]

end
;"Go" and "Activate Dyad" Commands

;Initialization of Agents
to initialize-i_actors
set size .4
set color pink
set shape "person"

set i random 2
set i 0
ask n-of person=1 i_actors [set i 1]
if i = 1 [set color white]
```

```
set reelection random-float 1
ifelse reelection  < reelection=1 [set reelection 1] [set reelection 0]
set competitiveness random-float 1
ifelse competitiveness  < competitiveness=1 [set competitiveness 1] [set competitiveness 0]


end
to initialize-igos
ask igos [move-to one-of patches with [not any? igos in-radius 2] ]

ask igos [set member nation_states-on neighbors]

ask igo 1 [set membership  1]
ask igo 2 [set membership  2]
ask igo 3 [set membership  3]
ask igo 4 [set membership  4]
ask igo 0 [set membership 0]
ask igo 4 [move-to patch 3 9 ]
ask igo 3 [move-to patch 5 6 ]
ask igo 2 [move-to patch 3 4 ]
ask igo 1 [move-to patch 5 3 ]
ask igo 0 [move-to patch 4 1 ]


set shape "circle"
     set color cyan
     set size .4


set i random 2
set i 0
ask n-of igo=1 igos [set i 1]
if i = 1 [set color white]

end

to initialize-nation_states

  ;; NEED TO INITIALIZE ALL THREE TYPES OF ACTORS

set color black
set shape "star"
set size .9

ask nation_states [ if pycor < 2 [
```

```
                set membership 0
                ]]
ask nation_states [ if pycor >= 2 [

                set membership 1
                ]]
ask nation_states [ if pycor >= 4 [

                set membership 2
                ]]
ask nation_states [ if pycor >= 6 [

                set membership 3
                ]]
ask nation_states [ if pycor >= 8 [

                set membership 4
                ]]


set utility-star random-normal 2.5 1

 if             utility-star < 1 [set utility 1]
if utility-star >= 1 and utility-star < 2 [set utility 2]
if utility-star >= 2 and utility-star < 3 [set utility 3]
if utility-star >= 3 and utility-star < 4 [set utility 4]
if utility-star >= 4             [set utility 5]


set non-compliance-star random-normal 2.5 1

 if             non-compliance-star < 1 [set non-compliance 1]
if non-compliance-star >= 1 and non-compliance-star < 2 [set non-compliance 2]
if non-compliance-star >= 2 and non-compliance-star < 3 [set non-compliance 3]
if non-compliance-star >= 3 and non-compliance-star < 4 [set non-compliance 4]
if non-compliance-star >= 4             [set non-compliance 5]

set compliance-star random-normal 2.5 1

 if             compliance-star < 1 [set compliance 1]
if compliance-star >= 1 and compliance-star < 2 [set compliance 2]
if compliance-star >= 2 and compliance-star < 3 [set compliance 3]
if compliance-star >= 3 and compliance-star < 4 [set compliance 4]
if compliance-star >= 4             [set compliance 5]
```

```
if Power-Distribution = "Poisson" [
set power random-poisson 1 + 1
if power > 5 [set power 5]
]

if Power-Distribution =  "Normal" [
set power-star random-normal 2.5 1
if           power-star < 1 [set power 1]
if power-star >= 1 and power-star < 2 [set power 2]
if power-star >= 2 and power-star < 3 [set power 3]
if power-star >= 3 and power-star < 4 [set power 4]
if power-star >= 4            [set power 5]

]
if Power-Distribution = "Uniform" [
set power random 5 + 1
if power > 5 [set power 5]
]


set i random-float 1
ifelse i < probability-i=1 [set i 1] [set i 0]

if i = 1 [set color white]

set ruling-p random-float 1
ifelse ruling-p < party=1 [set ruling-p 1] [set ruling-p 0]


ifelse show-power? [set label power ] [set label ""]
set label-color black


end

to initialize-turtles
 set dependence random-normal 2.5 1

set popularity random-float 1
ifelse popularity < popularity=1 [set popularity 1] [set popularity 0]


end
```

```
to setup-competitors
  ask nation_states
  [
    set my-competitors n-of 5 nation_states with [ self != myself ]
  ]
end

to setup-members
  ask igo 0
  [
    set my-members nation_states with [pcolor = 56]

  ]

  ask igo 1
  [
    set my-members nation_states with [pcolor = 8]

  ]
   ask igo 2
  [
    set my-members nation_states with [pcolor = 35]

  ]

 ask igo 3
  [
    set my-members nation_states with [pcolor = 118]

  ]
  ask igo 4
  [
    set my-members nation_states with [pcolor = 127]

  ]

end
```

To go

In the go procedure randomly two agents will be activated at each time tick. One of them is the receiver nation state and the other is a sender, which can be another nation state, an igo or a person. These two agents interact. Based on the interaction rules, the nation states decides to adopt a new policy or keep the status quo. There are separate rules for each mechanism. One of the four mechanisms is selected in the interface.

```
to go
 activate-dyad
 interact
 ask nation_states [if i = 1 [set color white]]
 if not any? nation_states with [color = black] [stop]
 calculate-proportion-i
 calculate-proportion-region-i
 calculate-power
 calculate-compliance
 Ask nation_states [set compet_i mean [ i ] of my-competitors]
  Ask igos [set member_i mean [ i ] of my-members]
   measure-system
tick
end

to activate-dyad
ask patches [
  if region = 0 [set pcolor 56] ; Reset the previous sender and receiver
  if region = 1 [set pcolor 9] ; to their original color of their region
   if region = 2 [set pcolor 35] ; Reset the previous sender and receiver
  if region = 3[set pcolor 118] ; to their original color of their region
  if region = 4 [set pcolor 127] ; to their original color of their region
   ]
ask one-of patches [set pcolor red] ; select a random receiver
ask one-of turtles [ifelse any? igos-on patch-here [set pcolor green] [set pcolor random-color]] ;
select a random sender

ask nation_states [
  set r? false ; reset the previous receiver
  if pcolor = red [set r? true ]]
```

```
ask nation_states [
set s? false ;reset the previous sender
if pcolor = sky [set s? true]  ; set indicator for sender and receiver
  ]
ask igos [

 set s? false ;reset the previous sender
  if pcolor = red and breed = nation_states [set r? true]
   if pcolor = green [set s? true]  ; set indicator for sender and receiver
  ]

ask i_actors [

  set s? false ;reset the previous sender
if pcolor = yellow [set s? true]  ; set indicator for sender and receiver
  ]

set i-s count turtles with [ i = 1 and s? = true] ; update the indicators
set i-n count nation_states with [i = 1 and s? = true] ; update the indicators
set i-ig count igos with [i = 1 and s? = true] ; update the indicators
set i-iactor count i_actors with [i = 1 and s? = true] ; update the indicators


set p-r count nation_states with [ ruling-p = 1 and r? = true ]

set commitment-r count nation_states with [ commitment = 1 and r? = true ]

set popularity-iactor count i_actors with [popularity = 1 and s? = true]  ; update the indicators

set reelection-s count i_actors with [reelection = 1 and s? = true and i = 1]

set competitiveness-s count i_actors with [competitiveness = 1 and s? = true]

set mem_i count igos with [s? = true and member_i >= 0.5]

end

to measure-compliance
  set max-compliance-difference compliance-difference
end

to measure-system
       set max-power-difference power-differ
       set lasttick_power end-powerdiff

       set max-regional-difference regional-proportion
```

```
        set lasttick_region end-regiondiff

        set max-compliance-difference compliance-difference
        set lasttick_comply end-complydiff
end

;Interaction Rules
to interact

if Mechanism = "Coercion" [

if i-n = 1
and hierarchy > 0
and dependency > 0
[
ask nation_states with [r? = true] [set i 1]

]

if i-ig = 1
and cost >= 0
 [
ask nation_states with [r? = true] [set i 1]

]
if i-iactor = 1
and popularity-iactor = 1
 [
ask nation_states with [r? = true] [set i 1]

]
]
if Mechanism = "Competition" [
if i-n = 1
and hierarchy <= abs 1

 [
ask nation_states with [r? = true and compet_i >= 0.5 ] [set i 1]
]


if i-iactor = 1
and competitiveness-s = 1

 [
ask nation_states with [r? = true] [set i 1]
```

```
]
]

if Mechanism = "Emulation" [
if i-n = 1
and hierarchy <= abs 1
and neighbor = true

[
ask nation_states with [r? = true] [set i 1]
]
if i-ig = 1
and mem_i = 1


 [
ask nation_states with [r? = true  ] [set i 1]
 ]


if i-iactor = 1
and p-r = 1

 [
ask nation_states with [r? = true] [set i 1]

]
]
if Mechanism = "Learning" [
if i-n = 1
and hierarchy <= abs 1
and benefit >= 0

[
ask nation_states with [r? = true] [set i 1]
]
if i-ig = 1

 [
ask nation_states with [r? = true] [set i 1]
 ]
if i-iactor = 1
and reelection-s = 1

 [
```

```
ask nation_states with [r? = true] [set i 1]

]
]

end


;Reporters and Output


to-report regional-proportion
```

The code to update the largest regional difference within a run

```
  let difference-set [ ]

  set difference-set lput proportion-regionA-i difference-set
  set difference-set lput proportion-regionB-i difference-set
  set difference-set lput proportion-regionC-i difference-set
  set difference-set lput proportion-regionD-i difference-set
  set difference-set lput proportion-regionE-i difference-set

  let maxproportion max difference-set
  let minproportion min difference-set

  let maxdifference maxproportion - minproportion

  ifelse (maxdifference > max-regional-difference)
    [
     report maxdifference
    ]
    [
     report max-regional-difference
    ]

end

to-report end-regiondiff

  let thistime lasttick_region


  let difference-set [ ]
```

```
  set difference-set lput proportion-regionA-i difference-set
  set difference-set lput proportion-regionB-i difference-set
  set difference-set lput proportion-regionC-i difference-set
  set difference-set lput proportion-regionD-i difference-set
  set difference-set lput proportion-regionE-i difference-set

  let maxproportion max difference-set
  let minproportion min difference-set

  let maxdifference maxproportion - minproportion

  if (maxdifference >= max-regional-difference)
   [
    set thistime ticks
   ]

  report thistime

end


to-report compliance-difference
  let this-difference  compliance-with-i - non-compliance-without-i
  if (this-difference > max-compliance-difference)
  [set max-compliance-difference this-difference
  ]
  report max-compliance-difference
end

to-report end-complydiff

  let thistime lasttick_comply

  let this-difference  compliance-with-i - non-compliance-without-i
  if (this-difference >= max-compliance-difference )
  [
   set thistime ticks
  ]

  report thistime

end


to-report power-differ
      let this-difference power-without-i - power-with-i
```

```
        if (this-difference > max-power-difference)
              [
                    set max-power-difference this-difference
              ]
        report max-power-difference
end

to-report end-powerdiff

  let thistime lasttick_power

          let this-difference power-without-i - power-with-i
          if (this-difference >= max-power-difference )
          [
            set thistime ticks
          ]

    report thistime
end


;max-power-difference
;max-regional-difference
;max-compliance-difference
;lasttick_power
;lasttick_comply
;lasttick_region

 to-report igo-membership
ask nation_states with [r? = true] [set membership-r membership]
 ask igos with [s? = true] [set membership-s membership]
 report membership-r - membership-s
end

to-report cost
 ask nation_states with [r? = true] [set compliance-r compliance]
 ask nation_states with [r? = true] [set non-compliance-r non-compliance]
 report non-compliance-r - compliance-r
end

to-report benefit
ask nation_states with [s? = true] [set utility-s utility]
ask nation_states with [r? = true ] [set utility-r utility]
report utility-s -  utility-r
end
```

```
to-report dependency
ask turtles with [s? = true] [set dependence-s dependence]
ask nation_states with [r? = true ] [set dependence-r dependence]
report dependence-s -  dependence-r
end

to-report hierarchy
ask nation_states with [s? = true] [set power-s power]
ask nation_states with [r? = true ] [set power-r power]
report power-s -  power-r
end

to-report neighbor
ask nation_states with [s? = true] [set neighborhood-s region]
ask nation_states with [r? = true] [set neighborhood-r region]
ifelse neighborhood-s = neighborhood-r [set same-region? True] [set same-region? false]
report same-region?
end

to-report trade

ask nation_states with [s? = true] [set tp-s tp]
ask nation_states with [r? = true] [set tp-r tp]
ifelse tp-s = tp-r  [set trade? true] [set trade?  false]
report trade?
end

to-report random-color
  report one-of [sky yellow]
end



to calculate-proportion-i
set-current-plot "Proportion of States with i=1"
let number_i count nation_states with [i = 1]
let number_nation_states count nation_states
let proportion-i number_i  / number_nation_states
plot proportion-i
end

to calculate-proportion-region-i
set-current-plot "Regional Difference"

set-current-plot-pen "RegionA"
let number_regionA_i count nation_states with [i = 1 and region = 0]
```

```
let number_regionA_nation_states count nation_states with [region = 0]
set proportion-regionA-i number_regionA_i  / number_regionA_nation_states
plot proportion-regionA-i

set-current-plot-pen "RegionB"
let number-regionB-i count nation_states with [i = 1 and region = 1]
let number-regionB-nation_states count nation_states with [region = 1]
set proportion-regionB-i number-regionB-i  / number-regionB-nation_states
plot proportion-regionB-i

set-current-plot-pen "RegionC"
let number_regionC_i count nation_states with [i = 1 and region = 2]
let number_regionC_nation_states count nation_states with [region = 2]
set proportion-regionC-i number_regionC_i  / number_regionC_nation_states
plot proportion-regionC-i

set-current-plot-pen "RegionD"
let number-regionD-i count nation_states with [i = 1 and region = 3]
let number-regionD-nation_states count nation_states with [region = 3]
set proportion-regionD-i number-regionD-i  / number-regionD-nation_states
plot proportion-regionD-i

set-current-plot-pen "RegionE"
let number-regionE-i count nation_states with [i = 1 and region = 4]
let number-regionE-nation_states count nation_states with [region = 4]
set proportion-regionE-i number-regionE-i  / number-regionE-nation_states
plot proportion-regionE-i

end

to calculate-power
set-current-plot "Power Difference"
set-current-plot-pen "Mean-i=0"
set power-without-i mean [power] of nation_states with [i = 0]
plot power-without-i
set-current-plot-pen "Mean-i=1"
set power-with-i mean [power] of nation_states with [i = 1]
plot power-with-i

end

to calculate-compliance
set-current-plot "Compliance Difference"
set-current-plot-pen "compliance-i=1"
set compliance-with-i mean [compliance] of nation_states with [i = 1]
plot compliance-with-i
```

```
set-current-plot-pen "non-compliance-i=0"
set non-compliance-without-i mean [non-compliance] of nation_states with [i = 0]
plot non-compliance-without-i

end
```

VITA

Khatera Alizada
Graduate Program in International Studies
7045 Batten Arts & Letters
Hampton Blvd
Old Dominion University
Norfolk, VA 23529

Khatera Alizada earned her undergraduate degree in political science specializing in American politics and international relations from Old Dominion University in Norfolk, Virginia. She spent a semester studying abroad at Leicester University, Leicester, UK. She holds a Master's degree in International Peace and Conflict Resolution from American University's School of International Services in Washington D.C. where she received the Hall of Nations Fellowship Award. While completing her doctoral degree at Old Dominion University, she performed the function of graduate assistant and participated in International Studies Association's Annual Conventions.

EDUCATION

2017	Ph.D., International Studies, Old Dominion University
2012	M.A., International Peace and Conflict Resolution, American University
2010	B.S., Political Science, Old Dominion University
2008	Study Abroad, Leicester University, Leicester, England