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Understanding the Mechanisms of Diffusion of National Renewable Energy Targets

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B.A. Universidad Católica Argentina, 2016

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An abstract of
A thesis submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
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Abstract

Understanding the Mechanisms of Diffusion of National Renewable Energy Targets

By Candelaria Bergero

This thesis aims to better understand the mechanisms of diffusion of national renewable energy targets in 187 countries from 1974 until 2017. It does so with a systems framework by invoking the Panarchy adaptive cycle, and by understanding policy as a theory of social change. The research design uses a mixed methods approach, combining an event history analysis (EHA) and a qualitative comparative analysis (QCA). The outcome of interest is the first national renewable energy target adopted in each country. Targets are adopted through policies, thus this research analyzes four mechanisms of policy diffusion: learning, economic competition, emulation and coercion. Additionally, the control variables of oil price, population size, energy use per capita, and income are taken into account. The results from both the EHA and QCA suggest that countries emulate each other with respect to renewable energy target adoption. Target adoptions appear proportional to oil price and inversely proportional to population size - most countries adopt the policy when oil prices are high and population size is small. However, QCA results also suggest the presence of the other mechanisms of policy diffusion, showing a total of ten combinations of variables that lead to target adoption, therefore contemplating for equifinality and conjunctural causation.

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Understanding the Mechanisms of Diffusion of National Renewable Energy Targets

In this research, the author attempts to understand what mechanisms drive countries to adopt policies of renewable energy targets for the first time. A systems framework is used to better apprehend this phenomenon. This research is developed with a mix methods approach, combining a quantitative and qualitative analysis. Because of this broad approach, the thesis is divided into eight parts. The first part describes system models that have been applied to analyze change in social-ecological systems and it introduces the *Panarchy* adaptive cycle (1). In the second section (2) the author applies the system heuristic of the adaptive cycle to the adoption of renewable energy targets. The third part (3) introduces the relevant literature regarding policy diffusion from political science, as well as the four hypotheses to test. Part four (4) describes the methodology used in this research, which includes an event history analysis and a qualitative comparative analysis. In the following section (5) the author presents the study design with all the variables analyzed, as well as their operationalization. Part six (6) presents the results from each methodology, as well as a combined analysis that compares both. The last two parts include the discussion and policy implications (7) and the conclusions from this thesis (8).

1. Models of Change in Social-Ecological Systems

1.1 What is a System?

Given the complexity of life, it is useful to conceive the different dimensions of reality as different systems interacting with each other. A system, or systems framework, is one way of simplifying the complex, and focusing on the emergence of dynamic processes. A system is an abstract set of ideas that involves setting boundaries (usually in space or time) that define the limits to the system. Once boundaries are established, then inputs and outputs can be identified as entities (such as energy, information, materials) that move into and out of the system's boundaries. Within the system, components are identified, along with the rules or processes that mediate the interaction among these components. Different fields have adopted (and sometimes rejected) systems approaches. For example, systems frameworks are still used in ecological and earth sciences, as well as the social sciences.

1.2 Political Systems

David Easton (1957) introduced systems thinking into political science. For the author, it was relevant to view political life as a system of interrelated activities, understanding system as an interdependence of parts and a delimiting boundary: there are different elements interacting with each other in a given scenario. A political system (Figure 1) has inputs (which Easton defined as demands and support for the political system), outputs (which are decisions or policies made by the government), and an environment (the broader context within which the political system is embedded). The model includes a feedback loop in which individuals and groups react to the policy outputs and their consequences, which in turn, generates a new set of demands and supports for the political system. Easton mostly focused on the State[1], although his model has also been applied to subnational governments such as states, counties, or cities.

Easton focused on a political system, but acknowledged that in real life political issues cannot be isolated from the rest of social activity, and that different systems interact with one another.

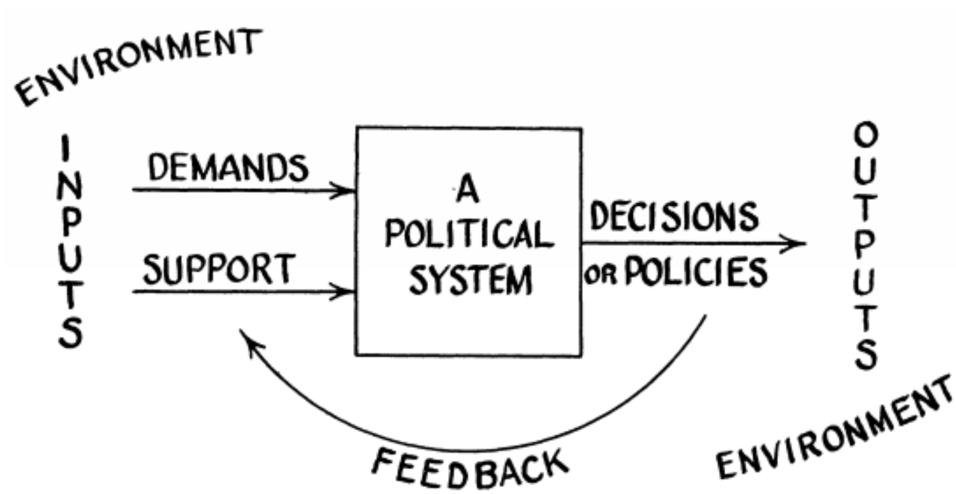

Figure 1. A political system
The system has inputs, a black box, outputs, feedbacks and an environment.
Source: Easton (1957)

It is important to assimilate the concept of systems because "much of what happens within a system has its birth in the efforts of the members of the system to cope with the changing environment" (Easton, 1957: 386). The environment, which Easton defined

[1] Along this work, State with a capital "S" refers to national entities; states with lowercase "s" refers to subnational entities.

broadly to encompass the social, economic, cultural, and physical environment in which political systems are embedded, is constantly changing, and this change may spark a shift in the configuration of a system.

1.3 Social-Ecological Systems

Theoretically, humans tend to see systems as individual entities. However, different systems are in constant relation with one another. For Ostrom (2009), the fact that humans fail to connect different systems has caused the loss of fisheries and forests, and the contamination of water systems, among others. There is a need for a common framework, and Social-Ecological Systems (SESs) is one approach. For Ostrom, SESs are analogous to organisms in the sense that there are multiple subsystems and internal variables within those subsystems: organisms are composed of organs, organs of tissues, tissues of cells, and so on, and so forth (Ostrom, 2009: 419).

The strength of SESs is that they emphasize the integrated concept of humans in nature, and the fact that the delineation between social and ecological systems is both artificial and arbitrary (Folke et al., 2005: 443). Social-ecological systems have strong reciprocal feedbacks, and are thus complex adaptive systems.

1.4 Simple Models of Change

Changes in a system can occur due to different disturbances. Olsson et al. (2006) introduced three triggers of change: (1) ecological crises, (2) shifts in the social components of the system (as is the case with social values or resources), and (3) economic or political change.

The shifts in a system are related to the notion of transformative change introduced by Walker et al. (2004). The authors defined transformability as one of the three attributes of social-ecological systems, the other two being resilience and adaptability. Resilience relates to the capacity of a system to absorb disturbance and continue its functions. Adaptability is related to the capacity of actors in the system to manage resilience. Transformability "is the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable" (Walker et. al, 2004). There is a major disturbance that undermines a system's resilience, and therefore its adaptability, and forces this system to transform into a new configuration.

Table 1. Three attributes of social-ecological systems
Source: Walker et al. (2004)

Resilience	**Adaptability**	**Transformability**
"Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks"	"Adaptability is the capacity of actors in a system to influence resilience. In a SES, this amounts to the capacity of humans to manage resilience"	"The capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable"

The uncertainty during a transformation is such that Olsson et al. (2006) referred to transformative change with the metaphor of "shooting the rapids", given the similar periods of abrupt change and turbulence of previous rules and social mechanisms.

The uncertainty in periods of change is such that governance can present several challenges. A governance system refers to “the interaction patterns of actors with conflicting objectives and the instruments chosen to steer social and environmental processes within a particular policy area” (Olsson et al., 2008: 9489). In other words, governance refers to the interactions of several actors with different, usually opposing, objectives, and how they end up influencing policy, the authoritative actions of governments. Adaptive governance refers to institutional and political frameworks that are designed to adapt to changing relationships between society and ecosystems (Carpenter & Folke, 2006). It is adaptive because it contemplates for a system’s inherent potential for change, and acts accordingly. Given that change is a constant, and systems are continually facing disturbances, an adaptive governance approach should be the horizon for dealing with these systems.

Olsson et al. (2006) analyzed how certain case-studies underwent through three specific phases of transformation towards adaptive governance: a preparation phase, a transition phase, and a resilience-building phase. A window of opportunity merges the preparation and the transition phase.

The preparation phase consists of exploring new system configurations and alternatives, as well as developing strategies for sorting these alternatives in the pursuit of adaptive governance. There are three critical factors in this phase: learning networks, networking and leadership. Learning networks provide the knowledge needed in order for change to be viable, and leaders guide this change. Networking is the process by which leadership and networks exchange knowledge and experience. Within the concept of a learning network, the authors introduce the notion of shadow networks. These are informal networks that group people and that tend to experiment and generate solutions to existing problems. Shadow networks are crucial transformations towards adaptive governance because they facilitate information flows, identify knowledge gaps, and create expertise. These groups may be more free to develop alternative policies, which can lead to a system transformation.

A window of opportunity links the preparation phase with the transition phase. According to Kingdon (2003), for the window of opportunity to appear there needs to be an alignment of three different elements: problems, solutions and politics - which translates into problems awareness, available solutions and political action. Usually rapid change and ecological crises provide windows of opportunity that trigger the emergence of new networks and promote new forms of governance. Environmental crises, policy failures, fiscal crises, activist groups, lawsuits, or a combination of these (Olsson et al., 2006) are good examples of these triggers.

The transition phase is “unpredictable and turbulent” and therefore the authors relate it to the metaphor of “shooting the rapids”. The rapids “can only be navigated, not planned” (Olsson et al., 2006: 18). In this stage, preparation, flexibility and the ability to improvise are key factors. The last phase consists of building resilience for future challenges; it is about preparing the system to absorb a certain degree of disturbances without losing its core functions. The three phases of transformation, as well as the window of opportunity, are illustrated in Figure 2.

The three phases of transformative change described by Olsson et al. (2006) relate to the four stages of an adaptive cycle heuristic proposed by Gunderson and Holling (2002) in *Panarchy*. Panarchy is the Greek god of nature, and the term is used to reflect the notion of both change and continuity - both the predictability and the unpredictability of systems.

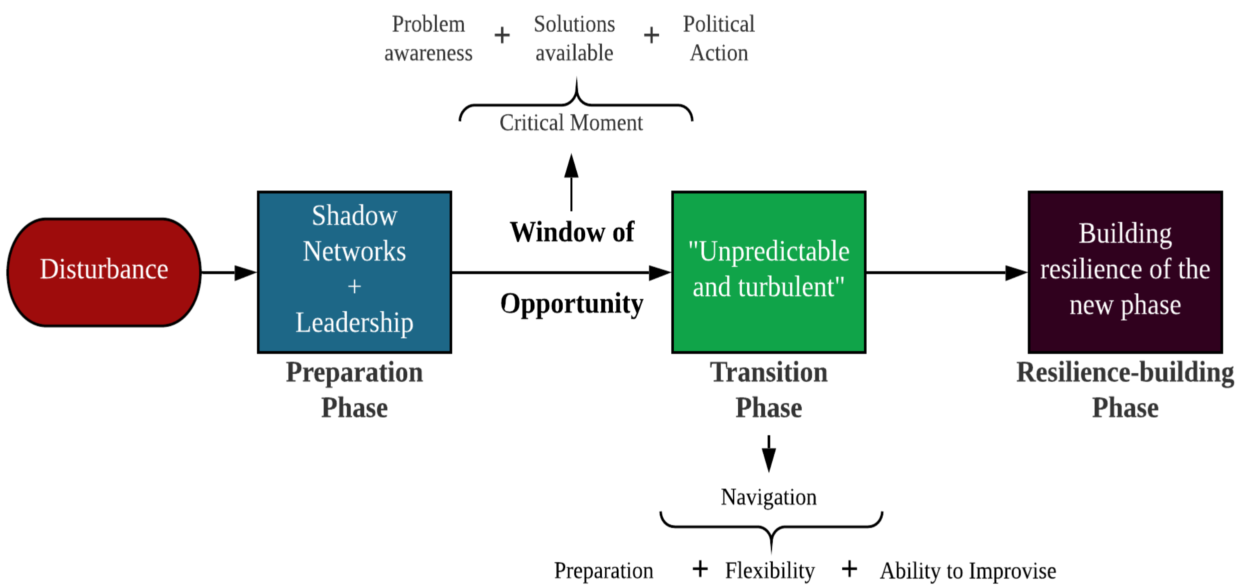

Figure 2. The three phases of transformation in Social-Ecological Systems
The first phase is a preparation phase, in which key groups and leaders can provide context for defining emergent problems, solutions and actions. The second phase is transition, which leads to a new system configuration. The last phase is about building resilience.
Source: Modified from Olsson et al. (2006)

The adaptive cycle discussed in *Panarchy* develops in two main dimensions: potential for transformation (y-axis) and the degree of connectedness between variables (x-axis). In ecological terms, the cycle begins with an exploitation phase (**r**) where there is a rapid colonization of recently disturbed areas. This exploitation phase derives into a conservation phase (**K**) where there is a slow accumulation and storage of energy. During the late **K** phase a little leverage is likely to result in a large and unpredicted change. The **K** phase is followed by an abrupt release (**Ω**), where the accumulation of biomass and nutrients becomes increasingly fragile until it is suddenly released (this can happen through forest fires, droughts, insect pests, etc.). The final stage is the reorganization (**α**) of the system, in which soil processes minimize nutrient loss and reorganize the properties of the system, preparing it for a new exploitation phase, thus perpetuating the cycle (Gunderson & Holling, 2002).

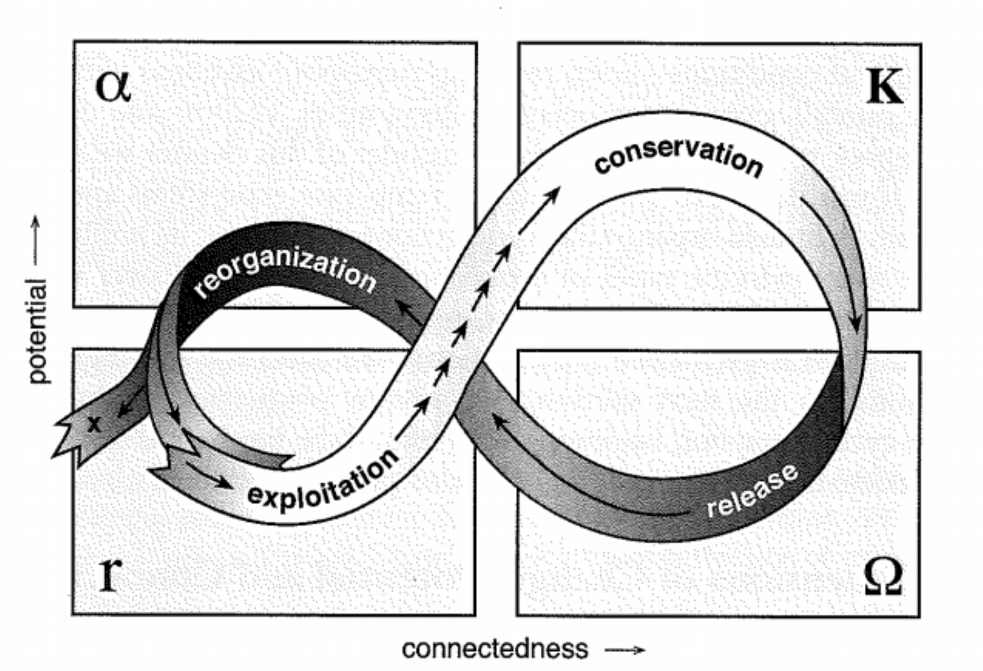

Figure 3. The Panarchy adaptive cycle
The cycle has four phases that represent slow growth, abrupt change, and new a new system's configuration. The cycle develops on two axis: potential for change and connectedness of the parts.
Source: Gunderson & Holling (2002)

This cycle was originally derived from the natural sciences, but can accurately apply to the social sciences as well. In social systems, "panarchical change can occur only when a triggering event unlocks the social and political gridlock of larger levels in the panarchy" (Gunderson & Holling, 2002: 91). Political scientists Frank Baumgartner and Bryan Jones (2013) referred to this as "punctuated equilibrium," and noted that it is this disruption that opens up the status quo to new actors, ideas, and solutions that often leads to non-incremental policy change. This four-phase model provides a useful framework for explaining change: periods of slow growth along with the implementation of certain policies, a crisis triggered by some event, new policies to adapt to a changing configuration, followed by a new system structure.

The preparation phase studied by Olsson et al. (2006) mostly relates to the transition between the exploitation phase (**r**) and the conservation phase (**K**), where after the exploitation and accumulation of resources, the system is ready to change. The window of opportunity strongly resonates with the release phase (**Ω**), where a crisis triggers the rethinking of the system and opens opportunities for change that were not previously available. The transition phase merges the release phase (**Ω**) to the reorganization phase (**α**). Resilience building happens in the reorganization phase (**α**), which leads to a new exploitation phase (**r**).

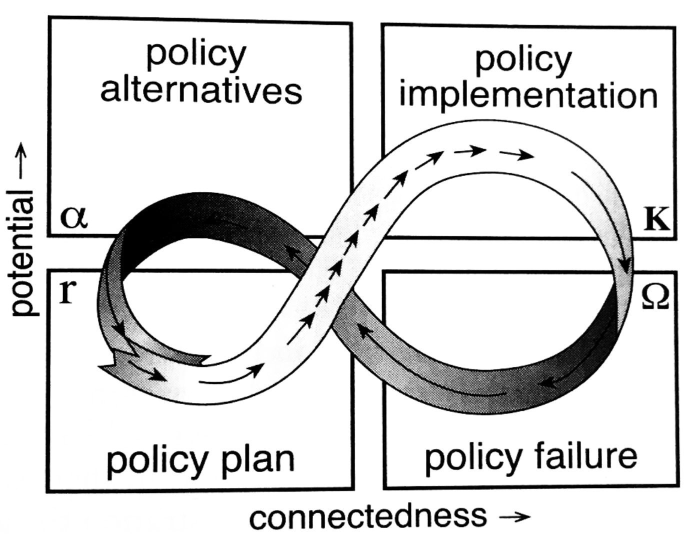

Figure 4. The *Panarchy* adaptive cycle applied to policy
The four phases of the adaptive cycle relate to the planning of a policy, its implementation, future failure, and the search for alternatives.
Source: Gunderson & Holling (2002)

In terms of policy, the adaptive cycle can serve as a useful framework for understanding change. As seen in Figure 4, the exploitation phase (**r**) can be identified to the planning of a policy. The conservation phase (**K**) is related to the implementation of a policy. Policy failure (release phase, **Ω**) triggers the pursuit for policy alternatives (reorganization, **α**).

The framework of an adaptive cycle (Figure 3 and 4) is used to interpret changes in national level energy policy, as described in the next section.

2. The Adaptive Cycle and the Development of a Fossil-Fuel-Based Economy

2.1 Navigating the Adaptive Cycle: From **r** to **K** Phase

The adaptive cycle described in *Panarchy* begins with an exploitation phase (**r**), that develops into a conservation phase (**K**). Renewable energy targets are, in part, a result of fossil-fuel exploitation. The exploitation phase of the adaptive cycle therefore relates to the rise of the fossil-fuel-based economy.

Bithas and Kalimeris (2016) explained how humankind went from wood as a primary energy source for society to oil as the primary source. For these authors (*op. cit*), the adoption of an "organic energy economy" began with the mastery of fire. This biomass consumption led to great progress of nomadic tribes: people were able to cook in stoves, develop pottery, and finally melt metals. The second stage of the organic energy economy was the Agricultural Revolution, where nomadic tribes turned into sedentary civilizations, with a great acceleration of population growth. Population growth put a great pressure on available resources - pressure released by the Industrial Revolution.

The steam engine, originally invented to pump water out of coal mines, became a machine used for extracting more coal and for powering ships and trains. The steam engine, improved by the Scottish inventor James Watt, "laid the foundation for today's complex and energy intensive human (economic) systems" (Bithas & Kalimeris, 2016: 7). During the 18th and 19th centuries, regulations were imposed to stop logging due to depletion of this resource. This caused wood-fuel prices to increase and thus fomented coal power. By 1900, steam-engines provided two-thirds of all power services (Bithas & Kalimeris, 2016).

As with wood-fuel, coal was over-exploited. After 1880, the combustion engine was invented in Germany and started to replace the steam engine. The combustion engine was propelled by refined oil, which replaced coal. In the late 1960s, oil production peaked in the United States. However, a couple of years later, oil consumption faced a major challenge. The two oil shocks of 1973 and 1979 led to a rapid increase in alternatives to oil: from natural gas and nuclear to geothermal and biofuel (Bithas & Kalimeris, 2016). Figure 5 depicts the world's primary energy production by source from 1900 until 2014.

To summarize these transitions, coal was added to biofuel in the early 20th century; oil overcame coal and peaked in the 1960s; natural gas (which had spread after World War II), hydropower, nuclear power and geothermal became more common during the 1970s; and biofuel, which had been increasing throughout the 20th century, became more popular by the 21st century (Bithas & Kalimeris, 2016). The logic continued to be the same: demand would grow until humans deplete a resource (or are close to doing so), which led to the discovery of a new resource. The exploitation of a resource would face a crisis and collapse, which would lead to a window of opportunity for a new resource to be exploited. During a very long period of time, fossil fuels were (and still are) the main source of energy production.

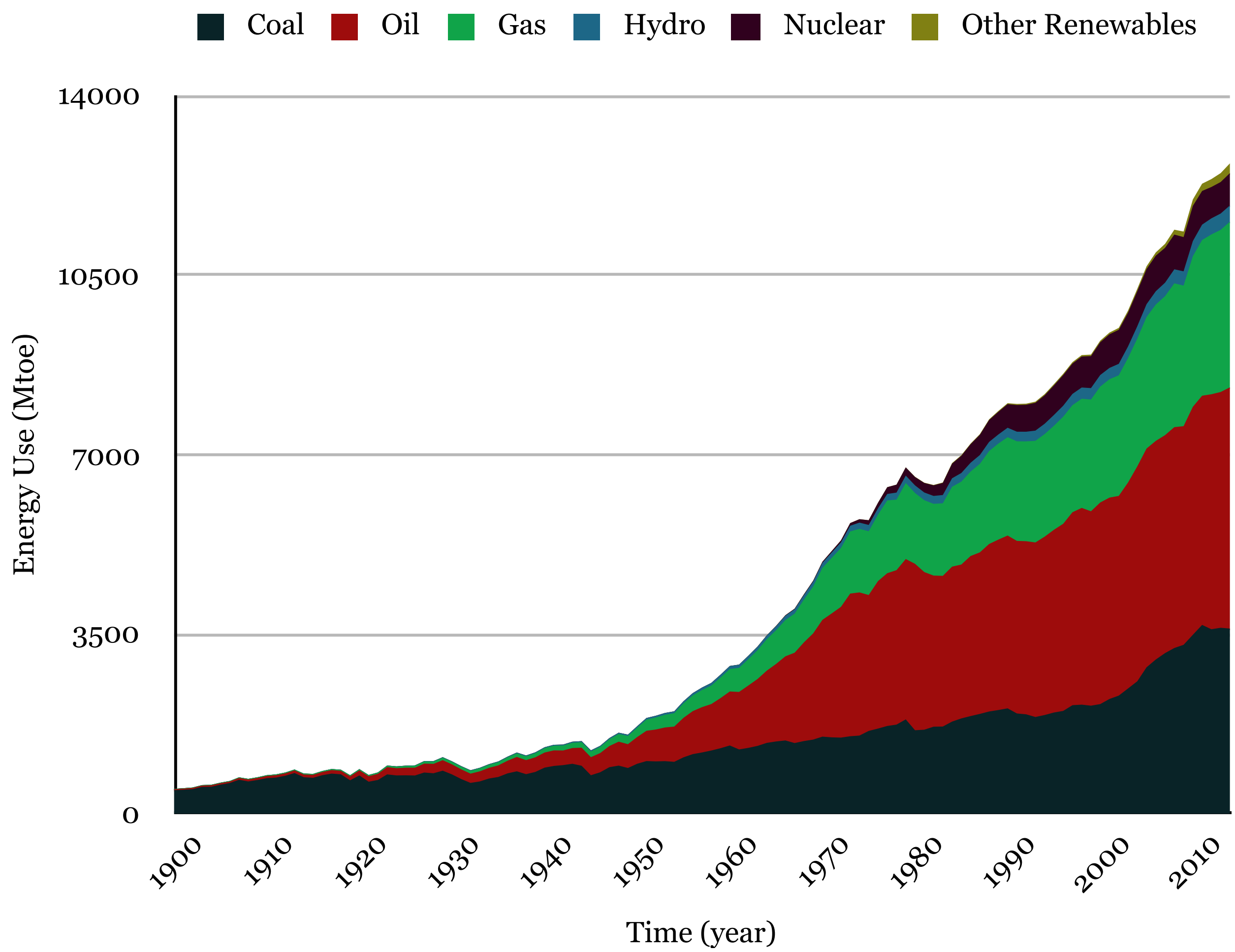

Figure 5. Global primary energy production (1900-2014)
Primary energy production around the world. The different colors represent different resources in million tones of oil equivalent.
Source: Modified from Etemad et al. (1991) & US EIA Historical Statistics (n.d.)

2.2 Navigating the Adaptive Cycle: From Late **K** to **Ω** Phase

The adaptive cycle described in *Panarchy* continues from the late conservation phase (**K**) to the release phase (**Ω**). In terms of renewable energy, this transition is related to the crises that changed people's perceptions of a fossil-fuel-based economy, and led to the development of renewable sources of energy such as hydropower, geothermal and nuclear.

During the 1970s there were two very important events that led to a crisis of the oil-based economy, and therefore to the consideration of alternatives to fossil fuels. On the one hand, the environmental movement was born; on the other hand, the oil shocks of the 1970s caused the price of oil to dramatically increase. Using the transition model of Olsson et al. (2006), the release phase of oil-based energy policy was triggered during the 1970s by an ecological crisis, by shifts on social values, and by an economic and political change.

During the 1960s the advancement of science allowed for new knowledge. A clear example of this relates to the measurements of Charles David Keeling in the Mauna Loa Observatory of carbon dioxide concentrations in the atmosphere, as well as the composition of these concentrations. The Swedish scientist Svante Arrhenius had written in 1896 that the mean temperature of the Earth was influenced by carbon dioxide (which he called "carbonic acid"), since atmospheric gases absorbed "considerable quantities of heat" (Arrhenius, 1896: 238). Keeling continued this work and, almost a century later, found enough evidence to show that the atmospheric concentrations of carbon dioxide followed seasonal oscillations, that they were steadily increasing, and that this increase was notoriously produced by combustion of fossil fuels (Keeling, 1973; Keeling et al., 1976). This discovery was very important in raising awareness of the environmental consequences of the fossil-fuel-based economy.

Along with a better scientific understanding of the environment's depletion, an environmental concern appeared in the late mid-twentieth century. "The story starts with the massive effort of an epistemic community of environmentalists working under the auspices of the International Council of Scientific Unions in the late 1960s" (E. Haas, 1990: 140). Their studies then spurred a 'flurry' of environmental legislation in the industrialized countries, which led to the United Nations (U.N.) Conference on the Human Environment of 1972, an attempt from the Western governments to create an international program to guarantee higher environmental standards. Developing countries were immediately opposed to this, arguing that such standards would make industrialization more expensive to them. Finally, these countries came to an agreement and the United Nations Environmental Program (UNEP) was created in 1972 (E. Haas, 1990: 140-2). This institution "brought about the acceptance of environmental concerns as fully legitimate in nations where the issue had never before been raised" (E. Haas, 1990: 141). The creation of UNEP introduced the environment to politics, legitimizing a phenomenon that was already happening, and giving a tangible face to tacit voices. Knowledge changed human aspirations; consensual knowledge guided policy-making (E. Haas, 1990: 11). By consensual knowledge Haas (1990) meant "the sum of both technical information and of theories about it that command sufficient agreement among interested actors at a given time to serve as a guide to public policy" (p. 74). This knowledge was not perfect: it was the product of consensus, and it was this consensual feature that urged action. In a sense, this knowledge shifted people's values towards environmental protection.

The other important phenomenon that opened a window of opportunity relates to the oil crises of 1973 and 1979, which awakened the industrial world of its dependence on cheap oil. The five countries[2] of the Organization of the Petroleum Exporting Countries (OPEC), who controlled 36% of the oil market, decided to decrease production in order to increase oil prices, in the margin of the Arab-Israeli war. This raised the price of oil

[2] Iraq, Iran, Kuwait, Saudi Arabia and Venezuela.

four times. In 1979 Iran's Shah was deposed and the price raised again (Campbell & Laherrère, 1998). Both crises showed the world that oil was not an infinite resource, thereby sparking investment in other sources.

Debates also arose about the time horizon of non-renewable fossil fuels, especially oil. According the Campbell and Laherrère (1998), the next oil flow restriction would not be temporary. Oil industry reports (Campbell & Laherrère, 1998) indicated that oil would remain plentiful and cheap for 43 years (until 2041). Campbell and Laherrère (1998) argued that the world would be transitioning from conventional oil closer to 2010. They (*op cit.*) argued that the four-decade estimate was wrong because of three factors. First, oil reports relied on distorted estimates on reserves, since exaggerated estimates could raise the price of an oil company's stock or allow a country to export more oil. Second, there was an assumption that production would remain constant, which is usually not the case, since demand increases. And third, reports assumed that the rate of extraction remained constant, when in reality the yield of oil from a field declines when about half of the crude oil reserve is gone (as predicted by Shell Oil company's geologist King Hubbert developed a model in 1956).

Oil reserves are decreasing while oil demand is increasing 2% a year. This will lead to higher oil prices. Therefore, from an economic point of view, alternatives to oil are a reasonable path. As Campbell and Laherrère (1998) concluded, natural gas, "safer nuclear power, cheaper renewable energy, and oil conservation programs could all help postpone the inevitable decline of conventional oil (...) Countries should begin planning and investing now" (p. 83).

2.3 Navigating the Adaptive Cycle: From **Ω** to **α** to **r** Phase

Following a release phase (**Ω**), *Panarchy's* adaptive cycle continues to the reorganization phase (**α**). After the **α** phase, the new systems configuration starts with a new exploitation phase (**r**). The cycle then repeats itself with the new configuration.

For renewable energies this transition is most visible in the adoption and implementation of policies that will foment the transformation from a fossil-fuel-based economy into a renewable-energy-based economy. This transition, however, is neither linear nor equal for all countries. There are interests aligned with the current system configuration, and some sectors are benefiting from such a system's arrangement. Given that change is initially costly and extremely uncertain, there may be pushbacks for a new configuration – pushbacks that delay or even halt the system's transformation. This directly affects the adoption and implementation of a policy.

This paper focuses on the adoption of renewable energy targets and not on their implementation. For this reason, policy implementation along the adaptive cycle will not be further developed.

To summarize these two sections, humans create conceptual models of different systems in order to better understand complex relationships between different elements within different systems. While doing so, it is important to remember that these constructions are both artificial and arbitrary. The concept of social-ecological systems (SESs) is very useful in bridging this gap; in constantly stressing that systemic constructions are nothing more than constructions, and that real life interactions are complex and dynamic.

Within these models, this research finds the adaptive cycle introduced in *Panarchy* as a useful framework in order to understand the transition from a fossil-fuel based economy into a more sustainable energy production model. Now this thesis will proceed to explain more specific concepts related to the adoption of renewable energy targets.

3. Changes in National Energy Policy

3.1 Definitions

3.1.1. Policy

A policy is a program of action from a public authority that enjoys governmental legitimacy (Parada, 2002) - a policy is a guidance frame for action (Meny & Thoenig, 1992). This program of action is designed to address a democratically defined objective. Policies address a social problem and therefore aim to change or modify a social reality, which is why every policy implies a theory of social change (Meny & Thoenig, 1992). For a policy to exist, a normal topic has to be considered a priority issue by both government and society (Tamayo, 1992).

3.1.2. Renewable Energy

Renewable energies are “all forms of energy produced from renewable sources in a sustainable manner” (IRENA, 2009). A renewable source is one where the use or interception rate (flow of energy extracted by humans) is approximately equal to the rate at which the energy is replenished or created. This is contrasted to non-renewable energy sources (such as coal or oil) in which the use rate is greater than the rate of creation.

IRENA (2009) categorizes renewable energies as: 1. bioenergy; 2. geothermal energy; 3. hydropower; 4. ocean energy[3]; 5. solar energy; and 6. wind energy.[4]

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[3] Including tidal, wave and ocean thermal energy.

[4] Note that nuclear power is not included in the International Renewable Energy Agency’s statute.

3.1.3. Renewable Energy Target

A renewable energy target is

> "an official commitment, plan or goal set by a government (at the local, state, national or regional level) to achieve a certain amount of renewable energy by a future date. Targets may be backed by specific compliance mechanisms or policy support measures. Some targets are legislated while others are set by regulatory agencies, ministries or public officials" (REN, 2017: 218).

3.1.4. Policy Diffusion

Broadly speaking, there are three subfields in political science that interact with the concept of policy diffusion: American politics, comparative politics and international relations (Graham et al., 2013). The first of these three to begin studying diffusion was American politics, when Walker (1969) published his paper on T*he Diffusion of Innovations among the American State*s. Walker defined "diffusion of innovations" 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" (p. 881). Walker wondered why some American states acted as pioneers by adopting new programs more rapidly than others, and how these new policies spread among states. After analyzing eighty-eight different policies enacted by at least twenty legislatures prior to 1965, Walker observed that the adoption of new programs was more likely to happen in places that were bigger, richer, more urban, more industrial, had more fluidity and turnover in their political systems, and had legislatures which more adequately represented their cities. Walker concluded that policies diffuse because decision makers emulate other states that proved to be successful; since decision makers face similar problems, and they do not have the capability to absorb all the knowledge needed to find the best solution to the state's problems, decision makers decide to emulate other states.

Some years later, Savage (1985) defined policy diffusion as a policy change, which was either pushed by the federal government, or by the states independently. The author observed how policies were diffusing among American states even without intervention from the federal government. Certain conditions, such as a sophistication of communication technology, the development of propagation agencies, and homogenization of sociocultural and economic structures in the United States could have led to the spread of policies. Shipan and Volden (2008) defined policy diffusion as "the spread of innovations from one government to another" (p. 841).

In the field of comparative politics, Weyland (2005) defined policy diffusion as "the adoption of the same innovation in diverse settings" (p. 267). For Tews (2005), writing in both the fields of comparative politics and international relations, policy diffusion referred to the spread of innovations among countries in the international system due to communications between these countries.

In the field of international relations, Graham et al. (2013) stated that "diffusion occurs when one government's decision about whether to adopt a policy innovation is influenced by the choices made by other governments" (p. 675). Policy diffusion is a process of the adoption and adaptation of policy innovations among different countries in the international system, where different sub-mechanisms are in play. For the authors (*opt cit.*), it was important to take into consideration the dynamics of the international system and national factors of each country, since both of these factors provided the context for diffusion or non-diffusion. To obtain the whole picture, the authors argued, one needs to include a micro- and meso-level perspective to policy diffusion.

For Busch et al. (2005), "diffusion refers to an international spread of policy innovations driven by information flows rather than hierarchical or collective decision making within international institutions" (p. 147), which is similar to Peter Haas' (1992) idea of the epistemic community. For Busch et al., environmental regulatory instruments spread even in the absence of international agreements. Both Graham et al. (2013) and Busch et al. (2005) indicated that the dynamics of the international system, domestic factors, and policy characteristics could affect international diffusion patterns.

There seems to be a consensus among scholars that study American politics, comparative politics and international relations that policy diffusion is related to the adoption of an innovative policy by one entity (city, state or country) based on the earlier adoption by another entity. It is important to differ here between policy diffusion and policy adoption. Diffusion is a part of the larger process of adoption. Diffusion is related to the movement of a policy across jurisdictional boundaries. Adoption is the decision of establishing a policy in a singular place (Karch, 2007).

3.2 The Mechanisms of Policy Diffusion

Since there is general agreement that policies do diffuse (Shipan & Volden, 2008), the most recent generation of publications focuses mainly on the mechanisms by which policies diffuse. Shipan and Volden (2008) suggested that diffusion is not merely a geographic clustering of similar policies. In a time where communications have no boundaries, this explanation would be a limitation. There are several mechanisms by which policies diffuse and there is little consensus on the categorization of these mechanisms: different authors tend to name similar mechanisms in different ways.

Busch et al. (2005), for example, introduced two levels of mechanisms (micro-level and multi-level) and several diffusion mechanisms: social learning, copying, and mimetic emulation; as well as regulatory, political and economic competition. Tews (2005) described other processes: harmonization, hierarchical imposition, competition, and communication. Weyland (2005) identified four mechanisms: external pressure, symbolic or normative imitation, rational learning and cognitive heuristics. Karch (2007) also introduced four mechanisms of policy diffusion: geographic proximity, imitation, emulation and competition. Graham et al. (2013) argued for the existence of four main processes: learning, competition, coercion and socialization. Shipan and Volden (2008, 2012) also introduced four mechanisms, but name them a little differently than the previous authors: learning, economic competition, imitation and coercion. Paterson et al. (2014) mentioned four other categories: coercion, competition, learning and emulation, and harmonization. They finally added the importance of epistemic networks and transnational actors. Maggetti and Gilardi (2015) argued for three mechanisms: learning, emulation and competition. Table 2 shows the different categories mentioned by various authors.

There is no doubt about the relevance of analyzing *how* policies diffuse, however, it seems that each scholar has been reinventing the wheel. Table 2 shows that there are some similarities in the definitions of mechanisms of diffusion given by different scholars. These similarities imply that the mechanisms can be combined into the four categories introduced by Shipan and Volden (2008; 2012): learning, economic competition, emulation and coercion.

A note on emulation. Shipan and Volden (2008; 2012) actually refer to “imitation”, but emulation is a more accurate term. According to Karch (2007), for example, emulation is a form of imitation. According to Thesaurus dictionary in sociology (where the concept of policy diffusion originally comes from), “imitation” means copying the patterns of activity and thought of other groups or individuals. “Emulation”, however, is closely to the effort or desire to equal others, which is a closer description to the process analyzed in political science.

Table 2. Mechanisms of policy diffusion
Source: Defined in each column

Mechanisms of policy diffusion used by different scholars. Each column in this table represents a paper with its author and respective year of publication. Each row represents different mechanisms found in the literature. Cells that have an "•" represent the existence of the mechanism for each scholar. "AP" stands for American politics, "CP" for comparative politics and "IR" for international relations.

	Karch (2007)	**Shipan & Volden** (2008; 2012)	**Weyland** (2005)	**Tews** (2005)	**Busch et al.** (2005)	**Graham et al.** (2012)	**Paterson et al.** (2014)	**Maggetti & Gilardi** (2015)
	AP	AP	CP	CP / IR	IR	IR	IR	-
Learning		●	●	●	●	●	●	●
Economic Competition	●	●		●	●	●	●	●
Imitation	●	●	●		●			●
Coercion		●	●	●		●	●	
Harmonization/ Socialization				●		●	●	
Geographic Proximity	●							
Cognitive Heuristics			●					

3.2.1 Learning

Learning is a process by which decision makers adopt a policy because of its success in another unit with which they have some sort of connection. Learning can be completely rational when policymakers take into consideration all the information in an efficient way, or it can be bounded when they employ “cognitive shortcuts”, since information is not always fully available (Weyland, 2005; Füglister, 2012). It is key to highlight two qualities from learning: the success of the policy and the connection between the units adopting the policies.

The more successful the policy is in terms of its goals, the more likely it becomes that another government will adopt such a policy (Meseguer, 2006; Gilardi et al., 2009). Policymakers are constantly facing challenges that might have been solved somewhere else, so they use successful cases to try to remediate their own challenges. Success can be measured in economic terms (Fink, 2013; Arbolino et al., 2018) or in terms of policy goals.

Nonetheless this success needs to be “channeled” through institutions, and international membership is a key part of the learning process (Füglister, 2012). Whereas success answers the question of “what” States learn, institutions answer the question of “where” they do so. Both in certainty and in times of crises, policymakers rely on their networks to analyze possible solutions. Association can indeed affect policy diffusion (Balla, 2001; Tews, 2005; Moynihan, 2008; Fink, 2013). This association can be in the form of professional groups, international organizations, intergovernmental organizations, etcetera. And it can be in sectors as varied as automobile emission standards in developed and developing countries (Saikawa, 2013), as privatization policies of electricity companies in members of the Organization for Economic Cooperation and Development (Fink, 2013), as health reforms in Switzerland (Füglister, 2012).

Therefore, one can expect that if a renewable energy target policy is successful in a country, it is more likely that other countries learn from it. States would learn this successful case through association in international governmental organizations and transnational networks related to energy and the environment. Since measuring success of policy can be extremely time consuming (and sometimes even subjective), only membership is considered in this research.

Learning Hypotheses

General: The chances of a policy spreading increases when the policy is successful and there is association in international governmental organizations.

Specific: The chances for a given country to adopt a renewable energy target increase as the number of energy related environmental agreements in which the country is a member increases.

3.2.2 Economic Competition

Economic competition implies that countries would adopt a policy in order to either gain competitive advantages (offensive behavior) or to avoid losing certain resources (defensive behavior) (Baybeck et al., 2011). The idea behind this mechanism is that States decide to adopt or not to adopt policies based on their desire to remain competitive in a market.

Economic competition could lead to two major "races": a race to the bottom and a race to the top. The notion of a "race to the bottom" implies that countries lower their standards in order to avoid capital leaving. The idea of the "race to the top" implies that countries adopt policies in order to secure "first-mover advantages" (Busch et al., 2005; Tews, 2005; Paterson et al., 2014). For this reason economic competition can have both positive and detrimental effects on the country adopting the policy, since it could motivate either of the two races (Graham et al., 2013). The potential spillovers of adopting a policy determine the likelihood of the policy being adopted (Shipan & Volden, 2008; 2012). Comparative advantages therefore, can be considered as a tradeoff between the two races: between avoiding capital leaving the country (race to the bottom) and securing the first-mover advantage (race to the top).

Charles Tiebout wrote about local expenditure competition, where the policy of one small town directly affects the policy of its neighbors. At the local level, a "consumer-voter" moves to a town whose government spends in what he/she considers to be relevant, which directly affects the future policies of neighboring towns (Tiebout, 1956). Tax competition is a clear example of the race to the bottom, where governments lower their taxes in pursuit of higher investment rates. Such a policy would make sense, looking at each government individually. However, the more government that compete, the lower the taxes, which in turn affects the community (Wilson, 1999).

States are extremely interrelated, and the adoption of policies depends as much on internal as external factors (Berry & Berry, 1990). Baybeck et al. (2011), for example, studied this behavior with lotteries. For the authors, American states have a defensive and an offensive motivation. The defensive motivation implied that states allowed lotteries in order to prevent the loss of revenue from its residents playing in other nearby states. The offensive motivation implied that states adopted lotteries in order to lure people to go play in their states and increase their revenues. Cary (1974) named this race to the bottom the “Delaware effect,” getting its name from the excessive corporation privileges given in the state of Delaware to companies in order to increase its revenues. Since states have the power to provide corporate charters, and these charters are legally recognized in all states, Delaware lowered its chartering requirements in order to attract more applicants, thereby creating a race to the bottom.

Contrary to this, the race to the top implies that policy diffusion can actually tighten standards instead of lowering them to a least common denominator. Vogel (1995) reached the conclusion that, opposite to what environmental and consumer groups believed, trade liberalization did not undermine environmental regulations; instead, liberalization most of the times enhanced environmental standards. Nations import and export as many policies as they do goods. In contraposition to the “Delaware effect,” Vogel (1995) identified this as the “California effect,” where the “critical role of powerful and ‘green’ jurisdictions” promotes a “race to the top among their trading partners” (p. 6). This is possible because the cost of complying with stricter environmental standards is not as high as to force jurisdictions to lower their standards in order to keep domestic business competitive. In fact, many environmental regulations are the source of competitive advantages. When a group of countries engage in trade liberalization, and the most powerful among them has influential domestic constituencies that support stronger regulatory standards, trade liberalization will most likely strengthen the standards on the less powerful countries.

Saikawa (2013) added to Vogel's theory that the race to the top happens in developing nations even without the existence of international agreements. Developing countries adopt standards, in this case automobile emission standards, in order to stay competitive in the market, without being forced to do so by an agreement. Exporting companies in developing countries are forced to adopt the standards of their destination markets, which increases their operation costs. These companies, in turn, lobby their own governments to adopt the same standards nationally so that they do not face a domestic disadvantage with their competitors in the national market. Thus, due to competitive mechanisms, strict regulations diffuse from developed to developing countries.

Therefore, one could expect economic advantages to play an important role in the mechanism of economic competition. In the case of this research, special attention is paid to the country's energy profile: whether the country is a net importer of energy or a net exporter of energy, and by how much. Countries that export energy would be more reluctant to adopt renewable energy targets, since they would face negative economic consequences by doing so. Contrary to this, a country that imports energy would be more likely to adopt renewable energy targets, since this would involve the country producing its own energy and being less dependent on the fluctuations of the international price of energy.

<u>Economic Competition Hypothesis</u>

General: The chances of a policy spreading will depend on the competitive advantages/disadvantages that such an adoption would bring to the unit.

Thus, the greater the competitive advantage from adopting a policy from another unit, the greater the likelihood of policy adoption. The lesser the competitive advantage (or greater disadvantage) from adopting a policy from another unit, the lesser the likelihood of policy adoption.

Specific: The chances for a given country adopting a renewable energy target are greater if the country is a net energy importer, and therefore lower if the country is a net energy exporter.

3.2.3 Emulation

Emulation means copying the actions of other governments in order to look like these governments. The focus on this mechanism is on the other government, and not so much on the policy itself. The greater the number of countries that adopt the policy, the more countries that will adopt it. Early adoption of renewable energy targets would seem to legitimize later adoptions, since the higher the number of adopters, the more countries there is to copy, therefore the higher the potential for emulation (Saikawa, 2013).

Similarity is what drives states to emulate each other. Analyzing policy changes in children's health insurance in American states, Volden (2006) found that policymakers adopted policies found in states with similar partisan and ideological leanings, with similar demographics and with similar budgetary situations. Volden also used "success of policy" as an important indicator, since for him it was not likely that states will just emulate every single policy.

Sharman (2010) illustrated how negative this mechanism can be. In extremely complex subjects such as tax policies, decision makers tend to copy existing policies containing mistakes and add some of their own, enlarging and perpetuating the negative consequences of adopting such a policy. For him (*opt cit.*), in the case of tax blacklists[5] policymakers have been "cutting and pasting from foreign models" (Sharman, 2010: 623).

Therefore, the more complex a renewable energy target policy appears, combined with a large number of countries that already have a renewable energy target, the more likely a country will copy it from a similar national State (in political, economic and social terms). Since complexity of the policy is a difficult quality to grasp in quantitative terms, it is assumed to have little or no effect on the evaluation of this mechanism on policy diffusion.

Emulation Hypothesis

General: The chances of a policy diffusing are higher among similar countries. The probability increases as more countries adopt the policy.

Specific: The likelihood of a given country adopting a renewable energy target increases as the number of similar countries with a renewable energy target increases.

[5] Blacklists are regulations that prescribe certain transactions with specific foreign jurisdictions Welch and Thompson (1980).

3.2.4 Coercion

Coercion implies the imposition of a policy from outside a state. Tews (2005) defined coercion as a "hierarchical imposition", where convergence is forced by exporter units, which tend to be "stronger" (in political or economic terms) than importer units, that tend to be "weaker" and expect to gain something from this adoption.

Scholars recognize the distinction between a vertical coercion (where policies are imposed by international organizations, or higher level governments in a federal system) and a horizontal coercion (where policies are imposed by other nations) (Graham et al., 2013; Paterson et al., 2014; Shipan & Volden, 2008, 2012; Weyland, 2005).

Trade and economic sanctions are the tools through which coercion is seen the most (Shipan & Volden 2008). An example of this was presented by Welch and Thompson (1980), who after analyzing 57 state public policies found that policies with federal incentives (mainly grants) diffused faster than those with no incentives. For the authors the federal government applies a "carrots and sticks" logic by giving money for a policy's implementation (carrots), and by threatening not to continue existing grants if certain requirements are not met (sticks).

Therefore, one can expect that the higher the environmental economic aid that a country receives, the more likely it is that this country adopts renewable energy targets. Given the lack of data on environmental aid (only available for the period 2002-2016) the Official Development Assistance (ODA) is used in order to measure coercion.

Coercion Hypothesis

General: The greater the economic aid that a country receives the more likely it is for this country to adopt a policy from donor countries.

Specific: The chances for a given country adopting a renewable energy target increases the more economic aid this country receives.

3.3 The Mechanisms Along the Adaptive Cycle

As it was previously mentioned, the adaptive cycle introduced in *Panarchy* (Gunderson & Holling, 2002) consisted of four stages: an exploitation phase (**r**), a conservation phase (**K**), a release phase (**Ω**), and finally a reorganization phase (**α**). After the reorganization phase, the cycle gives birth to a new configuration, and these stages begin once again.

In the previous sections the adaptive cycle was illustrated in terms of energy policy. The transition from the exploitation phase to the conservation phase consists of the establishment of a fossil-fuel-based economy (Bithas & Kalimeris, 2016). Then, there is a window of opportunity between the late conservation and the release phases. During the 1970s the fossil-fuel-based model was questioned by two, and then three, major triggers (in terms of Olsson et al. 2006). On the one hand, environmental awareness became institutionalized in the international level, and the findings by Keeling established a clear connection between fossil fuel consumption and the warming of the planet - there was growing evidence of the ecological crisis. This crisis changed people's perceptions - there was a shift in social values (Arrhenius, 1896; Keeling, 1973; Keeling et al. 1976; E. Haas, 1990). On the other hand, there were two major increases in oil prices, which highlighted the world's dependence on cheap oil, and pushed some governments to find alternatives to this (now expensive) commodity - there was an economic and political change (Campbell & Laherrère, 1998).

Governments therefore adopted policies to foment the transition from a fossil-fuel-based economy to a different model. After the exploitation and conservation phases came the crises, which triggered the pursuit of a new system configuration. Renewable energy targets are a clear example of such a pursuit, where governments foment the increase of renewable energies in their country's energy matrix.

The mechanisms by which countries adopted renewable energies differ from case to case. However it is likely to find learning and economic competition as the main diffusion mechanisms during the window of opportunity (from **K** to **Ω**), whereas the diffusion mechanisms of emulation and coercion would be more related to the transition (from **Ω** to **α**) and resilience building phases (from **α** to **r**). These are, of course, generalizations that are used to better understand the systemic dynamics of the adaptive cycle of the diffusion of renewable energy targets.

The rise in environmental awareness and the better understanding of the science of the environmental consequences of exploiting fossil fuels led to an increase in international institutions. The goal of these institutions, these epistemic communities, is to share knowledge. Learning happens in these international institutions and therefore the mechanism of learning is very important during this period.

The two oil crises of 1973 and 1979 were crucial for some oil-importing countries, such as Brazil, Guatemala and Honduras. An abrupt increase in oil prices undermined economic development in many States that relied on this cheap commodity, to the extent that these countries adopted policies in order to foment different sources of energy: from biofuel mandates to particular renewable energy programs. In order to stay competitive, some countries adopted renewable energy targets.

Emulation implies that one country would copy another one in order to look like this country. Emulation only make sense after a country has adopted a policy by any of the other three mechanisms. This mechanism would be more predominant in the transition phase, after countries have adopted a renewable energy target and are in the process of implementing this policy.

Coercion, the mechanism of “carrots and sticks”, could happen anywhere along the adaptive cycle. However, one could expect this mechanism to rampant after it was proven successful somewhere else. International aid is key in order to understand coercion, and this international aid would be more available once the policy has been implemented and succeeded elsewhere.

4. Methodology

4.1 A Mixed Methods Approach

In spite of a large number of published papers on policy diffusion, many scholars argue that there is still a long path to travel; the scholarship is "intellectually poorer than (it) should be" (Graham et al. 2013, p. 675). The only thing that seems to be clear in the policy diffusion literature is that there is no clarity on this issue (Howlett & Rayner, 2008). There seems to be confusion regarding the dependent variable: " 'what' is being diffused is sometimes lost in the concern for 'how' diffusion takes place" (Howlett & Rayner, 2008), and there is not even consensus on the *how*. The three subfields of political science previously introduced (American politics, international relations and comparative politics) seem to have gone on their own, instead of building from each other's work, and this has caused inefficiency and redundancy (Graham et al., 2013). This gap is such that Graham et al. (2013) titled one of the sections of their paper as "Divided we write". The scholarship needs to reach a common ground.

In pursuit for this common ground, Maggetti and Gilardi (2015) analyzed 114 studies published between 1990 and 2012 and found that the "same mechanisms are operationalized using different indicators, and different mechanisms are operationalized using the same indicators" (p. 89). What is needed, according to these authors, is a proper conceptualization of each mechanism with a basic definition, a secondary one and finally an indicator. The authors do this operationalization for the mechanisms of learning, emulation and competition (since they do not consider coercion to be a relevant mechanism).

After analyzing the papers, Maggetti and Gilardi (2015) recognized the use of mainly six indicators: structural equivalence, geographic proximity, joint membership, success of policy, number of previous adopters and trade flows. The authors (*op cit.)* proceeded to do a qualitative comparative analysis (QCA) to find out which indicators seemed to reflect each of the three mechanisms of policy diffusion

Although *learning* has been operationalized in many different ways, the most relevant indicator is "success of policy" and the focus of analysis tends to be countries or federal states, with a heavy reliance on quantitative methods. *Competition* has been measured with a more varied number of indicators. The key is to identify which jurisdiction is competing with the unit of analysis, and therefore trade is a dominant core condition (Gilardi, 2016; Maggetti & Gilardi, 2015). *Emulation* seems to have a more diverse body of indicators in the literature. Critical mass or interaction (*e.g.* co-membership in a transnational network) seem to be a relevant indicator. For the authors, the fact that so many indicators are used to measure emulation in the literature is a clear sign of conceptual overstretching, where one concept seems to stretch out to fit different indicators.

Maggetti and Gilardi (2015) found three key conclusions, which are crucial for the future of policy diffusion scholarship. First, researchers should pay greater attention to conceptual clarity: the literature still uses different concepts to explain the same phenomenon, and the same concepts to explain different events. If there is consensus on the definition of policy diffusion and partly on the mechanisms, it is better to stick to these common definitions until there is evidence that they do not hold anymore. Second, there should be a connection between the concepts scholars use and how they measure them: researchers should avoid mismatch between concepts and measurement. This is closely related to operationalization, and it is here where scholars face the greatest inconsistencies, therefore challenges. Finally, the authors emphasized the importance of being extremely creative while designing the methodology of studies, and go beyond standard designs (Gilardi, 2016).

Following the last point, Howlett and Rayner (2008) emphasized the necessity of recognizing that the dependent variable (policy adoption) is often composed by many different elements. Scholars need to understand the interaction of these elements and develop and employ a plurality of methods, "from thick descriptions and policy narrative case studies, to small-n and large-n studies" (p. 398).

Several of the articles reviewed stress the need of combining methodologies (Howlett & Rayner, 2008; Starke, 2013; Maggetti & Gilardi, 2015; Gilardi, 2016). There seems to be an extended use of quantitative analyses in policy diffusion literature, and although these studies provide great tools for generalizations, they sometimes miss the interactions within each mechanism by which policies diffuse. Event history analysis (EHA), broadly used in quantitative studies of policy diffusion, is very useful for identifying state-level characteristics associated with the adoption of policies, yet, it does not help in understanding exactly how policies diffuse from one State to the other (Karch, 2007). Since there is an increased interdependence between the cases studied, there is little reason to expect that "qualitative research is bound to become irrelevant" (Starke, 2013, p. 576). Qualitative methodology can enhance "decomposing the dependent variable" and show the different "settings" from diffusion (Howlett & Rayner, 2008, p. 392).

In the pursuit of obtaining the “thickness” provided by quantitative studies and the “broadness” obtained from qualitative research (Collier & Elman, 2008), this investigation will use both quantitative and qualitative methodologies, the definition of mixed methods research (Hesse-Biber & Johnson, 2015). Mixed methods study has a variety of advantages, namely, it triangulates findings in order to corroborate results and have a better understanding of the phenomenon being studied (Hunter & Brewer, 2015). While a quantitative methodology will show the relevance of mechanisms at stake, a qualitative methodology will detail the process by which countries adopt renewable energy targets. Mixed methods offset each methodology’s weaknesses, so both methodologies together will provide a more complete explanation for policy diffusion of renewable energy targets (Creswell & Clark, 2011).

As a result, both an event history analysis (EHA) and a qualitative comparative analysis (QCA) were used. Each of these is explained below.

4.2 Event History Analysis

An event is a qualitative change that occurs at a specific point in time, in this case, the adoptions of renewable energy targets. An event history analysis (EHA) is a linear regression model that tries to predict or explain the occurrence of events (Hardy & Bryman, 2009, p. 369). EHA is a relevant quantitative method because it includes time and therefore provides a “potentially richer understanding of the social process underlying the problems” (Box-Steffensmeier, 2004: 2).

There are two key concepts in EHA: the risk set and the hazard rate. The risk set is the group of individuals (in this study, countries) who are at risk of the event analyzed at each point in time. The hazard rate, also known as occurrence rate, is the probability that an event will occur at a certain time to a specific individual (country), given that such an individual (country) is at risk at that time (Allison, 2011). In this paper the hazard rate is the probability of a State adopting a renewable energy target in a given year, given that the country has not yet adopted the policy. The hazard rate is supposed to be determined by several independent variables (in this research four variables – one for each of the mechanisms of learning, economic competition, emulation and coercion; and three control variables – oil price, population, and energy use per capita).

Since the dependent variable is a dichotomous one, *probit* or *logit* are the preferable estimation techniques (Berry & Berry, 1990). Logistic (*logit*) regression is used in this case. The method is based on discrete-time variables. Once a State has adopted a renewable energy target, the individual is removed from future analysis, since it is no longer at risk of adopting the policy (Volden 2006; Saikawa, 2013).

Much policy diffusion research has been done using this method, or variations of this method such as dyadic logistic regressions (Berry & Berry, 1990; Volden, 2006; Gilardi, Füglister & Luyet, 2009; Baybeck, Berry & Siegel, 2011; Saikawa, 2003; Arbolino et al., 2018).

4.3 Qualitative Comparative Analysis

Qualitative comparative analysis (QCA) is a set-theoretic approach that uses a case-oriented method based on Boolean algebra. The purpose of this approach is to summarize data (describing the cases in a synthetic way), to check the analytical coherence of certain cases, to evaluate existing theories, and to elaborate new ones (Marx, Rihoux, & Ragin, 2013).

This method's strength is three-fold. First, it recognizes the existence of equifinality (there might be several paths leading to the outcome of interest). Second, it is useful to understand conjunctural causation (sometimes the outcome is determined by a combination of several different factors, which may or may not be independently determinative). Third, QCA contemplates for asymmetry of causal relations (the determinants of the absence of a condition are not necessarily inversely related to its opposite; the determinants of autocracy are not simply the same conditions, with opposite signs, that determine democracy) (Schneider & Wagemann, 2012). Note that QCA deals with conditions instead of variables, which would be a more quantitative concept.

The main characteristics of QCA are that it is case-based (cases are analyzed in a holistic way), comparative, and constantly bridging theory and evidence (during calibration in the operationalization stage). Broadly speaking, QCA translates into "crisp sets" or "fuzzy sets". In a crisp set (csQCA), an object can either be inside the set or outside the set (1 and 0 respectively). In a fuzzy set (fsQCA), relevant objects can have varying degrees of membership in a set, from fully being part of it, to not being in the set at all (from 1 to 0, stopping all over the scale). Fuzzy sets are key at analyzing diversity, since they contemplate for both differences in kind (in and out - a qualitative variation) and differences in degree of membership (how much in and how much out - a quantitative variation) (Ragin, 2000; 2008).

The most delicate part in QCA is the calibration of each observation, since data needs to be transformed from continuous to fuzzy-set categories, based on evidence and case knowledge. Here, a clear conceptualization helps find the thresholds and then the researcher assigns each case a value.

QCA summarizes the possible combinations of conditions in a truth table, where each column represents a condition, each cell shows the presence or absence of such condition, and each row represents a unique configuration of conditions. Each combination of conditions represents certain number of cases, although some combinations might not represent any case at all. The final number of combinations is achieved due to Boolean minimization, a process that reduces combinations by dropping off conditions that are not relevant based on cases. The objective is to minimize the number of combinations to a degree that still represents the cases analyzed, but that one can grasp (not 100 combinations, but not 1 either).

To this author's knowledge, there are no papers using QCA to test the different mechanisms of policy diffusion. Maggetti and Gilardi (2015) used QCA in order to examine how the different policy diffusion mechanisms are operationalized in the literature. There have been additional studies analyzing environmental policy that use QCA, as is the case with Damonte (2013), Never & Betz (2014), Mao (2018), and Huh, Kimand & Hailiey Kim (2018).

Damonte (2013) used QCA to analyze the causal recipes for environmental performances in 13 EU countries[6] and identified four types of successful strategies.

[6] Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

Never and Betz (2014) used this method to compare the climate policy performance of different emerging economies[7] based on their domestic green economies, their fossil fuels to financial power ratio, their international negotiation position, and their environmental civil society. Mao (2018) used a mixed methods approach (fsQCA combined with a multiple regression) to analyze the relationship among decentralization, national context and environmental policy performance in 118 countries around the world. Huh, Kimand and Hailiey Kim (2018) used fsQCA to develop an empirical framework of the green state and then to compare OECD countries under such a framework.

Both methodologies, EHA and QCA, are used simultaneously but in an independent form, following what Creswell and Clark (2011) identified as “the convergent parallel design”, where the methodologies are developed side by side and then mixed for analyzing results. The strength of this research design is that it provides a more complete understanding and corroborates quantitative scales, since it obtains different but complementary data.

[7] Brazil, China, India, Indonesia, South Korea, Mexico, and South Africa.

5. Study Design

As suggested by several scholars (Howlett & Rayner, 2008; Starke, 2013; Maggetti & Gilardi, 2015; Gilardi, 2016), special attention is now given to conceptual clarity and to the operationalization of the variables. First, the dependent variable is explained (section 5.1). Second, the four mechanism variables are defined and the indicators for each mechanism are introduced. Additionally, an explanation on how each variable is used and calibrated for the QCA is presented (section 5.2). Third, the research analysis is discussed (section 5.3)

There are 187 countries analyzed in this study,[8] with a time frame ranging from 1974 (one year before the adoption of the first target) until 2017 (when the researcher finished collecting data on the dependent variable). For the EHA, the 187 countries in the time frame analyzed became 6,750 country-year cases, since cases were removed after the target was adopted. For the QCA, 114 countries are derived from the 187 cases analyzed.[9]

[8] The list of countries can be found at Appendix 1 and is based on the report by IRENA (Kieffer & Couture, 2015). The original list contained 193, however, 6 countries were eliminated from the list given missing data for the dependent variable - no evidence was found of target adoption for these countries, and according to the cited report these 6 countries had the target. These 6 countries are: Botswana, Burundi, Gabon, Guinea, Qatar and Togo.

[9] The model started with 187 cases. Given the frequency threshold, the consistency threshold, and the process of Boolean minimization the final result included 149 cases, from which 114 are not repeated. This is detailed in the Results section for QCA.

Table 3. Summary statistics for analyzed variables
Source: Author's data

This table shows all the variables and conditions included in this analysis, their sources, and their minimum value, median, mean, maximum value and the missing data.

	Variable / Condition	Min.	Median	Mean	Max.	No Data[10]
Learning	Cumulative Membership to Energy IEA	0	1	1.7	27	0
	Source: IEADP (Mitchel, 2002)					
Economic Competition	Energy Profile	-10003.21	16.22	-69.79	100	2645
	Source: WB (2014)					
Emulation	Similarity Index	0.00	1.44	2.38	9.22	0
	Source: Created by author with indicators data from WB and Polity (Center for Systemic Peace, 2016)					
Coercion	ODA	24.03	513.50	557.33	3024.31	1930
	Source: OECD (2019)					
Control	Oil Price	21.69	46.36	54.38	113.64	0
	Source: Dow Jones & Company (2013); U.S. Energy Information Administration (2019)					
Control	Population	6.972 e+03	5.104 e+06	2.568 e+07	1.318 e+09	23
	Source: WB					
Control	Energy Use per Capita	9.58	940.65	2022.96	18157.60	2509
	Source: WB					

[10] The total is 6,750.

Control	Income Level[11]	1	2	2.05	4	20
	Source: WB					
Control	Year of Adoption	1974	1992	1992	2017	0
	Source: Various					

5.1 Dependent Variable / Outcome[12]: Renewable Energy Targets

The first step in this research was to create a dataset that identified the first renewable energy target adopted in each of the 187 countries. For this purpose, the researcher analyzed the 2,166 policies available in the *IEA/IRENA Joint Policies and Measures database* (IEA/IRENA). Since this dataset did not have information on all countries, additional policies were gathered from *Climatescope 2018* (BloombergNEF), which has more than 800 policies, as well as government websites for some specific countries. Of the original 193 countries analyzed, by 2017, 162 countries had a renewable energy target, 25 countries did not have a renewable energy target, and data was not found for 6 countries. The last group was omitted from further analysis, since it could not be identified with any of the first two groups (adopters VS non-adopters). These resulted in the 187 countries included in the analyses.

[11] Income level: low income = 1, lower-middle income = 2, upper-middle income = 3, high income = 4

[12] Note that for QCA the dependent variable is called outcome, and that the independent variables and control variables are called conditions.

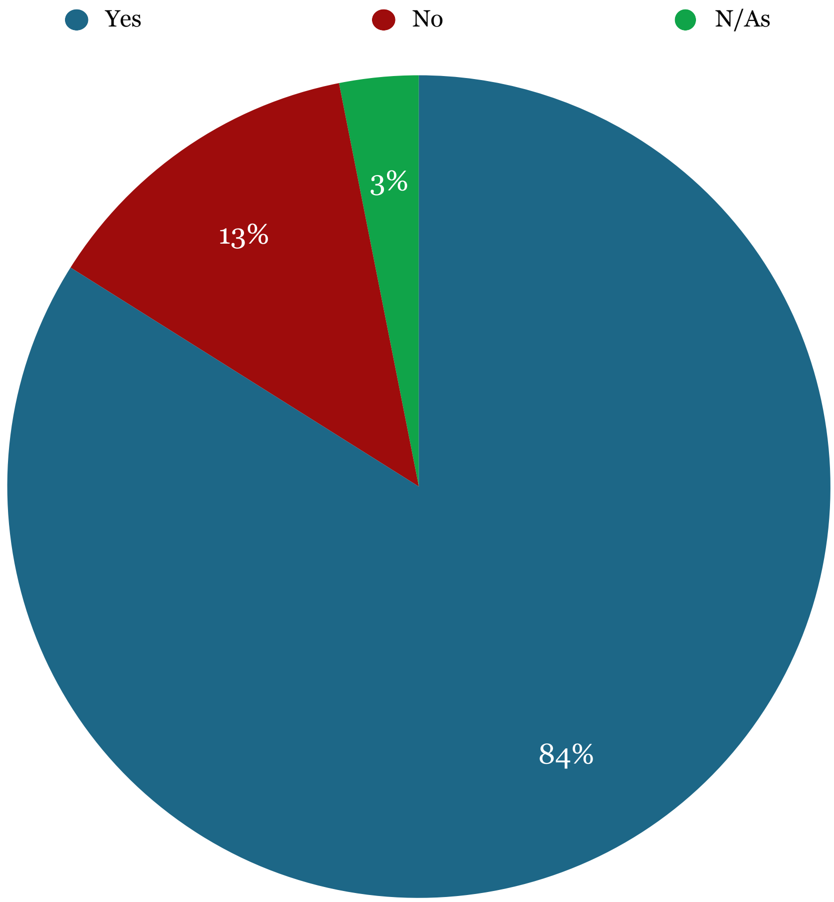

Figure 6. Global distribution of renewable energy targets in 2017

N= 193. Blue represents 162 countries that had a renewable energy target in 2017, red represents the 25 countries that did not have a target, and green represents 6 countries for which data on renewable energy target policies was not available.
Source: Author's data

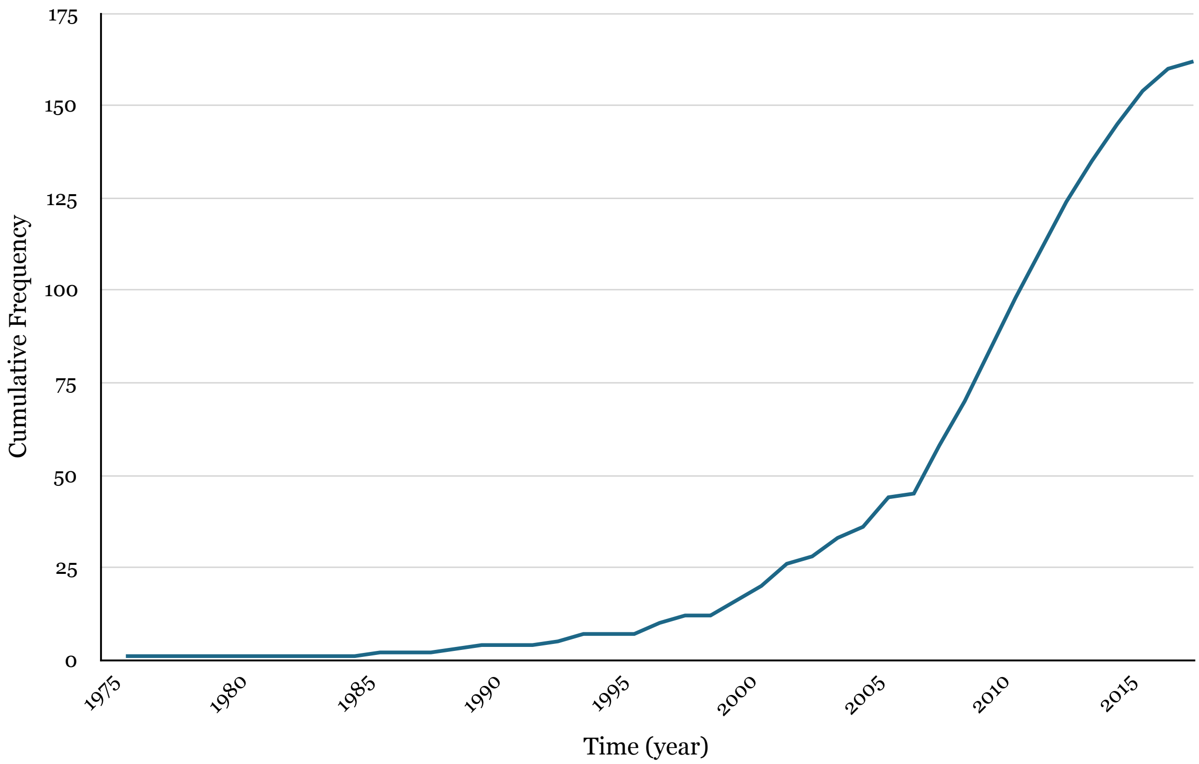

Figure 7. Global cumulative frequency of adoptions over time
The graph represents the amount of countries with renewable energy targets in the world in each year.
Source: Author's data

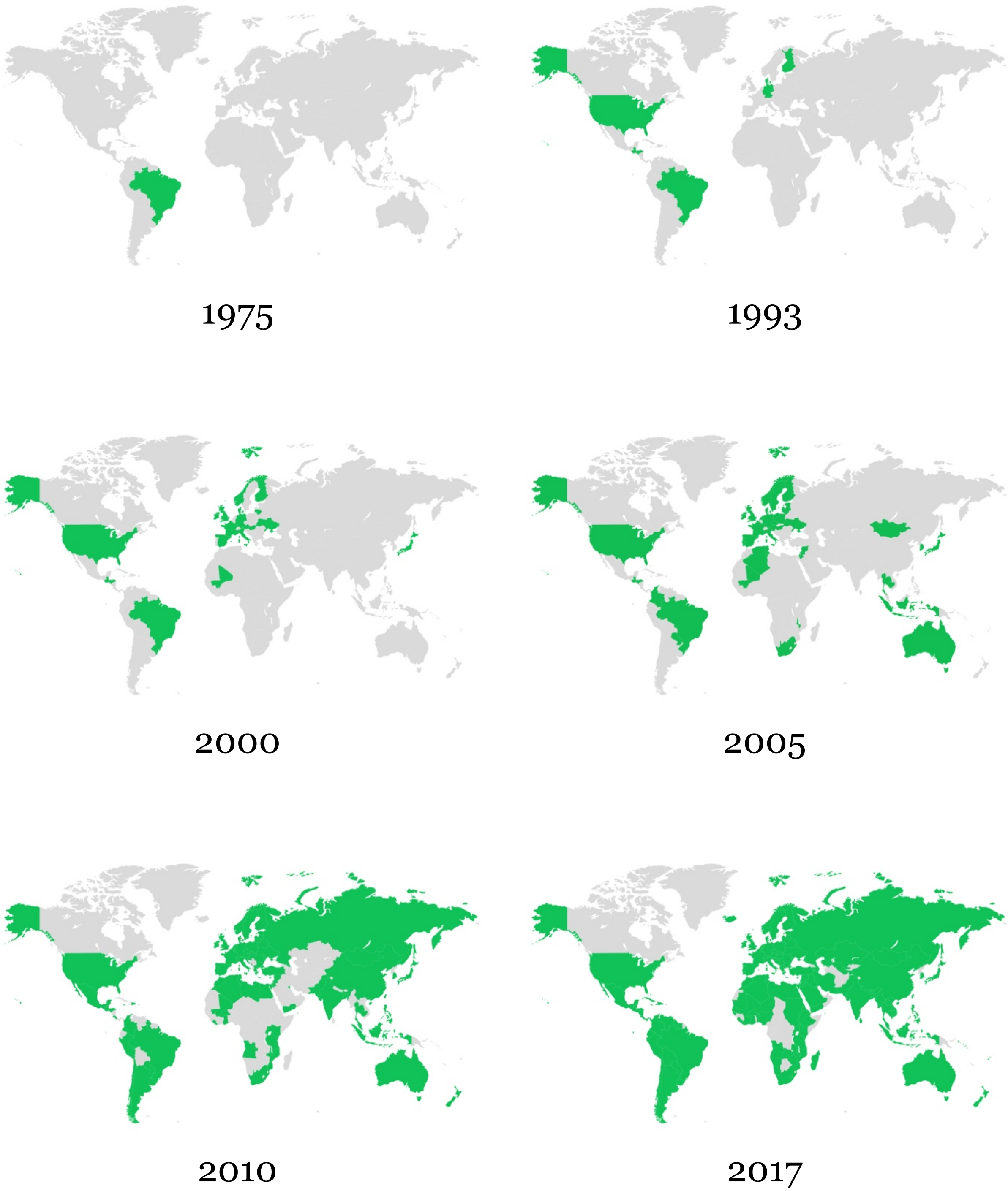

Figure 8. Renewable energy target maps
Each map represents countries that had adopted their first renewable energy target in a given year. Green represents countries with a target and grey represents countries that did not have a target.
Source: Author's data

5.2 Independent Variables / Conditions: Diffusion Mechanisms and Controls

Each of the four policy diffusion mechanisms was measured with one variable/condition (Figure 9). Additionally, seven control variables/conditions were contemplated, although three control variables/conditions were included in the final model.[13] The selection of indicators, as well as their operationalization, were informed by previous studies. The final selection of the control variables was determined by the process of model selection (forward, backward and Stepwise). The variables are explained below.

[13] The seven variables were: percentage of regional adopters, GDP per capita, cumulative NGOs membership, CO_2 emissions, oil price, population and energy use per capita. Only the last three were included in the EHA. For the QCA the same four mechanism variables were used, along with oil prices, income and year of adoption.

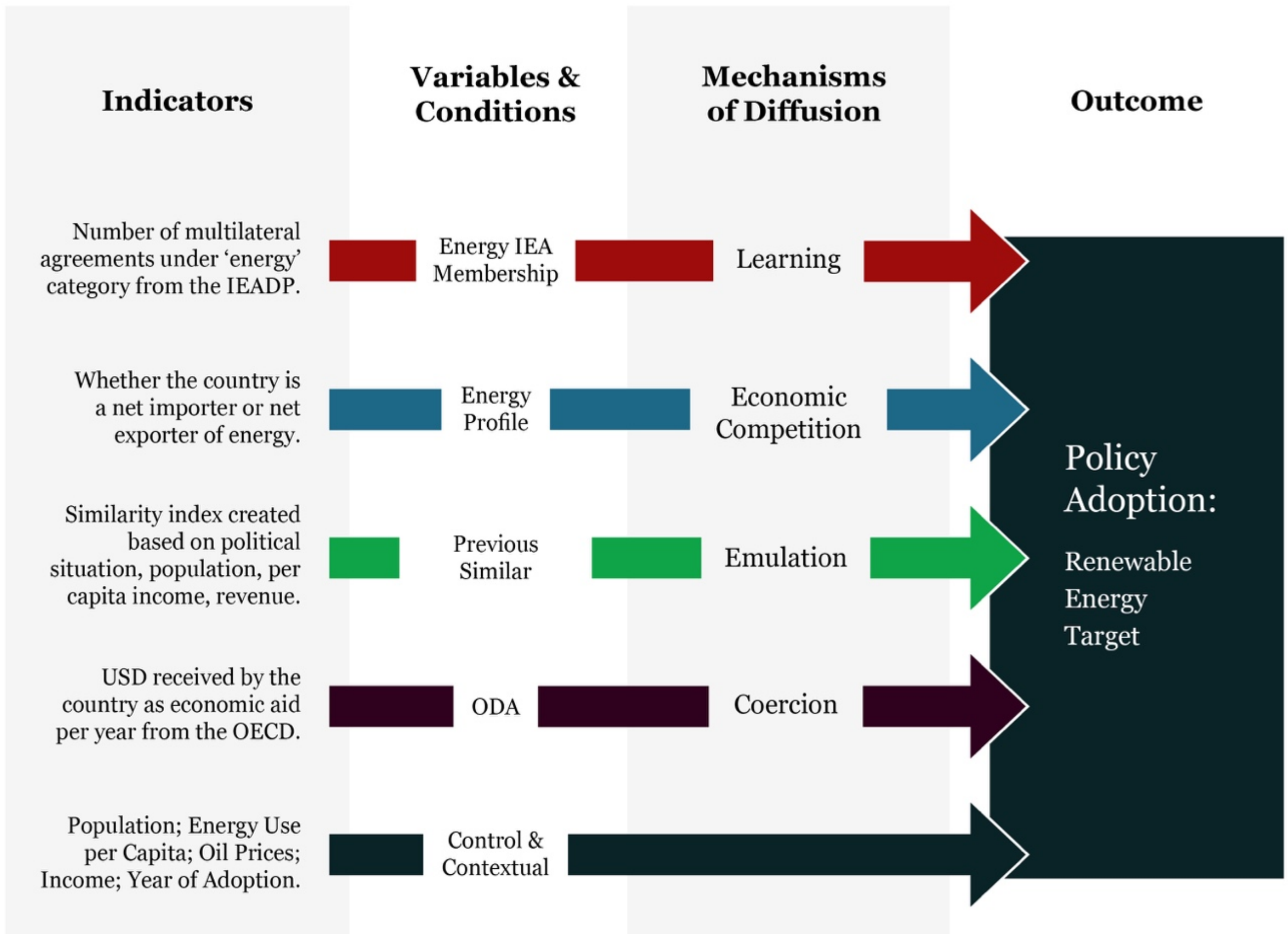

Figure 9. Thesis design
This figure represents the operationalization of each mechanism, with respective variables and indicators.
Source: Author's design

5.2.1 Learning - Cumulative Membership to Energy IEA

This variable/condition represents the cumulative membership of each country in each year in energy related international agreements. All data was obtained from the International Environmental Agreements (IEA) Database Project, elaborated by Ronald B. Mitchell (2002). An IEA is "an intergovernmental document intended as legally binding with a primary stated purpose of preventing or managing human impacts on natural resources" (Mitchell, 2002). Energy related international agreements are the ones that contain one or more of the following terms/phrase in the treaty name, as suggested by Mitchell: nuclear material, energy, power plant, transportation of nuclear material, joint works, common works, power and irrigation, hydraulic, Senegal river plus development. There were 249 agreements included. The date considered for this study is entry into force of the agreement, and not signature only, since learning would take place once the institution enters into force.

For QCA the cumulative value for energy-related international agreements was translated into membership in the set of countries that have a high number of agreements. Calibration used a continuous scale fuzzy set with the cut points of: fully out (*i.e.* no agreements, 0) = 0 agreements, crossover point (*i.e.* the boundary, 0.5) = 3.5 agreements, fully in (*i.e.* high number of agreements, 1) = 8.5 agreements. This was based on case knowledge and frequency distribution.

The purpose of this variable/condition is to capture the potential of learning in energy matters for countries. If countries do learn from each other, they do so in the exchange that takes place in international organizations. Therefore, the higher the number of energy related agreements, the more likely it is that a country adopts a renewable energy target.

5.2.2 Economic Competition - Energy Profile

This variable/condition represents a country's net energy imports (energy use less production) as a percentage of energy use. A negative value in this variable indicates that the country is a net exporter, whereas a positive value indicates that the country is importing part or all of its energy. The data was extracted from the World Bank (2014). The unit for this variable/condition is a percentage.

For QCA this variable was translated into membership in the set of energy importing countries, using a continuous scale fuzzy set with the cut points of: fully out (*i.e.* the country exports energy) = -20% of energy use, crossover point (*i.e.* neither importer nor exporter) = 0% of energy use, fully in (*i.e.* energy importer) = 50% of energy use. This was based on case knowledge and UN definitions.

The more energy a country imports, the more likely it is for this country to adopt a renewable energy target, since this would imply diminishing the country's exposure to international factors that the country does not control, such as the price of oil.

5.2.3 Emulation - Similarity Index

To measure the mechanism of emulation, this author created a similarity index based on Volden's (2006) findings. This involved a dyadic format event history analysis in order to measure similarities in each pair of countries in each year. The 6,750 observations turned into 1,530,408 observations (unique country pairs per year). In this index, four indicators were used to measure the three dimensions mentioned by Volden[14] (2006): political dimension, demographics dimension, and budgetary dimension. These are explained below:

- Political dimension
  - Absolute difference in Polity Index: this index represents the authority characteristics of States used for comparative, quantitative analysis. It was started by Ted Robert Gurr, and it is now the most widely used resource for monitoring regime change and studying regime authority (Center for Systemic Peace, 2016). The absolute difference is the absolute value of the subtraction of Polity Index of "country X" minus Polity Index of "country Y" in a given dyad in a specific year.

- Demographics dimension
  - Population ratio: total population living in a country with data from the World Bank (WB). Population ratio is the division of the larger population divided by the smaller population per dyad per year.
  - Absolute difference per capita income: gross domestic product was used for this indicator, which represents the sum of gross value added by all resident producers in the national economy plus any product taxes minus

[14] In his article, Volden (2006) uses six indicators for the three categories. However, two of these six are entirely based on his research topic: children's healthcare systems, therefore they are not included in this thesis.

subsidies. The data is from the WB. The absolute difference in this indicator is the absolute value of the subtraction of GDP per capita of "country X" minus GDP per capita of "country Y" in each dyad in each year.

- Budgetary dimension
  - Absolute difference in revenue: revenue is cash receipts from taxes, social contributions, and others (such as fines, fees, etc.), excluding grants. The data is from the WB. The absolute difference in this indicator is the absolute value of the subtraction of the revenue of "country X" minus the revenue of "country Y" per dyad per year.

The results of these four indicators were first transformed into values between 0 to 1 for comparison reasons. Zero represented high similarity and one represented no similarity. The four values were then averaged and subtracted to 1 in order to flip the relationship. Now, the closer to zero that this value was, the less similar the pair; the closer to one that this value was, the more similar the pair.

Since for the emulation mechanism it is relevant to include the number of previous similar adopters, this value was then multiplied either by 1 (when the partner in the dyad had adopted the target), or by 0 (when the partner in the dyad had not adopted the target). Then, in order to get a value for similarity per country (and not per dyad) per year, all the values for each country in each year were added and the divided by 186 (total of countries analyzed, minus one to avoid the country paired with itself). This number was then multiplied by 100. Finally the number was raised to ½ to get a normal distribution. This yields the similarity index, which ranges from 0 (not similar) to 10 (very similar).

For QCA the similarity index was translated into membership in the set of emulators, calibrating the condition into a continuous scale fuzzy set with the cut points of: fully out (*i.e.* not an emulator) = 0, crossover point (*i.e.* borderline) = 5.4, fully in (*i.e.* emulator) = 7.75. This was based on case knowledge and the distribution of adoptions.

A positive relationship is expected from the similarity index variable, with higher values relating to higher similarity. A more detailed explanation on the construction of this index is available in Appendix 2.

5.2.4 Coercion - ODA

The mechanism of coercion was measured by the Official Development Assistance (ODA) received by country. ODA is the government aid designed to promote development and welfare of developing countries. The data was taken from OECD and is expressed in 2017 U.S. dollars (OECD, 2019).

For QCA, ODA was translated into membership in the set of aid recipient countries. A continuous fuzzy set was used with the cut points of fully out (*i.e.* not an aid recipient) = 0 U.S. dollars, crossover point (*i.e.* borderline) = 1 million U.S. dollars, fully in (*i.e.* aid recipient) = 100 million U.S. dollars. This calibration strictly followed case knowledge.

The more aid a country receives, the more prone this country is to adopt a renewable energy target.

5.2.5 Control - Oil Price

This variable/condition indicates the international price of oil for each year. The data was retrieved from the Federal Reserve Bank of St. Louis, and it includes both the West Texas Intermediate (1946 - 2013, discontinued) (Dow Jones & Company, 2013) and the West Texas Intermediate Cushing (1986 - current) (U.S. Energy Information Administration, 2019). When there was a juxtaposition of data, an average of both values was calculated. The variable is in 2017 U.S. dollars.

For QCA the price of oil was translated into membership in the set of expensive oil. The fuzzy set continuous calibration was based on case knowledge and oil price fluctuations. The cut points are: fully out (*i.e.* inexpensive oil) = 20 U.S. dollars, crossover point (*i.e.* borderline) = 40 U.S. dollars, fully in (*i.e.* expensive oil) = 65 U.S. dollars.

Therefore, the higher the price of oil, the more incentives there are to look for alternative energy sources, therefore the more likely it is for a renewable energy target to appear.

5.2.6 Control - Population

The data for population came from the WB. The values shown are mid-year estimates.

For QCA, population was translated into membership in the set of big countries. Calibration was based on case knowledge, UN definitions and data distribution. The values were turned into a continuous fuzzy set scale with the cut points of: fully out (*i.e.* small population)= 2,700,000 people, crossover point (*i.e.* borderline) = 21 million people, fully in (*i.e.* large population) = 100 million people.

Thus, since bigger populations demand more resources, the larger a country's population, the less likely it is for this country to adopt a renewable energy target.

5.2.7 Control - Energy Use per Capita

The variable represents the use of primary energy before transformation to other end-use fuels (such as gasoline). Energy use is the national production of energy, plus imports and stock changes, minus exports and fuels supplied to ships and aircraft for international transport. This data was obtained from the World Bank, and the units are in kilograms of oil equivalent per capita.

5.2.8 Control - Income Level

This variable/condition was used for the robustness EHA and then for the general model in the QCA. The data comes from the World Bank classification into four categories (low income, lower-middle income, upper-middle income and high income) based on the country's gross national income (GNI). For this research these categorical tags were translated into values ranging from 1 to 4, where 1 represents low income, 2 represents lower-middle income, 3 represents upper-middle income, and 4 represents high income countries. The data is adjusted by time, ranging from 1987 to 2017. For years prior to 1987, the values for 1987 are used.

For QCA, income was translated into membership on the set of higher-income countries. Calibration was based on a continuous fuzzy set with three cut points: fully out (*i.e.* low income) = 1, crossover point (*i.e.* in between lower-middle and upper-middle income) = 2.5, fully in (*i.e.* high income) = 4.

5.2.9 Control - Year of Adoption

This variable/condition is used in the EHA in order to determine when the dependent variable (target adoption) changed from 0 (no target) to 1 (target). In the QCA this condition served to illustrate the different paths that lead to the outcome taking into consideration the year in which each country adopted the target. The data comes from different sources. Calibration consisted on a continuous fuzzy set with three cut points based on frequencies of adoption, case knowledge, and research: fully out (*i.e.* late adopter, which is no target) = 2018, crossover point (*i.e.* borderline) = 2006.5, fully in (*i.e.* early adopter) = 1990.

5.3 Analysis

5.3.1 Event History Analysis

The EHA was run using the software R and the package bife (Stammann, Czarnowske, Heiss & McFadden, 2018), which is used to fit fixed effect binary choice models (*logit* or *probit*), while correcting for the incidental parameter bias using Hahn and Newey's (2004) estimate.

For the EHA, seven variables were introduced in the final model (following model selection procedures), one to represent each mechanism, as well as three control variables. These variables are: "Cumulative Membership to Energy IEA" (mechanism of learning), "Energy Profile" (mechanism of economic competition), "Similarity Index" (mechanism of emulation), "ODA" (mechanism of coercion), "Oil Price" (control), "Population" (control), and "Energy Use per Capita" (control).

5.3.2 Qualitative Comparative Analysis

The QCA was elaborated simultaneously using the software fsQCA, developed by Ragin & Davey (2017). The first step was to calibrate each individual continuous value, as previously mentioned, into a fuzzy set ranging from 0 to 1. The numeric values in the QCA are based in set theory and therefore represent fully membership to the group (1), or fully exclusion from it (0). Depending on the variable, case knowledge and the literature the author decided specific thresholds for each variable to be used during the calibration.[15]

The QCA also analyzed seven conditions: the four mechanisms conditions (same as the EHA), and three "control" conditions (not exactly the same as the EHA). These conditions are: "Cumulative Membership to Energy IEA" (mechanism of learning), "Energy Profile" (mechanism of economic competition), "Similarity Index" (mechanism

[15] The calibration rules followed in this thesis are available in Appendix 4 (Table 15).

of emulation), "ODA" (mechanism of coercion), as well as "Oil Price" (control), "Income Level" (control), and "Year of Adoption" (control). "Population" (control) was analyzed in a different model as a "sensitivity" analysis (second model, Appendix 7, Table 19). This is explained in the combined analysis on the results section.

6. Results

6.1 Event History Analysis

6.1.1 General Results

The EHA included 187 countries over the period 1974 - 2017. The dependent variable was the first renewable energy target adopted in each country. This author predicted the impact that each of the four mechanisms had on the adoption of renewable energy targets, as well as the three control variables previously mentioned.

In order to select which variables to include in the final regression, two R packages[16] were used to perform the forward, backward and Stepwise model selection procedures. The three processes resulted in three relevant variables to consider: similarity index, population, and oil price. The other three mechanism variables were still incorporated in the model given that they are the hypotheses to test. Energy use per capita was also included in the final model given that the policy here analyzed is on energy.

This author performed a logistic regression in R using the package bife (Stammann, Czarnowske, Heiss & McFadden, 2018). The model was fixed by country in order to contemplate for unobserved parameters.[17]

The results, seen in Table 4, show that the only significant mechanism in the adoption of renewable energy targets is emulation. There are also two significant control variables: the price of oil and, less importantly, population.

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[16] Tidyr and dplyr.

[17] A comparison of this package results with a linear model and a rare event logistic regression is available in Appendix 3 (Table 14).

The similarity index variable, which measures the mechanism of emulation, is positive and significant ($p \leq 0.001$). This indicates that the more similar a country is to an adopter, the greater the odds for the adoption of a renewable energy target. To understand the odds of adoption one needs to raise the estimate of the logistic regression (log odds) to *e* (2.72), which is ~2.4. This indicates that increasing similarity index by 1 unit increases the odds for target adoption by ~2.4 times, holding all other variables constant.

The price of oil was also significant ($p \leq 0.01$) and positive in this model, which indicates that the higher the price of oil the more likely it is that a country adopts a renewable energy target, holding all other variables constant. Turning the log odds (~.02) into an odds ratio results in ~1.02, which would indicate that a one-dollar increase in the price of oil increases the odds ratio of adopting a renewable energy target by ~1.02, holding the other variables in the model constant. If there was a 10-dollar increase in the price of oil, holding the other variables in the model constant, then the odds ratio for a country adopting a renewable energy target would be 1.18. If there was a 50-dollar increase in the price of oil, holding the other variables in the model constant, then the odds ratio would increase to 2.26. This relationship is shown in Figure 10.

This graph, and the coefficient from the logistic regression for oil prices, clearly resonates with Figure 11, which illustrates the number of renewable energy targets per year, as well as the price of oil (in 2017 U.S. dollars). The lines do not perfectly match each other, but one can clearly see the positive relationship between both variables.

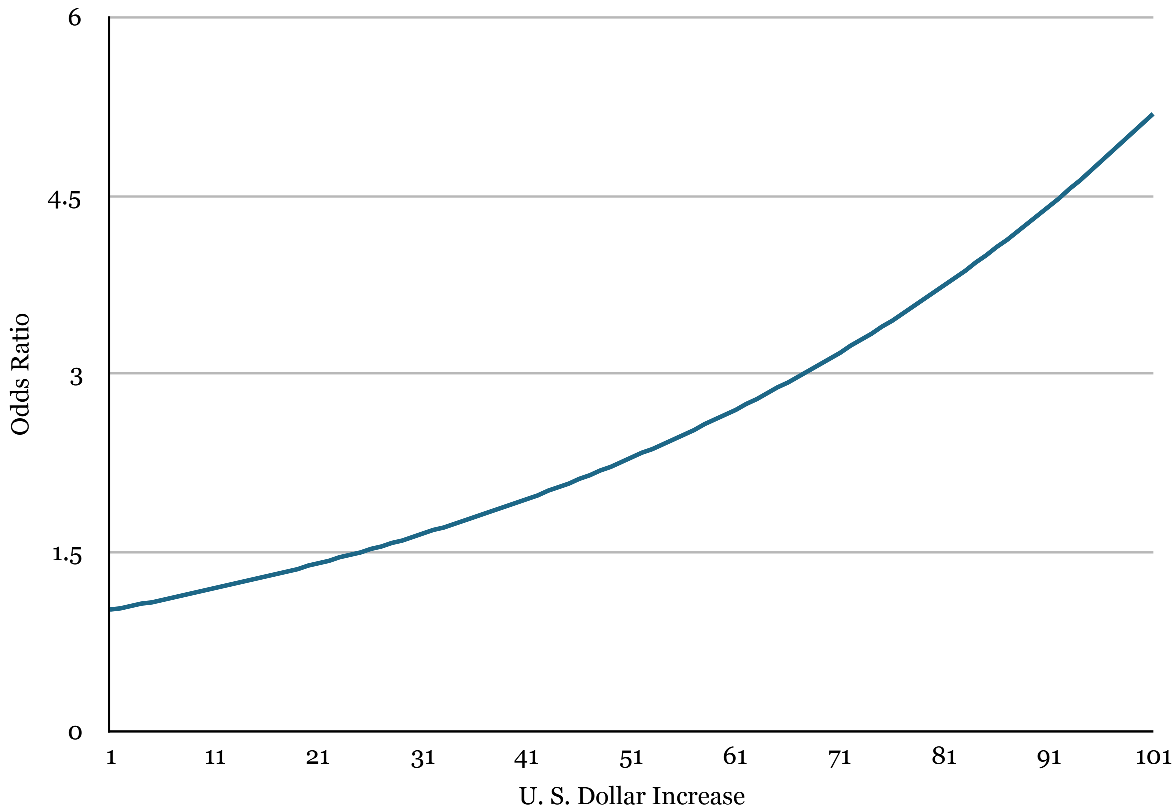

Figure 10. Odds ratio for adoption VS oil price increase
The higher the price of oil, the more likely it is for countries to adopt renewable energy targets.
Source: Author's data

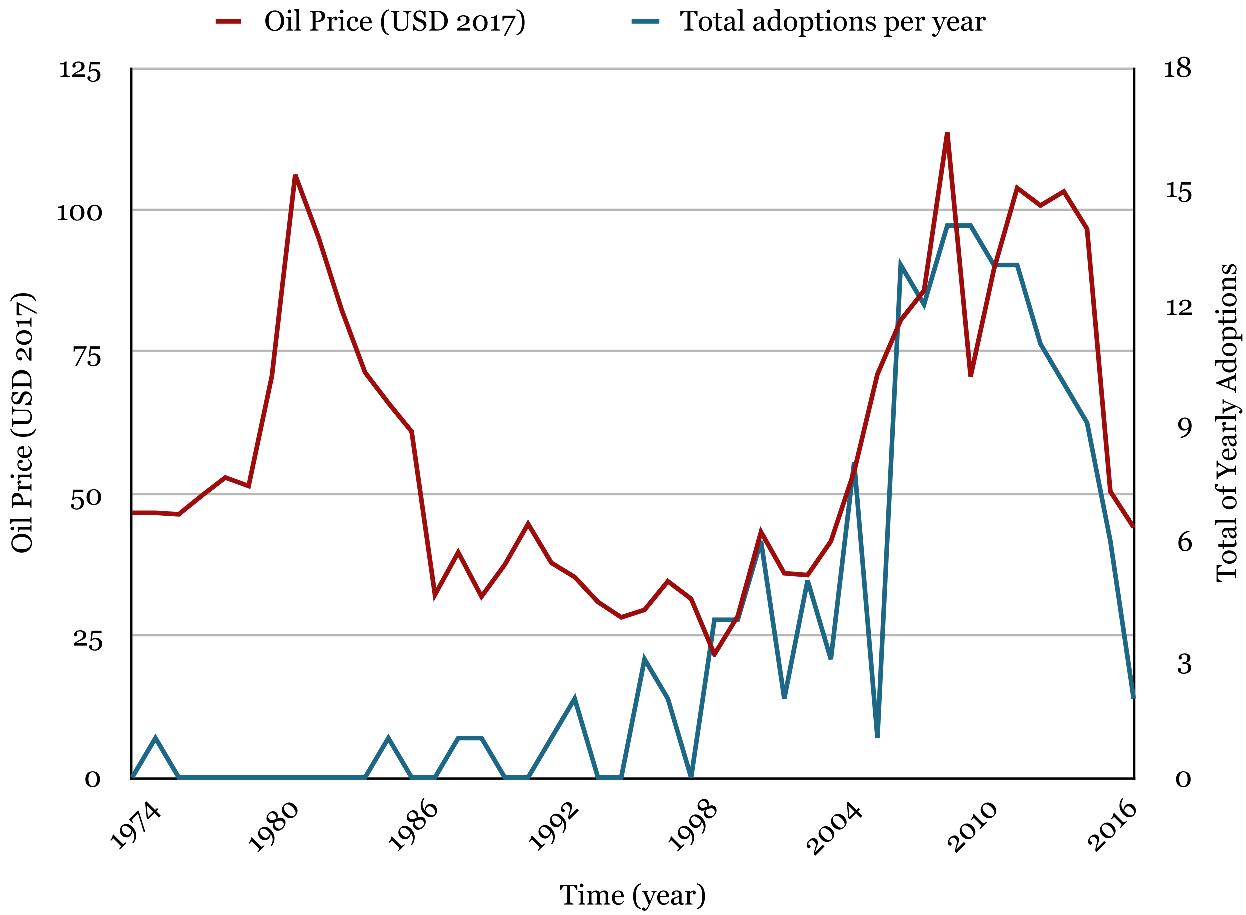

Figure 11. Total policy adoptions per year and oil price
The graph shows in blue the total number of the target adoptions per year (first per country only). The red line shows the international price of oil.
Source: Author's data & Federal Reserve Bank of St. Louis

Population also appeared to be a significant variable ($p \leq 0.01$). The coefficient is negative, and very small. The odds ratio for this variable are below 1, meaning that the larger the population size, the less likely it is that a country adopts a renewable energy target, holding the other variables in the model constant. To realize how small this coefficient is, a one-million increase in population would decrease the odds of a country adopting a renewable energy target to 0.99, holding the other variables in the model constant.

Table 4. EHA general model results
Source: Author's data

		General Model			
		Estimate	Std. Error	P (> t)	Odds Ratio
Mechanism Variables	Learning: Cumulative Membership to Energy IEA	-1.04e-01	1.68e-01	0.533	0.901
	Economic Competition: Energy Profile	5.71e-04	1.85e-03	0.757	1.001
	Emulation: Similarity Index	8.83e-01	1.20e-01	2.22e-13 ***	2.417
	Coercion: ODA[18]	-8.02e-04	7.69e-04	0.297	0.999
Control Variables	Oil Price	1.63e-02	5.63e-03	0.004 **	1.016
	Population	-1.26e-08	4.13e-09	0.002 **	0.999
	Energy Use per Capita	-1.11e-05	9.52e-04	0.991	0.999

Signif. codes: '***' p≤0.001 '**'p≤0.01 '*'p≤0.05 '^'p≤0.1
N = 2878
Log-likelihood = -166.095
AIC= 546.19, BIC= 1184.429

6.1.2 Robustness Analysis

To examine the robustness of the EHA findings, a series of models were run with different subsets of countries (*e.g.*, stratifying by different regions, income groups, and

[18] Transformed

among energy importers and exporters) in order to examine the possibility of heterogeneity across countries.

Regional Model

The regions here analyzed were derived from the WB division into seven regions: East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia, and Sub-Saharan Africa. Given data availability, these seven regions were grouped into three broader categories: Asia and Europe, the Americas, and Africa and the Middle East. The category of "Asia and Europe" includes the WB's categories of East Asia & Pacific, Europe & Central Asia, and South Asia. The category of "Americas" includes the WB's regions of Latin America & Caribbean, and North America. The category of "Africa and the Middle East" includes the WB's regions of Middle East & North Africa, and Sub-Saharan Africa.

Due to data availability,[19] it was not possible to include the same variables as in the general model for each of the three regions. Since no mechanism was significant apart from emulation in each region, the best feasible model included the variable of similarity index, as well as the three control variables used in the general model (oil prices, population, and energy use per capita).

Table 5 shows that similarity index is significant and positive across the three regions. However, the coefficients vary among them. Holding the other variables in the model

[19] All countries had data for region, however, there is missing data in some of the other independent/control variables. When running the logistic regression with a smaller N, since the countries are divided into different smaller groups, these missing numbers have a greater impact on the output.

constant, a one-unit increase in similarity index increases the odds ratio of adoption by a factor of ~2.9 in all regions; by a factor of ~4.5 in Asia and Europe; by a factor of ~3.3 in the Americas; and by a factor of ~12.1 for Africa and the Middle East. The high odds for Africa and the Middle East are, in part, explained by the fact that there are more late adopters than in the other regions, with ~42% of the adoptions happening since 2013. In Europe and Asia, ~16% of the adoptions took place since 2013, and ~15% in the Americas. Recall that the later in time a country adopts an energy target, the higher the similarity index, since there are more adopters in the world.

If one eliminated from the regional data in Africa and the Middle East all values after 2012 (*i. e.,* from 2013 onwards), then the coefficient for similarity changes from 2.49 (as seen in Table 5) to 2.19. The odds ratio decrease from ~12.1 to ~9. Still, emulation is the mechanism that seems to explain the spread of renewable energy targets across regions, especially in Africa and the Middle East.

The price of oil is positive and significant for all regions grouped together in this model, and remains significant for the Americas, with an even higher coefficient, indicating that the price of oil is very influential in this region. However, the price of oil is significant at the 90% confidence level for Asia and Europe with a smaller coefficient, and not significant at all for Africa and the Middle East.

Population is significant and negative in all the regions combined. However, the variable is only significant in Africa and the Middle East. Again, the coefficient is negative, although very small.

Table 5. EHA regional model results
Source: Author's data

		Regional Model			
		All Regions Together	Asia & Europe	The Americas	Africa & the Middle East
Mechanism Variable	Emulation: Similarity Index	1.08 *** (0.080) **2.94**	1.51 *** (0.201) **4.54**	1.19*** (0.221) **3.27**	2.49 *** (0.496) **12.1**
Control Variables	Oil Price	1.37 e-02 ** (4.23 e-03) **1.01**	1.65 e-02 ^ (8.44 e-03) **1.02**	3.39 e-02 ** (1.08 e-02) **1.03**	3.86 e-03 (1.56 e-02) **1.004**
	Population	-1.05 e-08 *** (3.03 e-09) **$0.\overline{999}$**	-2.49 e-09 (1.24 e-08) **$0.\overline{999}$**	3.69 e-08 (7.37 e-08) **1.00**	-2.63 e-07 *** (6.51 e-08) **$0.\overline{999}$**
	Energy Use per Capita	-2.23 e-04 (1.38 e-04) **0.999**	-9.95 e-05 (4.06 e-04) **0.999**	-2.14 e-04 (3.11 e-04) **0.999**	-3.85 e-04 (1.83 e-03) **0.999**
		n= 4241	n= 1955	n= 845	n= 1441

Signif. codes: '***' $p \leq 0.001$ '**' $p \leq 0.01$ '*' $p \leq 0.05$ '^' $p \leq 0.1$
Estimates are log odds, standard errors in parenthesis, and odds ratios in bold.

Income Model

Classification of countries by income groups was based on the WB division of countries into four categories, taking into consideration the changes across time in these dimensions. The four categories of low income, lower-middle income, upper-middle income, and high income were re-categorized into two: "high income" (including upper-middle income and high income) and “low income” (including lower-middle income and low income). Again, the general model could not be applied to theses groups individually given data availability.[20] As with the regional model, the only significant mechanism was emulation, and so the other mechanisms were dropped to find the best feasible model.

Table 6 shows that similarity (Emulation) is significant and positive across all models. Again, the coefficients vary in dimension. For lower-income economies, a one-unit increase in the similarity index increases the odds of adoption by a factor of ~3.7, holding all other factors in the model constant, whereas for higher-income economies this factor increases to ~4.7. This would indicate that higher-income countries emulate more than lower-income countries do. Within the higher-income group, upper-middle countries have a greater similarity average than high-income countries, which would indicate that upper-middle countries drive the odds in this case.

The variable of oil prices is positive and significant in both income groups together, however, it varies between the two. For the lower-income group, the price of oil is positive and significant ($p \leq 0.001$), with an odds ratio of ~1.04 for each dollar increase in the price of oil, holding all other factors in the model constant. However, for the higher-income group this variable is significant ($p \leq 0.05$) and negative, with an odds ratio of ~0.98, holding all other factors in the model constant. This would indicate that an increase in the price of oil would increase the chances of a renewable energy target being

[20] As it was the case of the previous robustness analysis, the grouping of the data into smaller groups increases the impacts of missing data on the final model, therefore the model needs to include less variables.

adopted in low/lower-middle income countries, but would have the opposite effect in upper-middle/high income countries. Why does this happen?

Even though the majority of country-years in the high and upper-middle income group are net energy importers, the average for the group is as a net energy exporter. This means that even though quantitatively there is a small number of net energy exporters, these countries are qualitatively large and driving the sign for the coefficient of oil price. In this group there are countries such as Oman, the United Arab Emirates, Saudi Arabia, Libya, Brunei Darussalam, Kuwait, Iraq, to name a few, that have exported between 1,790% and 10,003% of the equivalent of their energy use.

It makes sense that a net energy exporter would be more reluctant to adopt a renewable energy target, since these countries are directly benefiting from the expansion of fossil fuels. In this case, the fact that these countries are energy exporters drives the negative coefficient for the price of oil, and not the fact that these countries are higher-income. Thus, the coefficient for oil price should be negative for higher-income countries, as it is shown in Table 6.

Population is significant and negative across all regions, and it remains significant for lower-income countries (although with a smaller coefficient). Population is not significant for the high income group.

Table 6. EHA income model results
Source: Author's data

		Income Model		
		Both Groups Together	Low & Lower-middle Income	High & Upper-middle Income
Mechanism Variable	Emulation: Similarity Index	1.08 *** (0.080) **2.94**	1.32 *** (0.220) **3.75**	1.54 *** (0.167) **4.66**
Control Variables	Oil Price	1.37 e-02 ** (4.23 e-03) **1.01**	3.59 e-02 *** (1.05 e-02) **1.04**	-1.59 e-02 * (7.70 e-03) **0.984**
	Population	-1.05 e-08 *** (3.03 e-09) **0.999**	-9.92 e-09 * (4.80 e-09) **0.999**	-5.36 e-08 (5.97 e-08) **0.999**
	Energy Use per Capita	-2.23 e-04 (1.38 e-04) **0.999**	5.33 e-04 (1.05 e-03) **1.001**	-1.59 e-04 (1.78 e-04) **0.999**
		n= 4241[21]	n= 2523	n= 1698

Signif. codes: '***' p≤0.001 '**'p≤0.01 '*'p≤0.05 '^'p≤0.1
Estimates are log odds, standard errors in parenthesis, and odds ratios in bold.

Energy Model

The third stratification was based on net energy imports as a percentage of energy use for each country, with data from the WB. A net energy importer imports part of its energy, estimated as energy use less production, and measured in oil equivalents. A negative value in this variable indicates that the country is a net energy exporter.

[21] Note that when creating the two income groups N decreases given missing data on income for some country-years.

Emulation continues to be the only significant mechanism, and for comparison reasons this model analyzes the same variables as in the regional and income models.

Table 7 shows that similarity remains positive and significant across both groups. The odds ratio for similarity, holding all other factors in the model constant, are higher for energy importers (with odds of ~4.2) than for energy exporters (~3.5), which would mean that energy importing countries tend to emulate more than energy exporting countries do.

Holding all other factors in the model constant, the price of oil, positive and significant when combining both groups together ($p \leq 0.01$), is not significant for energy exporting countries, and is significant ($p \leq 0.001$) and positive for energy importing countries (with an odds ratio of ~1.03). This indicates that an increase in the price of oil has an impact on energy importing countries, and not on energy exporting countries.

The insignificant coefficient for the price of oil in net energy exporters might seem contradictory to the results discussed above on the income model for the high and upper-middle income group (significant and negative coefficient for oil price).

However, this might be due to the group of energy exporters including all energy exporters, whereas the high and middle-upper group only includes high-income exporter counties. It is possible that the group of energy exporters is diluted between "heavy" exporters and "light" exporters. It is not the same to export 0.1% and 10,000% of the equivalent of your energy use. The average value for high and upper-middle countries that export energy is 456.43%, whereas for low and lower-middle countries the average is 143.59%. It is possible that in the average of these two groups there is no significance in the price of oil, whereas when analyzing for high and upper-middle income groups, the heavy net energy exporters drive the negative sign of the price of oil, which is visible when stratifying by income.

Population is negative and significant for both groups analyzed together. The variable is not significant for energy importers, and is significant for energy exporters at the 90% confidence level, with a greater coefficient than for both groups combined.

Table 7. EHA energy model results
Source: Author's data

		Energy Model		
		Both groups together	Energy Importers	Energy Exporters
Mechanism Variable	Emulation: Similarity Index	1.08 *** (0.080) **2.94**	1.43 *** (0.129) **4.17**	1.26 *** (0.252) **3.51**
Control Variables	Oil Price	1.37 e-02 ** (4.23 e-03) **1.01**	2.49 e-02 *** (5.68 e-03) **1.03**	1.05 e-02 (1.14 e-02) **1.01**
	Population	-1.054e-08 *** (3.03 e-09) $\mathbf{0.\overline{999}}$	-2.44 e-09 (8.54 e-09) $\mathbf{0.\overline{999}}$	-4.97 e-08 ^ (2.76 e-08) $\mathbf{0.\overline{999}}$
	Energy Use per Capita	-2.23 e-04 (1.38 e-04) **0.999**	-1.14 e-04 (2.90 e-04) **0.999**	-2.93 e-04 (3.25 e-04) **0.999**
		n= 4241[22]	n= 2631	n= 1467

Signif. codes: '***' p≤0.001 '**'p≤0.01 '*'p≤0.05 '^'p≤0.1
Estimates are log odds, standard errors in parenthesis, and odds ratios in bold.

[22] Note that when dividing into two income groups N decreases given missing data on income, variable that is not included when both groups are analyzed together.

6.1.3 EHA Conclusions

After performing the logistic regression with the general model and the three stratified models, one can draw the following generalizations regarding the diffusion mechanisms that explain the adoption of renewable energy targets.

First, the only mechanism at play when analyzing the diffusion of renewable energy targets seems to be **emulation**, which would indicate that similar countries are copying each other in order to look alike, and that the increasing number of countries with renewable energy targets seems to legitimize new adoptions by other countries, particularly among late adopters. This holds true in the general model, as well as in models that stratify countries by different region, income groups and between energy importers and energy exporters.

Second, the **price of oil** plays an important role when analyzing the diffusion of renewable energy targets. There is a close relationship between the price of oil and the adoption of the first renewable energy targets.

When focusing on regions, the price of oil is significant in the Americas, home of the first renewable energy targets of the world. These first targets were biofuel mandates, a clear example of the impact that an increase in oil prices has on oil importing countries. In Asia and Europe, oil prices are significant at the 90% confidence level, and have a coefficient smaller than the Americas. The price of oil does not seem to have an impact in the diffusion of renewable energy targets in Africa and the Middle East, perhaps since this is the region that exports the most oil.

When focusing on income groups, the price of oil is significant and positive for low and lower-middle income countries. This indicates that the higher the price of oil, the more likely it is for this group of countries to adopt a renewable energy target. However, for the upper-middle and high income countries this trend is opposite: the higher the price of oil, the less likely it is for these countries to adopt a target. This was explained by the presence of large energy exporters in the high income group.

When focusing on energy importer and exporters, the price of oil is only significant for energy importers, since oil is a large part of these imports. The higher the price, the more likely that energy importers (who are mainly importing oil) adopt a renewable energy target in order to foment alternative technologies that produce energy domestically.

Third, **population** size is negative and has a very small coefficient in most models. It is significant in several models, indicating that greater population sizes tend to decrease the chances of a country adopting a renewable energy target. This might be related to the fact that big populations demand more resources, and most renewable energy sources are not yet efficient at delivering at large scales. Contrary to fossil fuels, renewable energies are land intensive resources. While fossil fuels can be exploited at high power rates (with power ranges between 200-11,000 W_e/m^2),[23] renewable energies have much lower power rates. For example, typical ranges are 2-10 W_e/m^2 for solar power plans, 0.5-7 W_e/m^2 for large hydroelectric, 0.5-2 W_e/m^2 for wind, and ~0.1 W_e/m^2 for biomass (Capellán-Pérez, de Castro, & Arto, 2017).

[23] This is the average power delivered to the grid in electric watts per square meter, taking into consideration the lifetime of the resource.

6.2 Qualitative Comparative Analysis

While the EHA provided a general assessment of the determinants of the diffusion of the adoption of energy targets (an analysis based largely on country averages and deviations from the average), the QCA treats each case as a holistic entity. QCA tries to find common patterns or configurations of conditions across cases that lead to the outcome of interest, in this case, the adoption of a renewable energy target. This analysis aims to show the different paths (configurations of conditions) that lead to the outcome, therefore contemplating for equifinality.

The QCA also included 187 countries in the time period studied in the event history analysis: 1974 - 2017. The outcome remained the same: the first adoption of a renewable energy target (0= no, 1 = yes). This means that this author combined crisp set QCA (dependent variable) with fuzzy set QCA (independent variables or conditions). This approach proves challenges for identifying necessary conditions, but is still useful at identifying different configurations of conditions that lead to adoption of renewable energy targets.

Each country was analyzed with data from the year that the country's first renewable energy target was adopted. Data from 2017 was used for non-adopters, since these countries had not yet adopted a renewable energy target by the time that this research ended.[24]

[24] Note that in QCA missing data for a case implies this case being eliminated from further analysis. In order to preserve as many cases as possible the researcher used the closest data in time to impute for missing values. For the "energy commerce" condition data was only available until 2015, and for "ODA" data was available until 2016. When the country was not in the dataset at all, the researcher used the country's regional average.

The QCA was run with the software fsQCA, which was used to calibrate all of the conditions (variables in quantitative terms) and to produce the truth tables and results shown here.

Calibration was needed since fsQCA uses values that range from 0 (non-membership in the set) to 1 (complete membership in the set). All calibration rules are detailed in Appendix 4 (Table 15).

The final QCA model included seven conditions: year of adoption, cumulative IEA membership, energy profile, similarity index, ODA, oil price, and income level. Population was only included for a sensitivity analysis. Four conditions would explain each of the four mechanisms for diffusion (as in EHA), along with two control conditions (the price of oil and income level), and one condition that represented time of adoption (year). Population size was omitted from the final QCA model in order to achieve a better fit; however, it was included for a sensitivity analysis.

As in quantitative methods, QCA has relevant parameters of fit to help assess how well the chosen combination of conditions explains the outcome of interest. The parameters of fit in QCA include: frequency threshold, consistency, solution consistency, solution coverage, raw coverage, and unique coverage. These are defined in Appendix 5 (Table 16). For more information on these parameters, refer to Ragin and Patros (2017) and Schneider and Wagemann (2012).

6.2.1 General Results

From the 187 countries included in this analysis, 149 were explained in the final output combination, with a total of 114 unrepeated countries (given that in some occasions a country can belong, in different degrees, to different combinations of conditions). These countries are listed in Appendix 6.

From the 128 possible pathway configurations (2^7), 94 were omitted due to a lack of cases, and 11 were further omitted due to low frequency (1 case only). Of the 23 final combinations in the truth table, 21 were considered to contribute to the outcome, and 2 were not (based on the consistency cutoff). The truth table is reported in Appendix 7 (Table 17).

Both of these reductions are a product of Boolean minimization, as used by QCA in order to minimize the number of possible combinations.

The final model resulted in 10 combinations, meaning that with the conditions included in the analysis, there are 10 unique paths that lead to the adoption of renewable energy targets, as seen in Table 8 and in more detail in Table 9.

The solution consistency for this model was 0.872, representing the degree to which a causal condition (or conditions) and an outcome is met. This happens when all cases with X=1 (have the conditions or combinations of conditions analyzed) are also members of the outcome Y=1 (adoption of a renewable energy target). Consistency measures the degree to which cases sharing a condition agree in displaying the outcome. In the QCA, there were cases without the outcome (Y=0) that were included in the final combinations (X=1). Including non-adopters diminishes the model's consistency, however, enriches the understanding of potential adoptions. Perfect consistency, where all countries included in the pathway have the outcome of interest, would yield a consistency score of 1.00.

Another relevant parameter of fit is the solution coverage, which provides a measure of empirical relevance. Coverage measures how many of the countries that have a target are covered in this model across all combinations (in this case, 10 combinations). The solution coverage measures what is the relation in size between subset X and superset Y. The model for the QCA had a solution coverage of 0.635, which indicates that almost 64% of cases that have a target are covered by this model.

As previously mentioned, the frequency cutoff was 2. This means that every combination with 1 or 0 cases was omitted from the truth table. The consistency cutoff was 0.80, meaning that combinations with a raw consistency of less than 0.80 were coded as not part of the outcome (2 in total), whereas greater consistency (scores greater than or equal to .80) was coded as combinations that would lead to the outcome (21 in total).[25] Table 8 shows the ten combinations of the output of the truth table.

Raw coverage represents the extent to which each path explains the outcome. However, since some cases repeat in different paths, attention is paid to unique coverage. Unique coverage represents the proportion of cases that can be explained exclusively by each path. The consistency for each path is a measure of how many cases in such a path have the outcome.

Table 8 shows that there are three combinations for early adopters (indicating that the countries under such a description adopted the target before 2007), six combinations for later adopters (after 2007), and one combination with no time specification. This last combination might contain both early and late adopters, therefore the year condition does not define this group. Each country included in each path is listed in Table 9.

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[25] The model was also run with a consistency cutoff of 0.9, . This would increase the solution consistency to 0.967, but decrease the solution coverage to 0.43.

Table 8. QCA general model results
Source: Author's data

QCA general results. The analysis included 7 conditions, with a frequency cutoff of 2, a consistency cutoff of 0.80, a solution coverage of 0.63, and a solution consistency of 0.87. Paths are ranked according to raw coverage.

General Model

Path	1	2	3	4	5	6	7	8	9	10
Time	Late Adopter					Early Adopter	Late Adopter	Early Adopter	No Time	Early Adopter
Learning	Few IEAs		---		Few IEAs		High IEAs			Few IEAs
Economic competition	---			Energy Importer	Energy Exporter		Energy Importer	---	Energy Importer	
Emulation	Emulator			---		Not an Emulator	---	Not an Emulator		
Coercion	Aid Recipient	---	Aid Recipient				Not an Aid Recipient			Aid Recipient
Context	--- Expensive oil	Higher income Expensive oil	Higher income Expensive oil	Lower income Expensive oil	Higher income Expensive oil	Lower income ---	Higher income Expensive oil	Higher income Cheap oil	Higher income Expensive oil	--- Expensive oil
Raw coverage Unique coverage Consistency	0.369 0.062 0.866	0.265 0.026 0.873	0.257 0.030 0.893	0.189 0.021 0.900	0.154 0.001 0.878	0.100 0.022 0.987	0.092 0.016 0.901	0.091 0.047 0.989	0.083 0.008 0.998	0.082 0.013 0.996

The ten paths are ranked based on their raw coverage. The most common path based on raw coverage is **Path 1** (with a raw coverage of 0.369), where there are countries such as Solomon Islands, Haiti, Micronesia, Nepal, and Sierra Leone. The main mechanisms driving the adoption of renewable energy targets are both coercion and emulation, in a context of expensive oil. In this group, four non-adopters are included.[26] These late coerced emulators are the part of the combination that most explains the outcome, representing twenty countries.

Path 2 (with a raw coverage of 0.265) represents late adopters in which the analyzed policy is diffused due to emulation, occurring in higher-income countries with a high price of oil. Brunei Darussalam, Iraq, Belize, Seychelles, Grenada, Antigua and Barbuda, and others are represented in this group. Again, there are three non-adopters in this combination.[27] There are also twenty countries in this late higher-income emulators path.

Path 3 (raw coverage: 0.257) highlights the mechanisms of emulation and coercion happening together. This group of higher-income countries adopted the renewable energy target when oil was expensive. Iraq, Azerbaijan, Albania, Serbia, Iran, Namibia, Panama, Fiji, and others followed this path. Path 3 countries are late higher-income coerced emulators. Path 3 represents tewnty countries.

Path 4 (raw coverage: 0.189) countries are late adopters, energy importers (adding to which oil was expensive) and received aid. This group of countries adopted the target due to the mechanisms of economic competition and coercion. The counties are lower-income. Tajikistan, Benin, Bhutan, Armenia, El Salvador, and Nicaragua are some of the

[26] These are: Afghanistan, Papua New Guinea, Somalia, and Sudan.
[27] These are: Andorra, Oman, and San Marino.

countries that followed this path. There are three non-adopters[28] and seventeen adopters in this late lower-income coerced market driven group.

Path 5 (raw coverage: 0.154) countries are late adopters that received aid, and therefore coercion seems to be the main mechanism at play. Adoptions take place even though countries are energy exporters and oil is expensive, which would indicate that countries would not adopt a target. Countries such as Iran, Ecuador, Iraq, Mexico, Suriname, and others, are represented in this group. There are three countries in this group that did not adopt the target,[29] even though they share very similar conditions to the other seventeen adopters. Path 5 countries are late higher-income coerced energy exporters.

Out of the three groups for early adopters, **Path 6** (raw coverage: 0.100) represents the group of countries that have adopted the target due to coercion (since they are aid recipients), in spite of being energy exporters. An energy exporter would be less likely to adopt a target, given that they are benefitting from exporting fossil fuels, the main competitor for renewable energies. However, since these countries are in the group of lower-income, it is possible that coercion played a relevant role, and the fact that they are energy exporters loses importance. In this group there are eight countries, including Mali, Colombia, Syria, Malawi, South Africa, and Algeria. Path 6 represents the early lower-income coerced energy exporters.

A combination of learning and economic competition drove countries such as Greece, Bulgaria, Macedonia, Belgium and Iceland to adopt renewable energy targets. These are higher-income countries which adopted their targets when oil was expensive. As

[28] These are: Afghanistan, Georgia, and Kyrgyzstan.
[29] These are: Bahrain, Equatorial Guinea, and Oman.

observed in **Path 7** (raw coverage: 0.092), there is one non-adopter in this group and eight adopters.[30] These are late higher-income market driven learners.

With high IEA membership, **Path 8** (raw coverage: 0.091) countries are the early learners. This group is characterized as high income and adopted the targets early in spite of oil being cheap. Norway, Denmark, Finland, Italy, Spain, Hungary, and Japan, are clear examples of this combination. There are sixteen countries in this early higher-income learner group.

Path 9 (raw coverage: 0.083) countries are distributed through different time periods. Countries in this combination mainly adopted their first renewable energy target due to the mechanisms of learning and economic competition. These countries are higher-income, and oil was expensive. Estonia, Slovenia, Austria, Luxembourg, and five other countries are in this group. The higher-income timeless market driven learners are the second to the last in terms of coverage

Path 10 (raw coverage: 0.082) countries adopted the target early due to coercion (since they received aid) and economic competition (since they import energy). Here, countries such as Guatemala, Brazil, Tunisia, and four others are found. Path 10 countries could be considered the early oil-shock coerced adopters.

[30] This is: Liechtenstein.

Table 9. Ten paths to renewable energy targets
Source: Author's data

This table represents the different paths that led to renewable energy targets. The first column numbers the path and matches the first row in Table 8. The second column represents the dimension of time. The third column synthesizes the diffusion mechanism at stake in each path, as well as some context information. Raw coverage is included for each combination. The last column lists the countries per combination, with their consistency and outcome status (0=no outcome, 1=outcome) in parenthesis (consistency, target status). The higher the consistency, the more the case belongs to the combination. Paths are ranked according to raw coverage.

Path	Time	Mechanism at Play	Cases Following the Path
1	Late	Emulation + Coercion • Expensive oil Raw coverage: 0.369	Solomon Islands (0.88,1), Haiti (0.81,1), Micronesia (0.81,1), Nepal (0.81,1), South Sudan (0.79,0), Papua New Guinea (0.79,0), Somalia (0.79,0), Fiji (0.78,1), Afghanistan (0.78,0), Nicaragua (0.78,1), Iraq (0.78,1), El Salvador (0.78,1), Sierra Leone (0.78,1), Serbia (0.78,1), Ecuador (0.78,1), Iran (0.78,1), Cabo Verde (0.78,1), Vanuatu (0.78,1), Cuba (0.78,1), Kiribati (0.77,1)
2	Late	Emulation • Higher-income • Expensive oil Raw coverage: 0.265	Brunei Darussalam (0.88,1), Oman (0.78,0), Andorra (0.78,0), San Marino (0.78,0), Trinidad and Tobago (0.76,1), Iraq (0.73,1), Belize (0.73,1), Seychelles (0.73,1), Grenada (0.73,1), Antigua and Barbuda (0.73,1), Maldives (0.73,1), Suriname (0.73,1), Cuba (0.73,1), Fiji (0.73,1), Panama (0.73,1), Iran (0.73,1), Ecuador (0.73,1), Serbia (0.73,1), Saint Vincent and the Grenadines (0.71,1), Saint Lucia (0.71,1)
3	Late	Emulation + Coercion • Higher-income • Expensive oil Raw coverage: 0.257	Iraq (0.73,1), Azerbaijan (0.73,1), Albania (0.73,1), Serbia (0.73,1), Ecuador (0.73,1), Iran (0.73,1), Namibia (0.73,1), Panama (0.73,1), Fiji (0.73,1), Cuba (0.73,1), Turkey (0.71,1), Montenegro (0.71,1), Palau (0.71,1), Venezuela (0.68,1), Mexico (0.66,1), Costa Rica (0.66,1), Croatia (0.66,1), Suriname (0.64,1), Maldives (0.63,1), Singapore (0.63,1)

4	Late	Coercion + Economic Competition • Lower-income • Expensive oil Raw coverage: 0.189	Tajikistan (0.84,1), Afghanistan (0.79,0), Benin (0.78,1), Haiti (0.75,1), Bhutan (0.73,1), Kyrgyzstan (0.73,0), Georgia (0.73,0), Armenia (0.73,1), El Salvador (0.73,1), Nicaragua (0.73,1), Senegal (0.73,1), Nepal (0.72,1), Zimbabwe (0.66,1), Kenya (0.66,1), Bangladesh (0.66,1), Morocco (0.66,1), United Republic of Tanzania (0.62,1), Sri Lanka (0.62,1), Uzbekistan (0.62,1), Zambia (0.62,1)
5	Late	Coercion • In spite of being energy exporters • Higher-income • Expensive oil Raw coverage: 0.154	Iran (0.73,1), Ecuador (0.73,1), Iraq (0.73,1), Mexico (0.66,1), Suriname (0.64,1), Antigua and Barbuda (0.58,1), Grenada (0.57,1), Oman (0.57,0), Dominica (0.56,1), Seychelles (0.55,1), Equatorial Guinea (0.54,0), Saint Kitts and Nevis (0.53,1), Belize (0.53,1), Libya (0.53,1), Trinidad and Tobago (0.52,1), Barbados (0.52,1), Saint Vincent and the Grenadines (0.51,1), Bahrain (0.51,0), Saint Lucia (0.51,1), Kuwait (0.51,1)
6	Early	Coercion • In spite of being energy exporters • Lower-income Raw coverage: 0.100	Mali (0.87,1), Colombia (0.73,1), Syrian Arab Republic (0.69,1), Malawi (0.65,1), South Africa (0.65,1), Algeria (0.61,1), Paraguay (0.57,1), Indonesia (0.57,1)
7	Late	Learning + Economic Competition • Higher-income • Expensive oil Raw coverage: 0.092	Liechtenstein (0.79,0), Greece (0.71,1), Bulgaria (0.71,1), The former Yugoslav Republic of Macedonia (0.71,1), Belgium (0.66,1), Iceland (0.65,1), Romania (0.6,1), Slovakia (0.53,1), Switzerland (0.53,1)

8	Early	Learning • Higher-income • Cheap oil Raw coverage: 0.091	Denmark (0.8,1), Italy (0.8,1), Norway (0.8,1), Finland (0.8,1), Spain (0.78,1), Hungary (0.71,1), Japan (0.69,1), France (0.69,1), United States of America (0.67,1), Australia (0.65,1), Czech Republic (0.65,1), Poland (0.65,1), Netherlands (0.65,1), Republic of Korea (0.65,1), Germany (0.59,1), Ireland (0.57,1)
9	N/A	Learning + Economic Competition • Higher-income • Expensive oil Raw coverage: 0.083	Estonia (0.73,1), Slovenia (0.69,1), Austria (0.6,1), Luxembourg (0.6,1), Portugal (0.55,1), Latvia (0.55,1), Switzerland (0.55,1), Sweden (0.55,1), Slovakia (0.52,1)
10	Early	Coercion + Economic Competition • Expensive oil Raw coverage: 0.082	Guatemala (0.83,1), Brazil (0.68,1), Tunisia (0.57,1), Cambodia (0.57,1), Jordan (0.57,1), Ghana (0.52,1), Nauru (0.51,1)

6.2.2 QCA Conclusions

One can conclude that there are mainly six paths that led to the adoption of renewable energy targets:

1. Emulation and coercion happening simultaneously (paths 1 and 3)
2. Emulation (path 2)
3. Coercion and economic competition happening simultaneously (paths 4 and 10)
4. Coercion (paths 5 and 6)

5. Learning and economic competition happening simultaneously (paths 7 and 9)
6. Learning (path 8)

The top three paths in terms of raw coverage (paths 1, 2 and 3) represent countries that are late adopters, **emulators**, and that adopted the target when **oil was expensive**. Two of these three paths (paths 2 and 3) are **higher-income** countries, and income status is not defined for the reaming group (path 1). There are a total of 60 countries encompassed in these three paths (45 non-repeated countries), including 7 non-adopters.[31] Also, the three least common paths in terms of raw coverage (paths 8, 9 and 10) are specified as non-emulators (this is, the countries followed other paths, and are specifically non-emulators).

Each of the six general paths have certain particularities which derive into the ten final combinations seen in Tables 7 and 8. Overall, in terms of combinations, in half of the paths adoptions happened with few IEAs (not learning), three paths have high IEAs (learning), and in two paths it was not specified. There are two energy exporter paths, four energy importer paths, and four non-specified paths regarding economic competition. There are four non-emulator paths (three of them at the early stage and one timeless), three emulator paths, and three unspecified paths. In terms of coercion, there are six aid recipients, three non-aid recipients, and one unspecified path.

In terms of raw coverage, which differentiates relevant paths from less important ones, the mechanism of emulation, and the combination of the mechanisms of emulation with coercion are the three most common paths. The fourth most common path involves the

[31] Non-adopters are Afghanistan, Andorra, Oman, Papua New Guinea, San Marino, Somalia, and South Sudan.

mechanisms of coercion and economic competition happening simultaneously, while in the fifth and sixth paths, coercion acts alone. The seventh, eighth and ninth most common paths follow the mechanisms of learning and economic competition happening simultaneously, as well as learning happening alone. The least common path shows the mechanisms of coercion and economic competition happening simultaneously.

In most of the paths, including the 5 most common paths, countries adopted the target when oil was expensive. Most of adoptions came from higher-income countries (upper-middle and high income), although there remain two lower-income adopters (paths 4 and 6).

In general terms, learning took place in higher-income countries that did not receive aid (no coercion), independently of oil prices (paths 7, 8 and 9); these paths seem to be close to last in terms of coverage. The mechanism of economic competition (condition of energy importer) appeared combined with expensive oil in all the paths (paths 4, 7, 9 and 10); these paths seem to be ranked differently in terms of coverage. Emulation was prevalent only in late adopters, and with expensive oil (paths 1, 2 and 3); these paths are the three most common ones. Coercion seems to have no time dimension, and happened across different configurations (paths 1, 3, 4, 5, 6 and 10); thus closer to more common paths than to least common ones in terms of coverage.

Lower-income countries received aid (coercion) (paths 4 and 6), and countries with a high number of IEAs (learning) are higher-income countries (paths 7, 8 and 9). The price of oil has several different configurations, but in most of them, oil is expensive (paths 1, 2, 3, 4, 5, 7, 9 and 10).

6.3 Combined Analysis

The comparison between EHA and QCA results is shown below, followed by a conclusion on the mixed methods approach.

6.3.1 Results Comparison

General Results Comparison

In the EHA, emulation was the only significant mechanism. In the QCA this finding was reinforced, since emulation (and a combination of emulation and coercion) was the most common mechanism for the adoption of renewable energy targets (paths 1, 2 and 3). These three paths are the top 3 in terms of raw coverage, and are in the top 4 in terms of unique coverage. This means that they make up for the largest contribution to the model. However, QCA also showed that there are other mechanisms at play, as well as different combinations of mechanisms - there are still seven more paths that led to the outcome. These other paths show the mechanisms of coercion, learning, economic competition combined with coercion, and learning combined with economic competition.

The price of oil was significant and positive in the EHA, meaning that the more expensive oil is, the more likely it is that a country adopts a renewable energy target. In the QCA this finding was reinforced, with 8 out of 10 configurations having expensive oil as a condition, including the top 5 (paths 1, 2, 3, 4, 5, 7, 9 and 10). In only one combination did countries adopt the target even when oil was cheap (path 8), and this path was the eighth to last in terms of coverage (raw coverage: 0.091), so not a very common path. These were higher-income countries with a high number of IEAs, meaning that for this group adoption followed a different logic - these countries are the early higher-income learners.

Population size was only included in the EHA. It was not originally included in the QCA because it decreased coverage, increased the number of paths by 50%, and decreased the number of cases included in the final analysis. However, a second model was run including population and excluding income. The overall results of this second model, which still shows emulation as the most common path, show that adoptions most of adoptions happened in countries with small populations (less than 21 million inhabitants). Although the most common path does not have population as a condition (raw coverage: 0.37), there are several paths that do: paths 2 (raw coverage: 0.33), path 3 (raw coverage: 0.27), path 5 (0.13), path 8 (0.08) and path 9 (0.06). Only paths 6 (0.11) and 10 (0.06) have big populations. The complete results are seen in Appendix 7 (Table 19).

Table 10. Comparison of EHA and QCA general results
Source: Author's data

	EHA Results	**QCA Results**
Mechanism	One mechanism at play: emulation appeared as the only significant mechanism and its relationship with target adoption was positive.	One main mechanism and several less common ones: emulation, and a combination of emulation and coercion are the top three paths. Other paths include learning, coercion, economic competition combined with coercion, and learning combined with economic competition.

Oil Price	Oil price was significant and positive.	Eight of ten combinations lead to the target when oil was expensive, and only one when oil was cheap.
Population	The greater the population, the lower the odds for adoption of renewable energy targets (although it is a small impact)	In the second model (Appendix 7, Table 19) small population is a condition for the outcome in paths 2, 3, 5, 8, and 9. Big population is a condition for the outcome only in paths 6 and 10.

Regional Results Comparison

In terms of regional results, the EHA revealed that emulation was particularly strong in Africa and the Middle East. This is not exactly what QCA showed, since paths 1, 2 and 3 have countries from all three regions analyzed. In the total of 60 countries that had emulation in their combinations, 25 are from Asia and Europe (out of 70 total in this region), 22 from the Americas (out of 42), and 13 from Africa and the Middle East (out of 37). QCA does not seem to find any regional distinction for emulation.

However, there seems to be a regional distinction for the mechanism of learning. A total of 33 out of 34 of the countries that are in the three paths that have high IEAs (paths 7, 8 and 9) are in Asia and Europe. The 34th one is the United States, located in the Americas.

The price of oil was significant and positive for the Americas and for Asia and Europe, though not significant at all for Africa and the Middle East. In the QCA, the top five paths have the condition of expensive oil. These five paths represent 100 countries, out of which 37 are from the Americas (out of 42 American countries), 35 from Asia and Europe (out of 70 countries in this region), and 28 from Africa and the Middle East (out of 37). In QCA almost all of the countries in the Americas adopted the target when oil was expensive, but there are still adopters in the other regions. The QCA results corroborate the EHA results, and also provide more information.

Table 11. Comparison of EHA and QCA regional results
Source: Author's data

	EHA Results	**QCA Results**
Mechanism	Emulation is strongest in Africa and the Middle East, followed by Asia and Europe, and finally the Americas.	No particular regional distinction for emulation. However, learning was a diffusion mechanism mostly in Asia & Europe.
Oil Price	Oil price was significant and positive for the Americas and for Asia and Europe, and not significant at all for Africa and the Middle East.	Almost all countries in the Americas adopted their target when oil was expensive, but something similar happened in Africa and the Middle East and, to a lesser extent, in Asia and Europe.

Income Results Comparison

In terms of income distinctions, EHA results show that emulation is stronger in higher-income countries than in lower-income ones. This is corroborated by the QCA, where, out of the three paths that followed emulation (paths 1, 2 and 3), two are higher-income, and the third one is not specified. However, there are also higher-income non-emulators (paths 8 and 9). If one pays closer attention in the QCA, one can notice that emulation is stronger in upper-middle income countries than in higher-income countries, where learning is predominant, or a combination of learning and economic competition.

In EHA, the price of oil was positive and significant for lower-income countries, whereas it was negative and significant for higher-income countries. This would mean that higher oil prices result in a greater number of lower-income countries adopting renewable energy targets, whereas higher-income countries are less likely to adopt an energy target (these countries would adopt the target when oil is cheap).

In the QCA, this view is not entirely corroborated. The only paths that match the EHA results are path 4 (lower-income countries that adopted the target when oil was expensive) and path 8 (higher-income countries that adopted the target when oil was cheap). Paths 2, 3, 5, 7, and 9 represent higher-income countries that adopted the target when oil was expensive. QCA seems to show a different picture than EHA.

Table 12. Comparison EHA and QCA income results
Source: Author's data

	EHA Results	**QCA Results**
Mechanism	Emulation: Higher-income countries are more likely to emulate in the adoption of renewable energy targets than lower-income countries.	Out of the three configurations of conditions that include emulation, two include higher-income countries, and one is not specified.
Oil Price	Positive and significant for lower-income countries, and negative and significant for higher-income countries.	In QCA most of the paths represent higher-income countries that adopted the target when oil was expensive. In Path 1 income is not specified.

Energy Results Comparison

In EHA, emulation was positive and significant for both energy importers and energy exporters, and the coefficient was greater for the former than for the latter. None of the 3 emulator paths in QCA specified energy status (paths 1, 2, and 3). However, 2 of the 3 non-emulators are energy importers.

The price of oil was positive and significant only for energy importers in the EHA. In the QCA, the three paths containing energy importers also contain high oil prices (paths 7, 9 and 10), although there are also two paths of energy exporters with expensive oil.

Table 13. Comparison of EHA and QCA energy results
Source: Author's data

	Energy EHA Results	**QCA Results**
Mechanism	Emulation is positive and significant. Coefficient is greater for energy importers than for energy exporters.	There are 3 paths for emulation, none of them specifies whether countries are energy importer or exporters.
Oil Price	Variable is positive and significant only for energy importers.	All paths containing energy importers also contain expensive oil.

6.3.2 Mixed Methods Conclusions

In some occasions QCA seemed to corroborate the results from the EHA, whereas in some others it did not. The general results from the EHA match the results from the QCA. However, QCA results do not always agree with the EHA in the stratified analysis (regional, income based, and energy based). This is clearly related to the nature of each of the two methodologies, and highlights the importance of having combined the two analyses.

The comparison of results for oil price in the income analysis (Table 12) is an example that better illustrates the nature of each methodology. According to the EHA results, higher oil prices increase the odds of target adoption in lower-income countries (positive coefficient), whereas it decreases the odds in higher-income countries (negative coefficient). According to the QCA only two paths followed that logic (path 4: lower-income + expensive oil; and path 8: higher-income + cheap oil). In QCA the majority of paths represent higher-income countries that adopted the target when oil was expensive (paths 2, 3, 5, 7 and 9).

This could be attributed to the fact, as mentioned in the EHA income model results, that although the majority of countries (quantitatively) in the higher-income group are net energy importers, the average of the group (qualitatively) is as a net energy exporter. A net energy exporter would be reluctant to adopt a renewable energy target when the price of oil is expensive since such a country is mainly exporting oil. The EHA is strongly driven by averages and therefore showed that countries such as Oman, the United Arab Emirates, Saudi Arabia, Iraq, Kuwait and Libya (that exported up to 10,000% of energy comparing their energy use) drove the negative coefficient for oil price in the higher-income group. This was not because the countries are higher-income, but because they are heavy energy exporters.

QCA does not focus on averages, but on combinations of conditions instead, which highlights some factors that might not be visible when mainly focusing on averages. Therefore QCA brought up that fact that most adoptions happened in higher-income countries when oil was expensive, and it showed that for the group of countries that drove the negative coefficient for oil price in higher-income countries (Oman, Iraq, and the others) the main mechanism at play was coercion.

In conclusion, EHA is a quantitative longitudinal method and therefore inferences can be very powerful (Allison, 2011). As a quantitative tool, EHA uses the average effects of independent variables to explain an outcome. Causation is assumed to be linear and one-dimensional. EHA assumes additive causation and does not contemplate for equifinality. Cases in EHA are treated as equals - all observations are a priori equally important. However, EHA is extremely useful for inferences and generalization, since it adopts a broad scope (Goertz & Mahoney, 2012).

QCA on the other hand, as a qualitative tool, seeks to explain individual cases (or group of cases). It focuses on necessary and sufficient conditions, instead of correlation. QCA does not assume additive causation and instead contemplates for equifinality. Cases are weighted and differences amongst cases are incorporated into the study design. As Berg-Schlosser et. al (2008) describe: QCA "goes beyond the (often superficial or misleading) means, correlations and regressions - computed across all cases at the same time - which average out the respective constellations and ignore specific, distinct patterns and 'outliers' " (p.9). However, QCA has a narrower scope and it is harder to quantify the dimension of each condition analyzed (Goertz & Mahoney, 2012; Berg-Schlosser et. al, 2008).

Therefore, it makes sense that QCA would corroborate the general conclusions of the EHA, but not all of the more specific ones. This is related to the fact that EHA is average-driven, and therefore the cases that are far from this measure do not appear as significant and are lost. EHA presents one path to the outcome, and excludes those countries who did not followed that path. QCA did a good job at recovering those cases and grouping them into other paths, therefore showing the complexity of the phenomena studied. Together, these two methods enriched the understanding of policy diffusion of renewable energy targets.

7. Discussion and Policy Implications

The EHA confirmed only one of the hypotheses tested: that countries emulate similar countries in order to look like them, and future adoptions are legitimized as more countries adopt renewable energies targets. This was the hypothesis for the diffusion mechanism of emulation. Additionally, EHA showed the relevance of oil price as well as population size.

The QCA mixed crisp set QCA (outcome condition) with fuzzy sets QCA (all causal conditions). Mixing both crisp and fuzzy sets makes it harder to identify necessary conditions. However, this methodology still proves relevant for analyzing sufficient conditions.

The QCA showed that there is more than one path to the adoption of renewable energy targets (equifinality), revealing various combinations of diffusion mechanisms that act together (conjunctural causation). In this regard, there are six general paths, and ten more specific ones that derive from these six, through which countries adopted renewable energy targets.

One can therefore identify ten paths that led to the outcome. The ten paths can be classified into late coerced emulators; late higher-income emulators; late higher-income coerced emulators; late lower-income coerced market driven adopters; late higher-income coerced energy exporters; early lower-income coerced energy exporters; late higher-income market driven learners; early higher-income learners; higher-income timeless market driven learners; and early oil-shock coerced adopters.

The mixed-methods approach has enriched this research and provided a better understanding of the phenomenon here studied. The EHA painted the big picture, and the QCA provided a more nuanced understanding of the paths countries took in adopting energy targets.

Based on these findings, future research would benefit from a more comprehensive conceptual operationalization of each of the diffusion mechanisms. Secondly, more detailed case studies of individual countries and the adoption of their energy targets would further illuminate the causal mechanisms leading to the adoption of energy targets.

It is possible that emulation was the only significant diffusion mechanism in the EHA due to an incomplete operationalization of each mechanism. Emulation was the only "comprehensive" variable, since it was an index based on several dimensions. A similar approach should be pursued in the future to measure the remaining three mechanisms.[32] Using only one variable to measure each mechanism might capture only a portion of a country's utilization of that diffusion mechanism. For example, for the mechanism of learning, a more comprehensive approach could include, in addition to IEA participation, participation in non-governmental associations, potentially with NGO membership.

For economic competition it would be relevant not only to distinguish how much energy a country is importing or exporting, but also to determine which are the structural vulnerabilities of theses countries in the international system – vulnerabilities that

[32] Applied in a different field than policy diffusion, this is what was done by Mao (2018), for example.

would make it likely for them to adopt a policy given an external factor. The price of oil should be included in this variable, since it was positive and significant in the EHA, and present in most configurations in the QCA. In this respect, the findings from Gupta (2008) on the oil vulnerability index could provide a great insight to enhance the measurement of economic competition. The environmental risks should also be added to Gupta's methodology (since he does not include them), since renewable energy targets are an environmental policy.

For coercion, a more comprehensive approach would focus on environmental aid and energy aid (although this data does have time restrictions). General aid might be too coarse of an approximation of a country's exposure to coercion.

It would also be important to add detailed case studies of a small number of countries to better understand the conditions that led to adoption of energy targets.

The QCA result showed the presence of some non-adopters in the configurations for adoption. This means that, given their characteristics, some countries that do not have a renewable energy target should have one. It is therefore not only important to understand why this policy diffused, but also, why it did not. The countries in question are Afghanistan, Andorra, Bahrain, Equatorial Guinea, Georgia, Oman, Papua New Guinea, San Marino, Somalia and South Sudan.

It might also be worth considering case studies of the countries that had the target but were dropped from the final model because they were in two configurations with mostly non-adopters (due to a low raw consistency). The countries in question are Lesotho, Bolivia, Rwanda, Egypt and Russia.

In terms of policy relevance, this thesis showed the strength of the mechanism of emulation in the diffusion of renewable energy targets. It seems that, in issues as complicated as energy policy, countries tend to emulate similar countries, leading to a trend of exponential reach: the more countries with renewable energy targets, the more likely similar countries will adopt these targets.

It is also relevant for policymakers to consider the impact of oil prices on the diffusion of renewable energy targets, especially when establishing policies (such as subsidies or taxes) that foment or inhibit oil consumption. Oil is an important driver for renewable energy trends, therefore if one wants to foment renewable energies one must consider oil prices.

It is also important to emphasize that, although in general terms emulation is a key mechanism, it is not the only mechanism that countries activated in the diffusion of renewable energy targets. Countries are clustered around 10 different paths, which indicates that there is no one recipe for the diffusion of policy innovations.

8. Conclusions

This thesis examined the mechanisms by which countries adopted a renewable energy target for the first time, and did so from a systems framework.

Simply put, a system is a mental construction that is recreated in order to better understand a complex reality. The notion of social-ecological systems is useful at bridging natural systems with social systems, which are inherently part of one same reality (Ostrom, 2009). Systems have inputs, processes (the "black-box"), and outputs and are embedded in an environment (Easton, 1957). The idea behind this thesis was to understand what happened in that black-box in terms of renewable energy targets - to comprehend the processes by which countries adopted this particular policy.

There are three major triggers of change in a system: an ecological crisis, shifts in social components (*i. e.* values), and economic or political change (Olsson et al., 2006). Given the great uncertainty in times of change, several scholars highlight the relevance of governance. Governance is adaptive when it contemplates for the changing nature of the system (Carpenter & Folke, 2006; Olsson et al., 2008).

The concept of adaptive governance resonates with the adaptive cycle from *Panarchy*, where there are four main phases: an exploitation phase, a conservation phase, a release phase, and a reorganization phase, which leads to a new exploitation phase (Gunderson & Holling, 2002). The adoption of renewable energy targets is a clear example of the adaptive cycle in general, and of adaptive governance in particular.

Renewable energy targets are, in part, a result of fossil fuel exploitation, which was the base for human survival and production for centuries (Bithas & Kalimeris, 2016).

However, during the 1970s changes started to be visible. On the one hand the environmental movement was born in response to several key scientific discoveries; on the other hand, the oil shocks of the 1970s showed the world the necessity of finding alternatives to fossil fuels (Arrhenius, 1896; Campbell & Laherrère, 1998; Keeling, 1973; Keeling et al., 1976; E. Haas, 1990).

These changes were such that countries began to adopt policies they deemed necessary. One of these policies are renewable energy targets. However, not all countries adapt the same way - there were different paths, different mechanisms at work.

The literature studies mainly four mechanisms of policy diffusion: learning, economic competition, emulation and coercion. In a very concise form, learning is the rational process by which countries absorb the lessons from other countries and apply the best practices to solve their own similar problems. This would be possible given the exchange that takes place in international organizations (Balla, 2001; Tews, 2005; Weyland, 2005; Meseguer, 2006; Moynihan, 2008; Gilardi et al., 2009; Füglister, 2012; Fink, 2013; Fink, 2013; Saikawa, 2013; Arbolino et al., 2018). Economic competition explains how countries adopt or refrain from adopting policies that would benefit or harm their economies, respectively (Tiebout, 1956; Cary, 1974; Berry & Berry, 1990; Vogel, 1995; Wilson, 1999; Busch et al., 2005; Tews, 2005; Shipan & Volden, 2008, 2012; Baybeck et al., 2011; Graham et al., 2013; Saikawa, 2013; Paterson et al., 2014). Emulation is the mechanism by which countries copy similar countries in order to look like them (Volden, 2006; Sharman, 2010; Saikawa, 2013). In coercion, policies are imposed from the top down, and therefore “carrots and sticks” is a relevant assimilation (Welch &

Thompson, 1980; Tews, 2005; Weyland, 2005; Shipan & Volden, 2008, 2012; Graham et al., 2013; Paterson et al., 2014).

There are three subfields of political science that study policy diffusion: American politics, comparative politics and international relations. Each of these disciplines has gone on its own and has been, to a certain extent, reinventing the wheel. Based on some scholars' recommendations (Howlett & Rayner, 2008; Starke, 2013; Maggetti & Gilardi, 2015; Gilardi, 2016), this research focused on conceptual clarity, variable operationalization, and creativity in the methodology.

In order to test which mechanisms were at stake in the adoption of renewable energy targets, this thesis used a mixed methods approach, combining an event history analysis (predominant method in the literature for studying policy diffusion) and a qualitative comparative analysis (more generally used in studies of comparative politics).

The results of the EHA show that emulation was the main mechanism for the diffusion of renewable energy targets, which indicates that countries are copying similar countries in order to look like them, and that the rising number of renewable energy targets seems to legitimize new adoptions. This held true across regions, income groups, and between energy importers and energy exporters. Another finding from the EHA was that the higher the price of oil, the more likely for a country to adopt a renewable energy target. Finally, the EHA results show that larger population sizes tend to be more reluctant to adopt renewable energy targets.

Findings from the QCA showed that there is no one single path for the adoption of renewable energy targets. As a matter of fact, there were ten different combinations of conditions that led to the outcome. These ten pathways can be synthetized into six, with some nuances in the fine print: the learners, the emulators, the coerced, the coerced emulators, the coerced market driven adopters, and the market driven learners. Most of the combinations include higher-income countries, and oil was expensive in most of the paths (although some exceptions apply). Even though there are several paths that led to the outcome, emulation (or some combination that contains it) was the most traveled path.

Visible in QCA, the early adopters of renewable energy targets followed the mechanisms of coercion, economic competition and learning. Only later in time does emulation emerge as a diffusion mechanism. It also becomes more common for later adopters to have combinations of mechanisms, instead of one unique mechanism. The key takeaway from QCA was emphasizing equifinality and conjunctural causation.

Tying these results back to the introduction, it is visible that learning and economic competition were the main mechanisms at early stages, along with coercion. These mechanisms took place during the "window of opportunity" referred to at the beginning (in *Panarchy's* terms, the transition from conservation to the release phase of the adaptive cycle). Emulation came later in time, when there were also more mechanisms that interacted with each other, making the case on how complicated the diffusion process is.

In closing, the research has advanced in a better understanding of the dynamics of policy diffusion, though there is still much work to be done to better understand the factors that are most influential in a country's adoption of renewable energy targets. First, understanding processes in a systems framework simplifies a complex reality, turning this reality into something one can grasp, therefore improve. Second, the adaptive cycle is a useful approach to analyze policy change, since every policy implies a theory of social change, and social change has naturally different stages. Third, a mixed methods approach enriched these findings tremendously. Specifically, using QCA as a means for understanding the dynamics of policy diffusion proved key for grasping the inherent equifinality of this phenomenon: there are different mechanisms at stake, and there are different interactions amongst these mechanisms. Fourth, emulation was the primary diffusion mechanism derived from the quantitative analysis and all four mechanisms were related in some fashion to the outcome of interest based on the QCA.

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10. Appendices

Appendix 1: Countries included in the analysis

1. Afghanistan
2. Albania
3. Algeria
4. Andorra
5. Angola
6. Antigua and Barbuda
7. Argentina
8. Armenia
9. Australia
10. Austria
11. Azerbaijan
12. Bahamas
13. Bahrain
14. Bangladesh
15. Barbados
16. Belarus
17. Belgium
18. Belize
19. Benin
20. Bhutan
21. Bolivia
22. Bosnia and Herzegovina
23. Brazil
24. Brunei Darussalam
25. Bulgaria
26. Burkina Faso
27. Cabo Verde
28. Cambodia
29. Cameroon
30. Canada
31. Central African Republic
32. Chad
33. Chile
34. China
35. Colombia
36. Comoros
37. Congo Dem. Rep.
38. Congo Rep.
39. Costa Rica
40. Côte d'Ivoire
41. Croatia
42. Cuba
43. Cyprus
44. Czech Republic
45. Denmark
46. Djibouti
47. Dominica
48. Dominican Republic
49. Ecuador
50. Egypt
51. El Salvador
52. Equatorial Guinea
53. Eritrea
54. Estonia
55. Ethiopia
56. Fiji
57. Finland
58. France
59. Gambia
60. Georgia
61. Germany
62. Ghana
63. Greece
64. Grenada
65. Guatemala
66. Guinea-Bissau
67. Guyana
68. Haiti
69. Honduras
70. Hungary
71. Iceland
72. India

73. Indonesia
74. Iran
75. Iraq
76. Ireland
77. Israel
78. Italy
79. Jamaica
80. Japan
81. Jordan
82. Kazakhstan
83. Kenya
84. Kiribati
85. Korea North
86. Kuwait
87. Kyrgyzstan
88. Lao PDR
89. Latvia
90. Lebanon
91. Lesotho
92. Liberia
93. Libya
94. Liechtenstein
95. Lithuania
96. Luxembourg
97. Madagascar
98. Malawi
99. Malaysia
100. Maldives
101. Mali
102. Malta
103. Marshall Islands
104. Mauritania
105. Mauritius
106. Mexico
107. Micronesia
108. Monaco
109. Mongolia
110. Montenegro
111. Morocco
112. Mozambique
113. Myanmar
114. Namibia
115. Nauru
116. Nepal
117. Netherlands
118. New Zealand
119. Nicaragua
120. Niger
121. Nigeria
122. Norway
123. Oman
124. Pakistan
125. Palau
126. Panama
127. Papua New Guinea
128. Paraguay
129. Peru
130. Philippines
131. Poland
132. Portugal
133. Republic of Korea
134. Republic of Moldova
135. Romania
136. Russian Federation
137. Rwanda
138. Saint Kitts and Nevis
139. Saint Lucia
140. Saint Vincent and the Grenadines
141. Samoa
142. San Marino
143. Sao Tome and Principe
144. Saudi Arabia
145. Senegal
146. Serbia
147. Seychelles
148. Sierra Leone
149. Singapore
150. Slovakia
151. Slovenia
152. Solomon Islands
153. Somalia
154. South Africa

155. South Sudan
156. Spain
157. Sri Lanka
158. Sudan
159. Suriname
160. Swaziland
161. Sweden
162. Switzerland
163. Syrian Arab Republic
164. Tajikistan
165. Thailand
166. The former Yugoslav Republic of Macedonia
167. Timor-Leste
168. Tonga
169. Trinidad and Tobago
170. Tunisia
171. Turkey
172. Turkmenistan
173. Tuvalu
174. Uganda
175. Ukraine
176. United Arab Emirates
177. United Kingdom
178. United Republic of Tanzania
179. United States of America
180. Uruguay
181. Uzbekistan
182. Vanuatu
183. Venezuela
184. Vietnam
185. Yemen
186. Zambia
187. Zimbabwe

Appendix 2: Steps followed in the construction of similarity index

1. First, data was gathered on four variables in three dimensions based on Volden's (2006) findings:
    a. political dimension:
        i. Polity Index
    b. demographics dimension:
        i. population
        ii. per capita income
    c. budgetary dimension:
        i. revenue
2. Second, a dyadic format was created in order to analyze each country with each other in every single year (1974 - 2017). The partners of countries with themselves were eliminated from the database. This led to a total of 1,530,408 observations.
3. Each of the four variables was compared in each dyad as follows:
    a. absolute difference in Polity index
    b. population ratio
    c. absolute difference in per capita income
    d. absolute difference in revenue
4. The all values were turned into a scale ranging from 0 to 1, where 0 indicated high similarity and 1 low similarity.
5. Then the four values were averaged per dyad.
6. In order to turn the relationship into positive, the average values obtained were subtracted to 1.
7. Finally, the values were multiplied by 1 when the partner in the dyad had adopted the target, and by 0 when this was not the case.
8. The last step was adding all the values for each country in each year and divide this value by 186 to get the average of similarity index per country per year.
9. The number was then multiplied by 100 in order to have a scale that went from 0 to 100, instead of 0 to 1.
10. In order to get a normal distribution, the square root of the similarity index was used.

Appendix 3: Quantitative model comparison

Table 14. Comparison of different regressions
Source: Author's data

In the table below the variable of similarity index (mechanism of emulation) is positive and significant. The variable of oil price is positive and significant in both models, and population is only significant in the Zelig rare event logistic regression.

	Linear Model	**Zelig** (rare event logistic regression)[33]
Fixed effects	Country	N/A
Cumulative Membership to Energy IEA	-6.953e-04 (2.517e-03)	-7.656e-03 (3.857e-02)
Energy Profile	-2.467e-06 (8.798e-06)	-2.823e-05 (7.605e-04)
Similarity Index	2.172e-02 *** (2.159e-03)	5.490e-01 *** (9.299e-02)
ODA (transformed) [34]	-2.057e-05 (1.546e-05)	-2.584e-05 (4.978e-04)
Oil Price	6.064e-04 *** (1.201e-04)	1.716e-02 * (8.055e-03)
Population	1.842e-10 (1.137e-10)	1.672e-09 * (6.276e-10)
Energy Use per Capita	-7.558e-0 (4.636e-06)	-2.889e-06 (1.057e-04)
Model's information	Intercept: -5.211e-02 (.), Residual standard error: 0.1392 on 2771 degrees of	Intercept: -7.244e+00(***), Null deviance: 606.15 on 2877 degrees of freedom, Residual

[33] Choirat et al. (2019)
[34] ODA transformed = log(ODA+968.54)

	freedom (3872 observations deleted due to missingness), Multiple R-squared: 0.1293, Adjusted R-squared: 0.09595 , F-statistic: 3.881 on 106 and 2771 DF, p-value: < 2.2e-16	deviance: 437.87 on 2870 degrees of freedom, (3872 observations deleted due to missingness), AIC: 453.87, Number of Fisher Scoring iterations: 8
Signif. codes: ‘***’ p≤0.001 ‘**’p≤0.01 ‘*’p≤0.05 ‘.’p≤0.1 (Std. errors in parenthesis)		

Appendix 4: QCA calibration rules

Calibration was done using fsQCA software, for which the researcher provided three values corresponding to fully in the set (1), a crossover point (0.5), and a fully out of the set (0). The rules followed are based on Schneider & Wagemann (2012) and Ragin (2000, 2008).

Table 15. QCA Calibration Rules
Source: Author's data

Variable (Condition)	Definition	Calibration	Explanation
Country (Country)	Name of the country analyzed	Not calibrated	Not calibrated. The name of each of the 187 cases analyzed.
Target (Target)	Whether the country has a renewable energy target until 2017 or not.	0 -> no target 1 -> target	Not calibrated. Variable was dichotomous to begin with.
Year of adoption (Year)	Membership in the group of early adopters.	0 -> 2018 (no target) 0.5 -> 2006.5 1 -> 1990	**0** - Non-adopters are here considered as late. **0.5** - In 2007 the IPCC releases its fourth assessment, to which Achim Steiner, executive director of UNEP said "February 2, 2007 will be remembered as the date when the question mark was removed from the question, if human activity had anything to do with climate change". Also Al Gore receives the Nobel Peace Prize for its environmental efforts (Brahic, 2007). Also, up until 2007, there were relatively few adoptions per year, an in most of them 0 adoptions. In 2007 there are 13 adoptions, and no following year passes with no adoptions. **1** - Early adopters are those before 1990s because of the rise of environmentalism and the creation of institutions such as UNEP, as discussed in this thesis.
Cumulative	Membership in the	0 -> 0	**0** - No treaties

Membership to Energy IEA (IEA)	group of countries with a high number of international governmental organizations based on the total number of energy treaties that the country is a party of (signed, ratified, and treaty in force).	0.5 -> 3.5 1 -> 8.5	**0.5** - Based on case knowledge (values for BRICS) and frequency distribution. Also relevant here, the mean is 4.26 and the median is 3. **1** - Based on case knowledge (USA, Russia / USSR, Germany, UK, etc.).
Energy Commerce (Ener)	Membership in the group of net-energy importers based on how much did the country import or export energy in a given year.	0 -> -20 0.5 -> 0 1 -> 50	**0** - the UN classifies a country as a fuel exporter if the share of fuel exports is greater than 20% (UN, 2014). **0.5** - a country that has a value of 0 is therefore not importer nor exporter. **1** - a country that imports more than half of its energy is therefore importing more than it is producing for itself.
Similarity Index (Sim)	Membership in the group of emulators based on how similar was the country in a given year to other countries that had a renewable energy target.	0 -> 0 0.5 -> 5.4 1 -> 7.75	**0** - Fully out is represented by 0 given that this implies the complete absence of similarity to adopters **0.5** - The value of 5.4 is close to the average value of similarity in the year 2007, which is when the targets seem to grow exponentially. **1** - High similarity value This variable was also re-calibrated based on case knowledge.
Total ODA (ODA)	Membership in the group of aid recipient countries.	0 -> 0 0.5 -> 1,000,000 1 -> 100,000,000	This variable was originally calibrated as a continuous scale, re-calibrated to dichotomous, to finally re-calibrated it again. The idea was to first distinguish between non-aid-recipients (0) to aid recipients, and then to calibrate recipients. That is why there is such a big range between the crossover point and the fully in.
Income level	Membership of the	0 -> 1	The original variable was coded as: low

(Inc)	country in the group of higher income.	0.5 -> 2.5 1 -> 4	income (1), lower-middle income (2), upper-middle income (3) or high income group (4). The thresholds follow this codification.
Oil Price (Oil)	Membership of the country in the set of expensive oil.	0 -> 20 0.5 -> 40 1 -> 65	This variable was re-calibrated based on case knowledge. General trends in the price of oil were also considered here.
Population (Pop)	Membership in the set of big countries	0 -> 2,700,000 .5 -> 21,000,000 1-> 100,000,000	This variable was calibrated taking into consideration the UN list of "small countries" based on their population, case knowledge, and the distribution of cases.

Appendix 5: Parameters of fit for QCA

Table 16. Parameters of fit for QCA
Source: Ragin & Patros (2017); Schneider & Wagemann (2012)

Parameters of Fit	Definition
Frequency Threshold	The frequency threshold represents the minimum number of cases to be assessed in the truth table.
Consistency	Consistency is a "goodness of fit" measure. It represents the degree to which membership in each solution term (pathway) is a subset of the outcome. A value of 1 indicates a perfect subset relation (all cases of X=1 are members of the set Y=1). In fuzzy set analysis perfect consistency occurs when all cases have smaller or equal membership in X than in Y. The consistency score indicates the extent to which a conclusion that a condition is a sufficient condition for the outcome of interest is supported by the empirical evidence.
Solution consistency	The solution consistency measures the degree to which membership in the solution (pathway) is a subset of membership in the outcome.
Solution coverage	Coverage tells how empirically relevant a condition is. It is comparable to explained variance in regression analysis. The solution coverage measures the proportion of membership in the outcome that is explained by all of the pathways.
Raw coverage	The raw coverage measures the proportion of membership in the outcome that is explained by membership in each pathway.
Unique coverage	The unique coverage measures the proportion of membership in the outcome explained solely and uniquely by each individual pathway.

Appendix 6: Countries included in final QCA model

Each country has their consistency score in parenthesis, followed by the status in the outcome variable. If the country has a target, then the second value should be a 1. If the country does not have the target, then the second value should be a 0. Note that there are some repeated countries. This means that such countries were identified with more than one combination (pathway).

1. Afghanistan (0.78,0)
2. Afghanistan (0.79,0)
3. Albania (0.73,1)
4. Algeria (0.61,1)
5. Andorra (0.78,0)
6. Antigua and Barbuda (0.58,1)
7. Antigua and Barbuda (0.73,1)
8. Armenia (0.73,1)
9. Australia (0.65,1)
10. Austria (0.6,1)
11. Azerbaijan (0.73,1)
12. Bahrain (0.51,0)
13. Bangladesh (0.66,1)
14. Barbados (0.52,1)
15. Belgium (0.66,1)
16. Belize (0.53,1)
17. Belize (0.73,1)
18. Benin (0.78,1)
19. Bhutan (0.73,1)
20. Brazil (0.68,1)
21. Brunei Darussalam (0.88,1)
22. Bulgaria (0.71,1)
23. Cabo Verde (0.78,1)
24. Cambodia (0.57,1)
25. Colombia (0.73,1)
26. Costa Rica (0.66,1)
27. Croatia (0.66,1)
28. Cuba (0.73,1)
29. Cuba (0.73,1)
30. Cuba (0.78,1)
31. Czech Republic (0.65,1)
32. Denmark (0.8,1)
33. Dominica (0.56,1)
34. Ecuador (0.73,1)
35. Ecuador (0.73,1)
36. Ecuador (0.73,1)
37. Ecuador (0.78,1)
38. El Salvador (0.73,1)
39. El Salvador (0.78,1)
40. Equatorial Guinea (0.54,0)
41. Estonia (0.73,1)
42. Fiji (0.73,1)
43. Fiji (0.73,1)
44. Fiji (0.78,1)
45. Finland (0.8,1)
46. France (0.69,1)
47. Georgia (0.73,0)
48. Germany (0.59,1)
49. Ghana (0.52,1)
50. Greece (0.71,1)
51. Grenada (0.57,1)
52. Grenada (0.73,1)
53. Guatemala (0.83,1)
54. Haiti (0.75,1)
55. Haiti (0.81,1)
56. Hungary (0.71,1)
57. Iceland (0.65,1)
58. Indonesia (0.57,1)
59. Iran (0.73,1)
60. Iran (0.73,1)
61. Iran (0.73,1)
62. Iran (0.78,1)
63. Iraq (0.73,1)
64. Iraq (0.73,1)
65. Iraq (0.73,1)
66. Iraq (0.78,1)

67. Ireland (0.57,1)
68. Italy (0.8,1)
69. Japan (0.69,1)
70. Jordan (0.57,1)
71. Kenya (0.66,1)
72. Kiribati (0.77,1)
73. Kuwait (0.51,1)
74. Kyrgyzstan (0.73,0)
75. Latvia (0.55,1)
76. Libya (0.53,1)
77. Liechtenstein (0.79,0)
78. Luxembourg (0.6,1)
79. Malawi (0.65,1)
80. Maldives (0.63,1)
81. Maldives (0.73,1)
82. Mali (0.87,1)
83. Mexico (0.66,1)
84. Mexico (0.66,1)
85. Micronesia (0.81,1)
86. Montenegro (0.71,1)
87. Morocco (0.66,1)
88. Namibia (0.73,1)
89. Nauru (0.51,1)
90. Nepal (0.72,1)
91. Nepal (0.81,1)
92. Netherlands (0.65,1)
93. Nicaragua (0.73,1)
94. Nicaragua (0.78,1)
95. Norway (0.8,1)
96. Oman (0.57,0)
97. Oman (0.78,0)
98. Palau (0.71,1)
99. Panama (0.73,1)
100. Panama (0.73,1)
101. Papua New Guinea (0.79,0)
102. Paraguay (0.57,1)
103. Poland (0.65,1)
104. Portugal (0.55,1)
105. Republic of Korea (0.65,1)
106. Romania (0.6,1)
107. Saint Kitts and Nevis (0.53,1)
108. Saint Lucia (0.51,1)
109. Saint Lucia (0.71,1)
110. Saint Vincent and the Grenadines (0.51,1)
111. Saint Vincent and the Grenadines (0.71,1)
112. San Marino (0.78,0)
113. Senegal (0.73,1)
114. Serbia (0.73,1)
115. Serbia (0.73,1)
116. Serbia (0.78,1)
117. Seychelles (0.55,1)
118. Seychelles (0.73,1)
119. Sierra Leone (0.78,1)
120. Singapore (0.63,1)
121. Slovakia (0.52,1)
122. Slovakia (0.53,1)
123. Slovenia (0.69,1)
124. Solomon Islands (0.88,1)
125. Somalia (0.79,0)
126. South Africa (0.65,1)
127. South Sudan (0.79,0)
128. Spain (0.78,1)
129. Sri Lanka (0.62,1)
130. Suriname (0.64,1)
131. Suriname (0.64,1)
132. Suriname (0.73,1)
133. Sweden (0.55,1)
134. Switzerland (0.53,1)
135. Switzerland (0.55,1)
136. Syrian Arab Republic (0.69,1)
137. Tajikistan (0.84,1)
138. The former Yugoslav Republic of Macedonia (0.71,1)
139. Trinidad and Tobago (0.52,1)
140. Trinidad and Tobago (0.76,1)
141. Tunisia (0.57,1)
142. Turkey (0.71,1)
143. United Republic of Tanzania (0.62,1)
144. United States of America (0.67,1)

145. Uzbekistan (0.62,1)
146. Vanuatu (0.78,1)
147. Venezuela (0.68,1)
148. Zambia (0.62,1)
149. Zimbabwe (0.66,1)

Appendix 7: fsQCA output

Table 17. QCA truth table and output for test of sufficient conditions
Source: Author's data

Energy importer	High similarity	Aid recipient	Expensive Oil	Higher income	Number of Countries	Target	Raw consist.	PRI consist.	SYM consist
1	1	1	1	0	27	1	0.930	0.930	0.930
0	1	1	1	0	24	1	0.817	0.817	0.817
0	1	1	1	1	19	1	0.875	0.875	0.875
1	0	0	0	1	14	1	0.998	0.998	0.998
1	1	1	1	1	11	1	0.977	0.977	0.977
1	1	1	1	1	10	1	0.952	0.952	0.952
1	1	1	1	0	9	1	0.874	0.874	0.874
0	1	1	1	0	8	0	0.792	0.792	0.792
1	1	0	1	1	7	1	0.887	0.887	0.887
1	0	0	1	1	7	1	0.998	0.998	0.998
0	1	1	1	1	6	1	0.819	0.819	0.819
0	0	1	1	0	5	1	0.986	0.986	0.986
1	0	1	1	0	5	1	0.996	0.996	0.996
1	1	0	1	1	4	1	0.804	0.804	0.804
0	0	1	0	0	3	1	0.949	0.949	0.949
1	0	1	1	0	3	1	0.992	0.992	0.992
0	1	0	1	1	2	0	0.726	0.726	0.726
0	1	0	1	1	2	1	0.841	0.841	0.841
0	0	0	0	1	2	1	0.962	0.962	0.962
0	0	1	1	1	2	1	0.981	0.981	0.981
1	0	1	1	1	2	1	0.995	0.995	0.995
1	0	1	1	0	2	1	0.995	0.995	0.995
1	0	0	1	1	2	1	0.997	0.997	0.997

Table 18. QCA main model intermediate solution output
Source: Author's data

Adoption of Renewable Energy Targets

Intermediate solution for outcome = Target

Solution term	Raw coverage	Unique coverage	Consistency
~Year*~IEA*Sim*ODA*Oil	0.36858	0.0622839	0.865613
~Year*~IEA*Sim*Oil*Inc	0.26463	0.0257408	0.872938
~Year*Sim*ODA*Oil*Inc	0.257346	0.0298149	0.893485
~Year*Ener*ODA*Oil*~Inc	0.188704	0.0212964	0.899912
~Year*~IEA*~Ener*ODA*Oil*Inc	0.153765	0.00117284	0.877731
Year*~IEA*~Ener*~Sim*ODA*~Inc	0.0995062	0.021852	0.98714
~Year*IEA*Ener*~ODA*Oil*Inc	0.0918519	0.0164815	0.900726
Year*IEA*~Sim*~ODA*~Oil*Inc	0.0908642	0.0474691	0.989247
IEA*Ener*~Sim*~ODA*Oil*Inc	0.0826543	0.00814813	0.997764
Year*~IEA*Ener*~Sim*ODA*Oil	0.0824691	0.0132098	0.996271
Frequency cutoff: 2 Consistency cutoff: 0.80433 Solution coverage: 0.635309 Solution Consistency: 0.871982			

Table 19. QCA second model intermediate solution output with population
Source: Author's data.

Adoption of Renewable Energy Targets with Population

Intermediate solution for outcome = Target

Solution term	Raw coverage	Unique coverage	Consistency
~Year*~IEA*Sim*ODA*Oil	0.36858	0.0348147	0.865613
~Year*~IEA*ODA*~Pop*Oil	0.325	0.00166667	0.864532
~Year*Ener*Sim*~Pop*Oil	0.269383	0.0620987	0.882329
Year*~IEA*~Sim*ODA*Oil	0.143086	0.00956798	0.991022
Year*~IEA*~Sim*ODA*~Pop	0.129938	0.0124074	0.990122
~Year*IEA*~Ener*Sim*Pop*Oil	0.106111	0.0127778	0.843474
Year*IEA*Ener*~Sim*~ODA*~Oil	0.0792593	0.024753	0.997669
IEA*Ener*~Sim*~ODA*~Pop*Oil	0.0775309	0.0120988	0.997617
Year*IEA*~Sim*~ODA*~Pop*~Oil	0.0646297	0.00746912	0.984948
~Year*IEA*Ener*ODA*Pop*Oil	0.0637654	0.00746912	0.910935

Frequency cutoff: 2
Consistency cutoff: 0.805157
Solution coverage: 0.623951
Solution Consistency: 0.869954