Renewable Energy Adoption Among OECD Countries:

The Role of Public Campaign Finance

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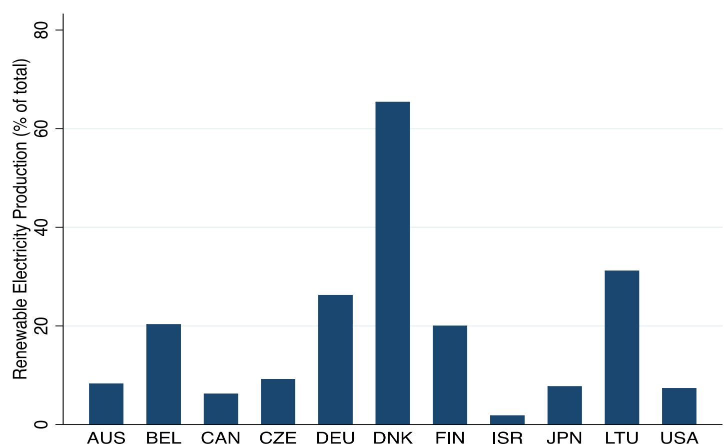
1. Introduction

There is growing consensus about the potential of renewable energy to improve human and environmental health, create jobs, improve energy security, and reduce geopolitical energy conflict. Furthermore, scientific evidence is clear that a steep reduction in fossil fuel combustion must occur to mitigate the impacts of climate change, which necessitates rapid transition to alternative energy sources (Edenhofer et al., 2012). Investment in and installed capacity of renewable energy, specifically from non-hydroelectric sources such as wind and solar, have grown rapidly over the past few decades (International Energy Agency [IEA], 2019). Recent growth, however, is not evenly distributed; while some countries have aggressively pursued renewable energy and reduced fossil fuel dependence, others continue to rely on traditional energy sources with minimal progress toward a lower-carbon future. Deployment asymmetry between developing and developed countries is not surprising. More puzzling is the wide variation between countries that share many key characteristics. OECD members, a collection of the most economically, politically, and technologically advanced countries in the world, vary greatly in their adoption of renewable energy.

Figure 1: Renewable Electricity Production Share: a sample of OECD Countries in 2015



(Data provided by the World Bank)

Recent studies attribute diverging renewable energy trajectories to a variety of factors including energy security, total energy consumption, income, energy prices, and renewable energy potential. Due to the large degree of variation left unexplained by such socio-economic factors, there is growing emphasis on political explanations. Political factors remain critical because in most circumstances, increasing the share of renewables in the energy mix requires policies that stimulate shifts in the energy system (Edenhoefer et al., 2012). For example, some authors examine the role of democracy and conclude that it facilitates renewable energy transitions by fostering innovation and an open marketplace of ideas and limiting the lobby and market power of incumbent firms (Bayer & Urpelainen, 2016; Dumas et al., 2016; Sequeira & Santos, 2018). Other researchers focus on corruption and conclude that because it biases government decision-making in favor of entrenched interests over citizen well-being and preferences, it impedes progress toward environmental sustainability (Cadoret & Padovano, 2016; Lopez & Mitra, 2000; Fredriksson et al., 2004).

Such political factors, however, provide an unsatisfying political explanation of how renewable energy deployment varies across developed democracies. This thesis addresses the research gap by examining the role of campaign finance systems, which vary significantly among OECD countries and remain unstudied in the existing literature about renewable energy. In such countries, private campaign funding may provide a legal avenue for established, wealthy interests such as the fossil fuel industry to gain disproportionate influence over political decision-making. This analysis attempts to empirically determine whether increasing public funding of elections, like rooting out corruption or strengthening democracy, accelerates the transition to renewable energy in OECD countries.

Campaign finance systems are made up of a complex set of regulations and practices that are unique to each country. I focus on the availability of public financing because it has the ability to shift incentives such that compromising policy utility and constituent responsiveness in order to secure private campaign contributions is no longer beneficial to politicians. Analyzing this aspect of the campaign system has advantages over examining various methods of regulating private funding; while such regulations may exist on paper, they are subject to loopholes and enforcement issues, even in generally law-abiding political systems (Fisman & Golden, 2017). The availability of public financing, by reducing dependence on private contributions, is applicable regardless of the other components of the campaign finance system.

My research focuses exclusively on non-hydroelectric renewable energy production, which has increased exponentially since the turn of the century and accounts for all of the recent growth in renewable energy production both globally and among OECD members (World Bank, 2020). I thus also contribute to the literature by re-evaluating the relationship between renewable energy production and independent variables discussed by past authors, most of whom do not discriminate between hydro and non-hydro sources (Cadoret & Padovano, 2016; Marques et al., 2010; Sequeiria & Santos, 2018). Characteristics including cost, environmental implications, future growth potential, and the presence of existing infrastructure differ between hydropower and other major renewable energy sources such as wind and solar, indicating that the correlates of their deployment may differ (Kaunda et al., 2012).

The following analyses explore the determinants of renewable energy adoption, and suggest that public campaign finance is an important factor. They also reveal that the effect of public campaign finance is magnified in wealthier, less corrupt, and more democratic OECD countries. Results suggest that previously established determinants of renewable energy outcomes, such as population, per capita energy consumption, and geographic area, have distinct magnitudes of effects on renewable energy production when excluding hydroelectric sources, though signs are comparable. Analyses in this thesis do not tackle issues of endogeneity, and additional research is necessary to rule out any potential reverse causality or omitted variable bias. Nevertheless, the results uncover novel insights that suggest directions for further study and shed light on crucial policy debates.

2. Literature Review

2.1 Renewable Energy: Role and Recent Trends

Oil, coal, and natural gas have fueled the rapid economic growth of the past two centuries, but not without significant negative externalities. Environmental degradation from the extraction and combustion of fossil fuels damages infrastructure, agricultural fields, and natural ecosystems and has a grave impact on human health, leading to around 8 million premature deaths each year (Ramanathan et al., 2015). Furthermore, consumption of fossil fuels drives anthropogenic climate change (Edenhofer et al., 2012).

Countries around the world are already experiencing profound effects from approximately one degree Celsius of global warming. Increasingly frequent and severe extreme weather events destroy infrastructure, natural habitats, and human lives (Ramanathan et al., 2015). Rising global temperatures impact human health by exacerbating allergies and the effects of air pollution and facilitating the spread of certain infectious diseases. Long droughts threaten food and water supply, while rising sea levels and extreme heat displace populations (Ramanathan et al., 2015). If current emissions trends continue, climate scientists estimate that the planet will experience warming of around two degrees Celsius above pre-industrial levels by 2050 and between two and half and nearly eight degrees Celsius above pre-industrial levels by 2100 (Masson-Delmotte et al., 2018). The goal of the Paris Agreement and the United Nations Framework Convention on Climate Change more broadly is to keep warming well below two degrees, which will require aggressive action from developing and developed nations around the globe (United Nations, 2020).

While taking the necessary action against climate change presents a challenge for governments, failing to do so will present even more pressing challenges in the coming decades.

For example, in a business as usual scenario, the World Bank estimates that climate change will displace as many as 143 million people by 2050 from Sub-Saharan Africa, South Asia, and Latin America (Rigaud et al., 2018). Mass migration will not only cause political upheaval in these regions, but also in those that will be required to absorb millions of climate refugees. Global warming related issues including extreme weather, natural disasters, and biodiversity loss occupy all of the top five positions in the World Economic Forum's list of global risks to economy and society in terms of likelihood over the next decade (2020).

The combustion of fossil fuels for energy accounts for the largest share of anthropogenic greenhouse gas emissions (Masson-Delmotte et al., 2018). Implementation of polices that stimulate changes in the energy system, therefore, is the single most effective means for governments to combat climate change. Three major pathways exist to reduce energy related emissions: renewable energy, nuclear energy, and carbon capture and storage (Bruckner et al., 2014). Renewable energy is widely considered to be the most sustainable option with potential for widespread use at large scale (Ramanathan et al., 2015). Electricity production from renewables does not directly emit greenhouse gasses, and even life-cycle emissions for these technologies are exceptionally low[1] (Edenhofer et al., 2012). Renewables offer the greatest long-term energy security because unlike fossil and nuclear fuel, they are inexhaustible resources. Furthermore, storage of carbon dioxide and nuclear waste come with health and environmental risks, especially when employed at large scales (Fogarty & McCally, 2010). While all three pathways may play a role in short-term emissions reduction, renewables are the option with most widespread acceptance among experts and the public. If implemented intelligently, they can contribute to social and economic development, reduce poverty, increase

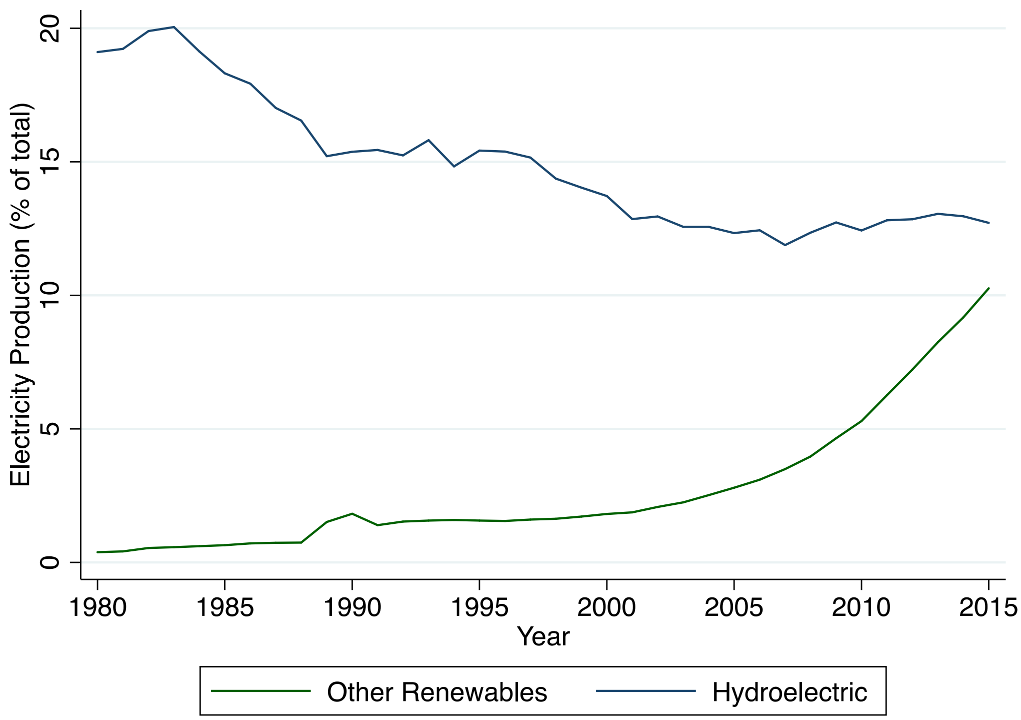
[1] Hydropower may be an exception, as discussed on page 7.

energy security, expand energy access, and reduce non-climate related human health and environmental impacts. Consequently, leading sustainable energy plans advocate electrification of the energy system and transition to largely renewable sources.

In recent decades, deployment and total energy production from renewables has increased, but so has global energy demand. The share of electricity production from renewable sources has thus increased minimally. Renewable electricity output as a percentage of total electricity increased from 19 percent in 1990 to 23 percent as of 2015 (World Bank, 2020). OECD countries, despite having the greatest economic and technological capability to transform their energy systems, experienced only a slightly greater increase. During the same time period, electricity production from renewables in OECD countries increased from 15 to 23 percent of total electricity production (World Bank, 2020). Over the past few decades, however, there have been significant changes in renewable energy adoption beyond what these generic trends suggest.

First, a major shift has occurred in the types of renewables deployed. Hydropower, the conversion of flowing water into electricity, is the most established form of renewable energy. For the past half-century, it has supplied between 15 and 20 percent of electricity both globally and in OECD countries and constituted the vast majority of renewable energy production (World Bank, 2020). In the past two decades, however, its dominance among renewables has diminished, particularly in OECD countries. The share of renewable electricity generation from hydro sources was 88 percent in 2000 but dropped to just over 55 percent by 2015. As total electricity demand increased over this 15-year time period, hydroelectricity decreased from 15.4 percent to 12.7 percent of total final electricity production from OECD countries. Combined production from non-hydro renewables, on the other hand, was low and stable before 2000 and has increased several-fold since the turn of the century. It hovered between 1.4 and 1.8 percent between 1990 and 2000 and increased to 10.3 percent by 2015. Hydroelectricity share has increased in only two of the 36 OECD members since 1990, each by less than six percent (World Bank, 2020).

Figure 2: Electricity Production from Hydroelectric and Other Renewable Sources (OECD)



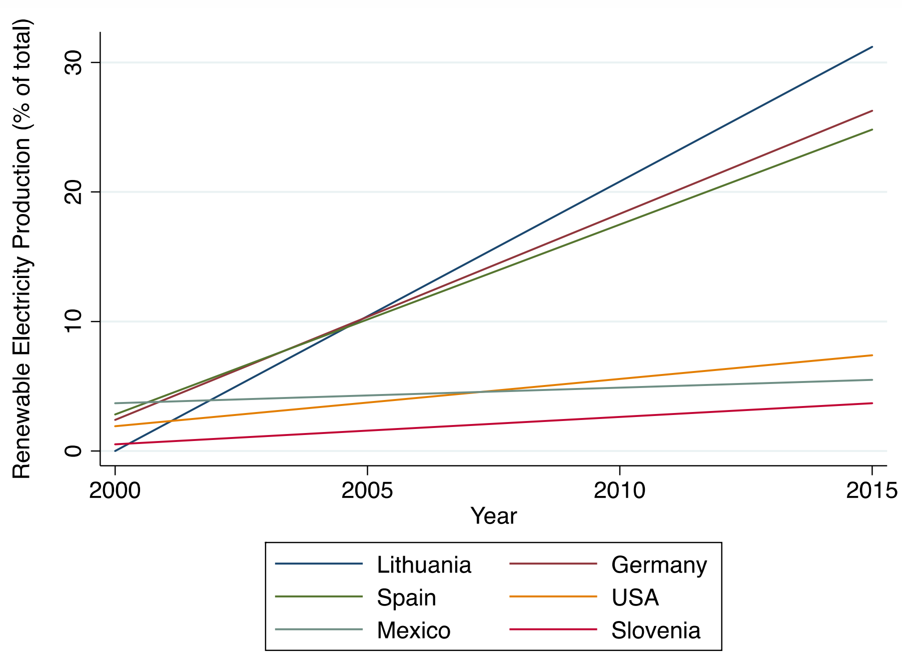
Practical constraints and negative externalities of hydropower explain why states have sought to diversify their energy portfolios and reduce greenhouse gas emissions by employing other renewables. Hydropower's technical potential is significantly lower than that of wind and solar at 50–60 EJ/year. In recent years, there has also been growing attention to its environmental and social costs. Hydroelectric structures alter the physical, chemical, and biological characteristics of river and fjord systems by disrupting sediment transport and fish migration and reducing waterflow (Egré & Milewski, 2002). According to research by the

University of Copenhagen, major new hydropower projects pose a serious threat to freshwater biodiversity (Zarfl et al., 2015). Flooding from dam construction often displaces surrounding human populations and leads to further consequences for downstream communities (Egré and Milewski, 2002). Recent research also implicates hydropower as a more significant contributor to climate change than previously thought. Lack of oxygen at the bottom of reservoirs leads to anaerobic bacterial decomposition of vegetation already present in the watercourse (Miller et al., 2017). This process produces an estimated one billion tons of greenhouse gases every year, 1.3% of all annual anthropogenic emissions (Miller et al., 2017).

The severity of these impacts per quantity of electricity generated is highly site-specific; locations to build new economically, socially, and environmentally sound hydropower facilities are limited, and most of the remaining capacity is in developing countries (Edenhofer, 2012). Finally, further cost reductions for hydropower are expected to be minimal compared to other sources of renewable energy, so economic incentives to increase shares of hydropower in the energy mix will not likely increase (Edenhofer, 2012). Stanford's Energy Modeling Forum on Global Technology and Climate Change Strategies (EMF 27), along with most other leading climate change mitigation analyses, foresee the greatest potential growth in wind and solar, with limited future growth in hydropower (Luderer et al., 2014). New investments in renewables over the past few years have also been predominantly in non-hydro renewables, particularly wind and solar (Lins et al., 2014).

In short, non-hydro renewable energy sources account for the recent growth in renewable energy production share and will likely continue to drive future growth. The analysis is therefore focused on explaining the relationship between campaign finance and non-hydroelectric forms of renewable energy. The five major sources in this category are wind, solar, biomass, geothermal, and ocean energy. Wind and solar account for the largest shares of non-hydro renewable energy production and have experienced the greatest recent growth. From 2000 to 2018, total solar electricity production in OECD members grew 40% annually while wind production grew 20% (OECD, 2020). In depth analysis of the growth profiles and correlates specific to each renewable energy source would provide interesting nuance but is outside the scope of this thesis. My analysis groups all non-hydro renewable energy sources into a single category as their benefits and thus the motivations for their deployment are similar (Twidell & Weir, 2015).

Figure 3: Growth in Renewable Electricity Share (excl. hydroelectric) by Country



The general trend of gradually increasing renewable energy production share over the last few decades fails to illuminate not only a dramatic shift in the types of renewables deployed, but also the large between country variance in growth and starting shares. Denmark's electricity production from non-hydro renewable sources increased over 50 points from 15 percent in 2000 to 64.4 percent in 2015. Lithuania produced no non-hydro renewable energy in 2000 but by 2015, 31.2 percent of all its electricity came from non-hydro renewable sources. In other OECD countries including the United States, South Korea, Mexico, Slovenia, and Israel, non-hydro renewable energy production has increased by less than six percentage points since the turn of the century (World Bank, 2020).

A growing body of qualitative and quantitative research attempts to explain the wide variation in renewable energy deployment. Most authors do not differentiate between hydro and non-hydro sources of renewable energy and analyze samples that include non-OECD members. However, their findings provide an important basis for my understanding of the factors that may potentially shape renewable energy outcomes.

2.2 Non-Political Explanations

As previously mentioned, the extant literature focuses on the relationship between non-political factors and renewable energy deployment.

Numerous studies have substantiated the positive relationship between GDP per capita and renewable energy deployment (Aguirre & Ibikunle, 2014; Marques et al., 2010; Sadorsky, 2009; Sequeira & Santos, 2018). Two explanations suggest a potential relationship. First, wealthier states are more able to develop technologies, build renewable energy infrastructure, and absorb other initial costs of transition. Second, citizens in more affluent nations tend to place higher priority on environmental concerns (Fagan & Huang, 2019). Another factor that has received significant attention in the literature is energy security. The potential of renewables to increase energy security is touted as one of their major benefits; the expectation is therefore that countries with less secure energy supplies will prioritize deploying renewables. However, empirical support for this hypothesis is mixed. Some past analyses find that heavy reliance on imported energy leads to greater adoption or renewables (Gan et al., 2007), some report no relationship between the two variables (Aguirre & Ibikunle, 2014; Marques et al., 2011), and others find the opposite relationship (Chien & Hu, 2008).

The relationship between traditional fuel prices and renewable energy is also not straightforward. Price increases contemporaneously depress energy demand, including demand for renewables (IEA, 2019). With time, however, they should also increase cost-completeness and encourage investments and policy supports for renewables as governments and investors recognize the benefits of promoting energy sources that are less vulnerable to exogenous price shocks. Chang et al. (2009) and Cadoret and Padovano (2016) find a significant and positive relationship between lagged energy prices and renewable energy deployment. Marques et al. (2010) and Aguirre and Ibikunle (2014), however, do not find fossil fuel prices to be informative variables.

Most previous authors conclude that variables related to energy demand are negatively associated with renewable energy production and consumption share (Marques et al., 2010; Bayulgen & Ludewig, 2017). High energy demand means that more aggressive renewable energy deployment is required to significantly increase percentage share. Furthermore, high demand can incentivize countries to tap into the densest, most readily available fuel sources.

Finally, differences in natural resource endowments make renewable energy transition more challenging for some counties than others and influence the types of renewables deployed (Aguirre & Ibikunle, 2014). This applies more to hydropower than to other renewable sources because it relies on the presence of major waterways. However, factors including solar irradiance, wind speed, and biomass quantity influence counties' overall non-hydro renewable energy potential (Edenhofer et al., 2012).

2.3 The Impact of Politics

While socio-economic factors and natural endowments give some countries a leg up, energy transitions are typically only possible with supporting government policies (Edenhofer et al., 2012). Governments possess a variety of policy tools to incentivize renewable energy deployment. Popular approaches that directly promote renewables include feed-in-tariffs, renewable portfolio standards, subsidies, direct capital investment, public financing, renewable energy certificates, and production and investment credits (Edenhofer et al., 2012). Policy approaches that force firms to internalize environmental costs, such as a cap-and-trade system or carbon tax, work in substitution for or in combination with direct renewable energy promotion. A variety of policy combinations have been successfully utilized in countries including Denmark, Iceland, Portugal, Germany, Greece, and Lithuania to spur rapid increases in non-hydro renewable energy share.

Whether governments use the pro-renewable policy instruments at their disposal largely depends on internal politics. Policy implementation entails a political decision-making process that is influenced by the winners and losers of such policies. Energy policy is a salient issue for several major industries; government renewable energy promotion efforts generate resistance from fossil-fuel companies that fear losing profits and market share as well as utility companies and fossil-fuel-intensive industries that are apprehensive about increased operating costs that could result from an upheaval of the energy system. Organized interests that support renewable energy, on the other hand, typically consist of environmental groups and renewable energy producers and investors, which have comparatively few monetary resources with which to lobby politicians (Brulle, 2018). This imbalance in coalition size suggests that to the degree to which special interests are able to sway the political process, their influence will largely be in opposition to renewable energy deployment. Despite a lack of wealthy, organized interests that promote renewable energy, there is widespread public support for its adoption throughout most of the developed world (Pohjolainen et al., 2019) Renewable energy outcomes are thus shaped by how politicians balance the interests of a few powerful groups against the preferences of larger, more diffuse constituencies. Past literature explores several related political variables.

Bayulgen and Ludewig (2017) conclude that governments with fewer political constraints experience a more rapid transition to renewable energy because winners in the status-quo have fewer veto channels through which they can stall reform. Cadoret and Padovano (2016) find that having a leftist ruling party also increases renewable energy promotion. Leftist parties and the constituents who support them generally favor government intervention in the market to a greater degree than their center or right-wing counterparts. They also tend to place higher priority on environmental concerns and are more willing to utilize the public purse to address them.

Research has consistently pointed to an association between democracy and renewable energy use (Bayer & Urpelainen, 2016; Dumas et al., 2016) and Sequeiria and Santos (2018) confirm the independence and robustness of its effect using three different measures of democracy. Democratic governments are thought to be more likely to promote renewables because they are more responsive to public environmental concern and likely to prioritize citizen wellbeing over benefits to a few narrow interests. Finally, a significant body of literature suggests that corruption levels also determine the degree to which environmental concerns are reflected in government policy. In his comparative analysis of 106 countries, Welsch (2004) finds that at any given income level, corruption is associated with increases across six indicators of ambient air and water pollution. Lopez and Mitra (2000) find that corruption raises the income level at which environmental protections are put in place. Fredriksson et al. (2004) examine the combined effects of corruption and industry size on the outcomes of energy policy in a sample of 12 OECD countries, and find that countries with larger energy-related industries and higher levels of corruption have less stringent energy policies. Cadoret and Padovano (2016) investigate whether these results apply to energy portfolio outcomes and find a negative association between corruption and renewable energy share in gross final energy consumption.

Without denying the important insights generated by this body of research, this thesis argues that campaign finance is another key, understudied factor that influences the adoption of renewable energy. Much of the variation observed in renewable energy adoption is among developed democracies with low levels of corruption. In such countries, I argue that publicly funded elections limit the ability of powerful beneficiaries of the status-quo energy system to influence elected officials and ultimately renewable energy outcomes. The theoretical discussion below investigates a key mechanism by which campaign finance affects political decision-making. For brevity, this rest of this thesis employs the terms “renewable energy,” and “renewables,” to refer to strictly non-hydro forms of renewable energy. It considers hydropower as a separate category.

3. Theory

The following theoretical discussion utilizes prominent extant literature that models the role of campaign contributions in political decision making. I apply the models in a novel way by exploring their implications on public campaign finance and in the context of energy policy.

There are established theoretical models for two primary avenues through which private campaign finance alters the behavior of elected officials. First, campaign contributions may secure access to a politician, allowing the groups that provide them to influence policy through the provision of information in favor of one policy or against another. Second, campaign contributions may be directly exchanged for policy favors.

The attention of policymakers is a scarce resource; regarding any given policy decision, a legislator is constrained in the number of groups with whom he can meet (Baumgartner et al., 2009). In an optimally efficient political system, policymakers would utilize limited meetings to gain as much policy-relevant information as possible. However, if legislators also value financial contributions, they face a tradeoff between granting access to gain reliable information and granting access to secure contributions. Indeed, empirical analyses find that financial contributions help wealthy groups outcompete other groups to secure meetings and other information transfers with party and elected officials in which they selectively share information and preferences on policies that impact them (Potters & van Winden, 1992). The quality of information elected officials receive from outside groups is particularly critical for decisions related to renewable energy; due to the scientific and political complexity of energy policy and climate change, elected officials are highly reliant on external sources of information and have poor proficiency in evaluating their veracity (Kluver, 2011).

Austen-Smith (1998) examines how politicians allocate access in his theoretical model of the information-contribution tradeoff. Each legislator has complete autonomy over whom he grants access to, and each legislator's vote and additional roles in the decision-making process are potentially consequential. Therefore, in Austen-Smith's model, legislators function as local monopolists who individually set prices for access, which vary from group to group depending on the information quality of the group and the degree to which the legislator values financial contributions relative to information. The legislator must choose one of two groups to grant access to, and the model predicts which group is offered access. When a legislator prices access to encourage contributions from wealthy yet uninformative groups, he is "to all intents and purposes sacrificing good policy making for increases in electorally useful contributions" (Austen-Smith, 1998).

The campaign finance system influences a legislator's price-setting system because it shapes the degree to which he values financial donations compared to information quality. When a politician has greater campaign funding security and is less reliant on private contributions, financial contributions are less salient. This reduces the degree to which he values contributions compared to information reliability, leading him to choose the more informative group more often. Ultimately, this means decisions about energy and environmental policy are more likely to be based on informed judgements rather than incomplete information that is favorable to the interests of groups with the greatest ability to purchase access.

In other models of the effects of campaign finance, politicians sell policy favors instead of access. The dominant models in this category conceptualize campaign donations as an all-pay auction (Baye et al., 1993; Che & Gale, 1998; Gavious et al., 2002). If legislators could explicitly auction off votes or favors to the highest bidder, their behavior could be modeled as a standard auction. However, open bribes of this sort are outlawed and severely punishable in democratic systems. Instead, campaign contributions function as a covert avenue for interest groups to purchase political favors. Lobbyists pay up front for a favor, and the group (or coalition of groups on a given side of a policy issue) that pays the highest price receives the prize. To give rebates to those that fail to win the prize, however, would be to make explicit that the politician was selling favors. Instead, private campaign finance systems function as an auction in which all bids are forfeited.

In this model, the motivation of fossil fuel companies and energy intensive industries to contribute to political campaigns is clear: to obtain policy outcomes that benefit them through increased profits, financial security, or market share. Politicians, however, are only motivated to participate in the auction in so far as it increases their chances of being re-elected. In fact, by shaping their stances and votes on energy policy around the interests of the groups with the greatest willingness to pay, they sacrifice policy utility and constituent welfare (Cotton, 2009). A legislator is only incentivized to sell favors when the benefits of extra campaign funds outweigh the political cost he incurs from changing his policy position.

Robust public funding reduces the total amount of private donations that a politician must solicit in order to run a successful campaign. The marginal benefits of having more campaign funding decrease until, at a certain point, they are outweighed by the costs of policy shifts; the more public funding available, the lower the amount of private funding required to reach the point at which incentives shift. Politicians still may find it beneficial to sell favors, but on significantly fewer policy issues. For the most important issues, those for which he gains the most from choosing the best policy, the politician will not sell favors; only for issues he deems less important will he auction off favors. Given the growing public concern about environmental degradation and climate change, elected officials are likely, when they have sufficient public funding, to choose not to sell favors related to energy policy.

To be sure, these models oversimplify the political decision-making process. They assume that political actors are entirely calculating and rational, and do not account for norms and institutions of the local and national political system in which the actors exist. The models also assume that politicians sell either access or favors, not both. In reality, use of one or both of these potential channels may apply in the context of energy policy, in perhaps more subtle forms than those described by the models. Large contributions to political campaigns can increase the chances that wealthy industries gain access to a politician over more informative groups, leading the politician's understanding of energy policy and its social and environmental implications to be disproportionately shaped by entrenched interests that oppose change. They may also increase the degree to which impacts to these industries are consciously considered when the politician writes, sponsors, and votes on key bills. Because both avenues bias political decision-making in favor of affluent organized interests, which generally oppose the adoption of renewables, any combination is consistent with my theoretical argument.

Despite their simplifications, the models illustrate legitimate tradeoffs politicians face between making decisions based on high quality information that best meet the needs and desires of constituents, and appeasing narrow interests to secure campaign funding. They also demonstrate that the tradeoff exists only to the degree to which politicians rely on private funding for the success of their campaigns. Public funding has the ability to shift incentives so that compromising optimal policy for campaign contributions is no longer necessary or beneficial in most cases. Given the increasing economic and technological viability of renewable energy, public environmental concern, urgency of climate change, and recognition of additional benefits of renewable energy, politicians should generally not find it beneficial to compromise the utility of energy policy when significant public financing is available. This incentive shift suggests the following:

Hypothesis 1 (H1): The greater the role of public financing in a country's political campaigns, the greater its adoption of renewable energy.

While the salience of environmental issues and economic feasibility of renewables were established by the turn of the century, they have increased over time. Scientific certainty, public concern, observed impacts around the world, and international political discourse surrounding climate change have grown dramatically since 2000. From 2001 to 2006, surveys conducted in a large sample of countries found that the percent of respondents who had heard of climate change and the percent who considered it a "very serious problem" both increased significantly (Leiserowitz, 2008). International polling in 2013 and 2018 indicate a continuation of the trend of increasing climate concern (Fagan & Huang, 2018). The price gap between renewable energy and fossil fuels also substantially narrowed throughout the analysis period. In combination, these factors make the promotion of renewables an increasingly beneficial policy decision as the analysis period progresses.

Hypothesis 2 (H2): The effect of campaign finance on the adoption of renewable energy has increased in recent years.

I anticipate the effect of campaign finance on renewable energy production to be heterogeneous not only over time, but also across income, prevalence of political corruption, and strength of democratic institutions.

A key component of the theoretical discussion above is that public funding of elections increases the degree to which policy reflects the priorities and interests of the electorate. The effect of public funding on government promotion of renewables, therefore, depends on the degree of public environmental concern. Inglehart demonstrates that as a country becomes more affluent, the concerns of its citizens gradually shift from the fulfillment of basic acquisitive or materialistic needs to the pursuit of non-materialistic values (1971). Political priorities among voters both between countries and within a given country over time vary based on its level of economic development. While voters in less affluent nations prioritize issues such as economic growth and a strong national defense, those in wealthier countries give high priority of postmaterialist concerns including environmental protection. Public opinion data also indicate that citizens in wealthier nations are more concerned about climate change and more supportive of government action to combat it (Fagan & Huang, 2018). The value changes in citizens as income increases suggests the following:

Hypothesis 3 (H3): Public campaign finance has a greater positive effect on the adoption of renewables in countries with higher levels of GDP per capita.

I also expect the effect of public campaign finance to be heterogenous across levels of political corruption. Both private campaign finance and corruption provide avenues through which entrenched interests bias political decision-making. Even when private funding plays a major role in campaigns, interest groups may still prefer to seek influence through explicit bribes because they can have greater certainty that they will produce results and do not face the risk of forfeiting money without securing access or favors. Increasing the role of public campaign funding narrows one channel of disproportionate political influence, but this only has a significant impact if other equally or more expedient avenues do not exist. Therefore, public funding may have little if any effect in corrupt political systems. I therefore expect to observe the following in my empirical analysis:

Hypothesis 4 (H4): Public campaign finance has a greater positive effect on the adoption of renewables in countries with less corruption.

Several characteristics of strong democracies make their policy outcomes particularly sensitive to changes in the campaign finance system. In strongly democratic regimes, elections are open, competitive, costly, and consequential. Obtaining the resources to run a successful campaign under these conditions is critical for challengers to gain power and for incumbents to maintain it. In the absence of robust public funding, politicians in fair and competitive democratic elections are heavily reliant on private funding and therefore likely to alter their behavior and sacrifice optimal policy to secure campaign contributions. Reducing reliance on private donations can therefore have a particularly dramatic effect on the incentives and resulting behavior of elected officials. Moreover, in the absence of concerns about obtaining funding, politicians and parties in pure democracies are more likely to represent the interests of their constituents than those in flawed democracies, who may be accountable to other political actors who help them maintain power. Consequently, I expect to find the following:

Hypothesis 5: Public campaign finance has a greater positive effect on the adoption of renewables in strong democracies.

4. Methods

4.1. Dataset

I quantitatively analyze the determinants of renewable energy production in 35 OECD countries[2] from 2000 and 2015. All predictor variables are lagged by one year in the regression models; they are therefore observed from 1999 to 2014. The starting year of the analysis is based on the time at which renewable energy deployment began to rapidly increase. By the turn of the century, renewables were becoming economically viable and international awareness, political accountability, and public pressure surrounding sustainability and climate action were heightening. The Millennium Development Goals (MDGs) were signed in September of 2000; one of the eight goals was "to ensure environmental sustainability." The MDGs reflected growing concern about environmental degradation and codified sustainability as a key social priority. After 2000, therefore, one would expect responsive, well governed nations to increase renewable energy deployment. The dataset ends in 2015 because there are no subsequent data reported by the World Bank on the dependent variable and many of the independent variables (IVs) included in the analysis.

4.2. Variables

- Renewable energy production: My outcome variable is electricity production from renewable sources (excluding hydroelectric) as a percentage of total electricity production. This variable is provided by the World Bank. Within the dataset, renewable energy share ranges from 0 to 65.4 percent and the mean share is 6.4 percent. I use

[2] The dataset includes all OECD countries with the exception of Iceland due to lack of data availability on several independent variables.

percentage share as opposed to total kilowatt hour levels because the performance of renewables in relation to other fuel sources is a more meaningful indicator of climate change mitigation and progress toward a sustainable energy system. Consider a country which, over a five-year period of increasing energy demand, increased its kilowatt hour renewable energy production by ten percent and its fossil fuels energy production by 15 percent. Despite the increase in total renewable energy production, the country's dependence on fossil fuels and energy-related emissions actually increased. Furthermore, this comparative growth profile would not require significant pro-renewable policy intervention, which indicates that total renewable energy production is a particularly poor measure when analyzing political determinants. The limitation of the dependent variable is that it only includes renewable participation in the power sector; renewables are also used in heating, industrial processes, and transportation. The majority of current and future projected growth in renewable energy production, however, is in the power sector (IEA, 2015) suggesting that findings from the present study are relevant. Government policy is also particularly important in this sector as electricity generation and distribution is heavily regulated in most countries.

- Public campaign finance: My key independent variable is the "Public Campaign Finance" index from Variables of Democracy (V-Dem) Data Version 9 (Coppedge et al., 2019a). The dataset provides an index score, which is generated by averaging the scores assigned by at least five Country Experts.[3] Country Experts were asked the following question: "Is significant public financing available for parties' and/or candidates' campaigns for

[3] A Country Expert is "a scholar or professional with deep knowledge of a country and of a particular political institution… (who) is usually a citizen or resident of the country (Coppedge et al., 2019b, pp. 27).

national office?" Responses ranged from 0 ("No. Public financing is not available") to 4 ("Yes. Public financing funds a significant share of expenditures by all, or nearly all parties)". Within my dataset, the lowest score is .143, the highest score is 3.961, and the mean score is 3.01. H1 predicts a positive relationship between public campaign finance and renewable energy production share. H2 predicts a stronger relationship between the two variables in the more recent half of the time period.

To test H3, H4, and H5, which predict a heterogeneous effect of campaign finance across wealth, corruption, and democracy, I include the following variables. Given their significance in past literature, they also act as key controls when testing the main effect of campaign finance.

- GDP: To test H3 and account for variation in wealth, I include the natural log of GDP per capita (PPP). This variable is provided by the World Bank. H3 predicts a positive interaction effect of GDP and public campaign finance. Past research indicates that the independent relationship between income and renewable energy production is also positive.
- Corruption: I test H4 and control for overt corruption using V-Dem's political corruption index which asks "How pervasive is political corruption" (Coppedge et al., 2019b, pp. 54). The index runs from clean to corrupt in the interval [0,1] and measures both petty and grand corruption aimed at influencing law making and implementation. It is generated by averaging scores from V-Dem's public sector, executive, legislative, and judicial corruption indices. H4 predicts a negative interaction effect of corruption and public campaign finance. Existing literature indicates that the main effect of corruption is also negative.

- Democracy: I use polity scores from the Polity IV dataset to test H5 and account for the minor but still potentially consequential variation in regime type among OECD countries over time. Scores range from -10 (fully autocratic) to 10 (fully democratic). The lowest score in my dataset, however, is 3 and the mean is exceptionally high at 9.5. H5 predicts a positive interaction effect of democracy and campaign finance. Previous analyses find that the independent relationship between democracy and renewable energy deployment is also positive.

Finally, I account for one other political variable from the World Bank's Database of Political Institutions (DPI) and five additional non-political variables from the World Bank's World Development Indicators (WDI) dataset. The variables are selected as controls based on their significance in past research and their relevance given my sample and specification of the dependent variable.

- Leftist government ideology: I include a variable from the World Bank's Database of Political Institutions (DPI) that identifies whether a government is controlled by a right, center, or left majority. I convert the measure into a dummy variable for which '0' specifies a right or center majority and '1' indicates a left majority. I expect to find that leftist governments promote renewable energy more than governments controlled by right or center parties.
- Energy imports: As a proxy for energy security, I use net energy imports as a percentage of energy use. Findings on the relationship between this variable and renewable energy deployment are somewhat inconsistent, but generally suggest that it has a positive impact on renewable energy deployment.

- Population: The natural log of total population is one of two variables I employ to represent electricity demand. Most previous analyses find population to be negatively associated with renewable energy share.
- Electric power consumption: I use the natural log of electric power consumption per capita (in addition to population) to control for electricity demand. Previous research indicates a negative relationship between energy consumption and renewable energy share.
- Land area: Like previous authors (e.g. Margues et al., 2010) I use the natural log of surface area (sq. km) as a proxy for renewable energy production potential. While other aspects of climate and topography also have an impact, with sufficient geographic area to support renewable energy infrastructure, significant potential for some combination of renewable sources typically exists.
- Other fossil fuel alternatives: Finally, I account for use of other fossil fuel alternatives with the combined percentage share of electricity production from hydroelectric and nuclear sources. While this is not a variable included in previous research, I believe that it is particularly relevant in my analyses because I limit the dependent variable to non-hydroelectric sources. Both hydroelectric and nuclear electricity production share in OECD countries decreased between 2000 and 2015. However, countries that maintained relatively high shares of these alternatives may not have faced the same pressure to reduce energy-related emissions and deploy renewables. As I result, I expect that levels of other fossil fuel alternatives in the energy mix will be negatively associated with renewable energy production share.

4.3 Models

I analyze the effects of the independent variables on renewable energy production using Ordinary least squares (OLS) regression models, including pooled OLS and the addition of year and country fixed effects. My most inclusive model is specified by the following equation:

$$Y_{it} = \alpha + X_{it-1}\beta + \mu_t + \delta_i + u_{it}$$

Y_{it} is the outcome variable, (the percentage of electricity production from renewable sources) measured in country *i* in year t; X_{it-1} refers to the time-variant vector of the ten covariates observed in country *i* in year *t* – 1; μ_t denotes year fixed effects; δ_i represents country fixed effects; and u_{it} is a random error term. Note that the independent variables are observed one year prior to the dependent variable; this time lag accounts for the fact that changes in economic incentives or implementation of new policies are unlikely to have immediate effects on renewable energy production.

The first model I employ is a pooled OLS regression which includes my key independent variable and all other control variables but omits time and year fixed effects. Pooled OLS captures variation in the dependent and independent variables over time and across countries simultaneously. To test the robustness of my results and account for some sources of unobserved heterogeneity and the lack of observational independence in panel data observations, I also employ fixed effects regression models. My second model includes a full set of year dummies to account for omitted variables that change over time but are constant across countries. Potentially relevant time-variant factors include fluctuations in the market prices of renewable and non-renewable energy sources, technological developments, and various aspects of international politics. Finally, my third model includes both year and country dummies. The addition of country fixed effects allows for shifts in the regression line that arise from unobserved variables that differ between countries but are constant over time. The model therefore controls both for initial differences between countries and for changes over time that are not country specific.

To test H2, which predicts a stronger effect of public campaign finance in the latter portion of the time period, I use the model specifications described above but begin the analysis period in 2007. These regressions thus examine the role of the independent variables in roughly the second half of the time period. I test H3, H4, and H5 concerning the heterogenous effects of public campaign finance across GDP, corruption, and democracy scores (measured by Polity IV) by employing interactions. More specifically, for each interaction, models discussed are shown, including the public campaign finance variable, the moderator variable, and their interaction term.

It should be emphasized that while the use of control variables and fixed effects account for many correlates of the dependent variable, these regressions do not rule out omitted variable bias or tackle issues of endogeneity. Further study is needed to determine whether the relationships uncovered in this thesis are influenced by unobserved determinants of renewable energy deployment or factors that are correlated with both campaign finance and the dependent variable.

5. Results and Discussion

Table 1 summarizes the results of the three basic models in the entire time period and in exclusively the second half of the time period; the results on the left half of the table address the main effect predicted by H1, while the results on the right side address H2 concerning changes in effect size over time.

Table 1: Main effects of public campaign finance

	Pooled OLS (2000-2015)	Year FE (2000-2015)	Two-way FE (2000-2015)	Pooled OLS (2007-2015)	Year FE (2007-2015)	Two-way FE (2007-2015)
Public Campaign Finance	2.545***	2.239***	0.566	3.678***	3.259***	2.946***
	(0.31)	(0.29)	(0.65)	(0.46)	(0.43)	(1.08)
Left Majority	-0.049	0.302	0.306	0.338	0.651	0
	(0.58)	(0.54)	(0.36)	(0.83)	(0.78)	(0.45)
Democracy	1.086***	1.567***	-0.285	1.509***	1.984***	-0.034
	(0.3)	(0.28)	(0.43)	(0.41)	(0.39)	(0.5)
Corruption	-17.275***	-18.422***	-1.05	-22.121***	-22.968***	-1.654
	(2.21)	(2.05)	(5.63)	(3)	(2.82)	(6.97)
GDP	12.592***	4.960***	-2.184	15.370***	8.139***	6.426*
	(1.04)	(1.34)	(2.35)	(1.85)	(2.05)	(3.89)
Energy Imports	0.005**	0.005**	0.001	0.010***	0.009**	0.025**
	(0)	(0)	(0.01)	(0)	(0)	(0.01)
Population	-2.054***	-1.296***	-28.264***	-2.053***	-1.451***	-43.077***
	(0.31)	(0.3)	(5.26)	(0.43)	(0.42)	(8.58)
Electricity Cons.	-11.935***	-7.301***	-12.651***	-14.961***	-10.626***	-28.473***
	(0.96)	(1.04)	(2.59)	(1.48)	(1.53)	(4.51)
Surface Area	1.380***	0.636**	-18.376***	1.490***	0.795**	-18.348***
	(0.26)	(0.26)	(5.87)	(0.38)	(0.37)	(5.43)
Alternatives	-0.022**	-0.035***	-0.125***	-0.027*	-0.039***	-0.080***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)
Year Fixed Effects	No	Yes	Yes	No	Yes	Yes
Country Fixed Effects	No	No	Yes	No	No	Yes
Constant	-14.994*	13.516*	825.882***	-24.801*	4.626	1113.132***
	(7.9)	(8.08)	(115.33)	(13.2)	(13.1)	(160.27)
R-sqr	0.433	0.53	0.669	0.469	0.544	0.7
Observations	547	532	498	339	330	296

Note: the table displays coefficients with robust standard errors in parentheses.
*p < .10, ** p <.05, ***p < .01

The results of the quantitative analyses displayed above provide strong support for H1, the main effect of public campaign finance on renewable energy deployment and H2, the increased effect of campaign finance over time. To contextualize my findings on campaign finance, it is useful to compare them to those of the other political variables in my analysis. The only uninformative political variable is the dummy variable that distinguishes leftist governments from those with right or center majorities, which is insignificant in all six basic models. Polity, corruption, and public campaign finance have a highly significant effect on the dependent variable in most regression models. These results suggest that the quality and responsiveness of politicians and the institutions in which they operate, rather than their ideology, determines a country's adoption rate of renewables.

Corruption, polity, and campaign finance are all significant predictors of renewable energy production at the .1% level[4] in the pooled OLS regression and year fixed effect models that span the entire 15-year time period. In the two-way fixed effects model, the coefficients of all three variables are no longer statistically significant. Public campaign finance and corruption retain the hypothesized coefficient signs, and the effect of polity becomes negative. While the pooled and year fixed effects models measure the effects of both between and within country variation in the independent variables, the inclusion of country fixed effects in the third model limits the analysis to the effects of within country change over time. Variation on the time-series dimension of my dataset for polity, corruption and campaign finance, however, is minimal. Only five out of the thirty-five countries in my sample[5] fluctuated by one or more points in their scores

[4] The highest level of significance denoted in my tables is $p< 01$. However, the coefficients for corruption, public campaign finance, and polity variables are significant at the $p<.001$ (or .1%) significance level.

[5] The five countries that fluctuated by more than one point on the public campaign finance variable across the time period were Chile, Estonia, Korea, Lithuania, and Latvia.

on the public campaign index. Most of the observed variance in public campaign finance, as well as polity and corruption, is between countries, which limits the ability of the regression to identify within-country effects if they do exist.

The results displayed on the right half of the regression table address H2, which predicts a greater effect size of campaign finance in the second half of the time series due to more widespread economic viability of renewable energy and increased public concern surrounding climate change. I find that when I begin the analysis in 2007, the effect coefficient of the public campaign finance variable is greater across all three models. Furthermore, while the effect coefficient of public campaign finance was insignificant in the two-way fixed effects regression that spans the entire 15-year time period, it is highly significant when considering only the most recent half of the dataset. This result is particularly notable given the low level of within country variance on the campaign finance index. It suggests that once climate change was established as an urgent and politically salient issue, even small increases in the role of public funding have significant implications for government decision-making on renewable energy. The other governance variables (corruption and polity) also have a stronger effect in the second half of the time period, but are not significant in the two-way fixed effects model. Overall, a comparison of public campaign finance to previously established political factors underscores the prominence of its role. Of the four political variables I include in my statistical analysis, the effect of campaign finance is most robust; its positive effect remains highly significant across five out of the six models.

Based on the range of coefficients and standard errors given by the three models, a one-point increase along the public campaign finance index between 2007 and 2015 implies an increase in renewable electricity production share of between 1.9 and 4.1 percentage points. This is a particularly important quantitative effect given the average value of the dependent variable; between 2007 and 2015, the mean renewable electricity share was 9.5 percent and the median share was just 6.9 percent. The predicted difference in electricity share from renewables between a country with a campaign finance system in which no public financing is available and one in which it "funds a significant share of expenditures by all, or nearly all parties" (Coppedge et al., 2019b, pp. 54) is between 7.5 and 16.6 percentage points. The low end equates to a more than doubling of renewable electricity share. At the high end of the estimate, a transformation of campaign funding sources is associated with a more than tripling of the median share. The impact of renewable energy since 2015 and into the future may be even greater than it was between 2007 and 2015 because just as public and international pressure around climate change and sustainable energy increased from the first to the second half of the time series, it has continued to grow since.

Turning to control variables in the analysis, I find that most previously identified determinants of renewable energy deployment have the same directional effect when considering exclusively non-hydroelectric sources. Given the variety of approaches and samples used by previous authors, their conclusions about the role of some variables are inconsistent. The results displayed above, however, match the preponderance of past evidence. All control variables, with the exception of the leftist government dummy, are significant across a majority of models. Most nonsignificant coefficients appear in the two-way fixed effects regressions. These results are unsurprising, as country fixed effects wash out cross-sectional variation; most of the variance in many IVs occurs in this dimension of the data.

Some established correlates of renewable energy production appear to have distinct magnitudes of effects when considering non-hydroelectric renewable sources. Increases in energy demand, represented by the energy consumption per capita and population variables, have a very strong negative association with the dependent variable in all of the models. One potential explanation is that most countries still have less existing infrastructure for non-hydroelectric renewable energy. They are thus unable to quickly respond to increases in demand, and instead turn to more established energy sources such as hydropower or fossils fuels. Surface area, on the other hand, has a smaller positive effect than that found in previous research on all renewable sources. This is particularly surprising given the large geographic area required to generate a significant amount of energy from wind and solar, the two dominant and fastest growing non-hydro renewables. Nonetheless, the weak nature of the relationship calls into question the utility of surface area as an indicator for non-hydroelectric renewable energy production potential. Finally, the novel control variable that I include, combined electricity share from hydroelectric and nuclear sources, has a highly significant negative association with renewable energy production across all model specifications. This finding indicates that countries with a high share of other fossil fuel alternatives face less pressure to further reduce energy related emissions through the deployment of renewables. Given the significance of the relationship, subsequent analyses on the deployment of non-hydroelectric renewables should also account for the role of other fossil fuel alternatives.

Tables 2, 3, and 4 display the results of the models including interaction effects. These regressions test H3, H4, and H5.

Table 2: Heterogeneous effect of public campaign finance across GDP

	Pooled OLS (w/o controls)	Pooled OLS (all controls)	Year FE	Two-way FE
GDP	-1.184	7.456***	1.45	-8.294***
	(1.76)	(1.74)	(1.8)	(2.73)
Public Campaign Finance	-22.071***	-17.331***	-12.367**	-23.131***
	(6.02)	(5.43)	(5.07)	(5.69)

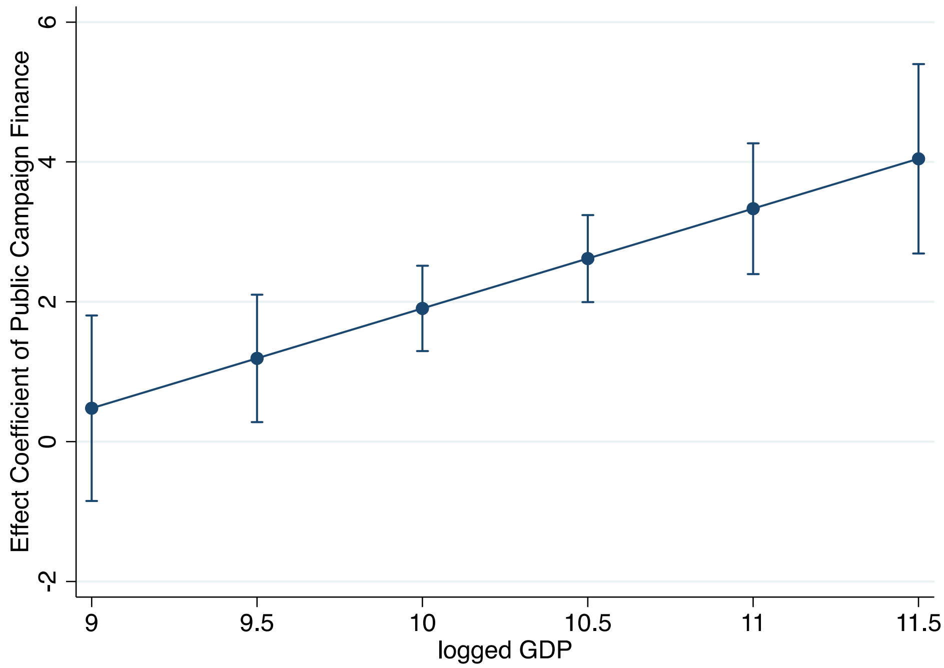
Interaction	2.324***	1.941***	1.427***	2.442***
	(0.59)	(0.53)	(0.5)	(0.58)
Left Majority		0.112	0.417	0.345
		(0.57)	(0.54)	(0.36)
Democracy		1.196***	1.631***	-0.214
		(-0.3)	(-0.28)	(-0.42)
Corruption		-15.507***	-17.077***	-5.219
		(2.24)	(2.09)	(5.63)
Energy Imports		0.006**	0.005**	-0.002
		(0)	(0)	(-0.01)
Population		-1.782***	-1.122***	-30.049***
		(0.31)	(0.3)	(5.19)
Electricity Consumption		-11.853***	-7.399***	-11.698***
		(0.95)	(1.04)	(2.56)
Surface Area		1.311***	0.610**	-19.632***
		(0.26)	(0.25)	(5.78)
Alternatives		-0.022**	-0.035***	-0.121***
		(0.01)	(0.01)	(0.02)
Year Fixed Effects	No	No	Yes	Yes
Country Fixed Effects	No	No	No	Yes
Constant	13.45	31.765**	46.912***	920.782***
	(17.96)	(14.97)	(14.09)	(115.69)
R-sqr	0.164	0.446	0.537	0.681
Observations	557	546	531	497

Note: the table displays coefficients with robust standard errors in parentheses.
*p < .10, ** p <.05, ***p < .01

The results above demonstrate that, consistent with H3, the effect of public campaign finance is greater as GDP per capita increases. This interaction effect is highly significant in all models. The large negative coefficients for the public finance variable represent its effect when logged GDP per capita is 0, which is not a plausible value under any circumstance. The lowest logged GDP per capita in the dataset is 8.9 ($7,400), for which Figure 4 shows the effect is insignificantly different than zero.

Figure 4 illustrates the heterogeneous effect of public campaign finance on renewable energy production across GDP[6]. The graph tracks the effect coefficient of public campaign finance as GDP increases.

Figure 4: Effect Coefficient of Public Campaign Finance Across GDP



The model suggests that when logged PPP GDP per capita is 9 ($8,100), an increase of one point on the public campaign finance scale results in only about a half of a percentage point increase in predicted renewable energy production share. In the wealthiest countries in the dataset, each one-point increase on the public campaign finance index increases predicted renewable energy production share by over four percentage points.

[6] For all graphs displaying the heterogeneous effects of campaign finance in renewable energy share, I use the year fixed effects model. I chose this model instead of the most inclusive model because as discussed in on p. 31-32, country fixed effects wash out much of the theoretically interesting variation in the predictor variables.

Table 3: Heterogeneous effect of public campaign finance across prevalence of corruption

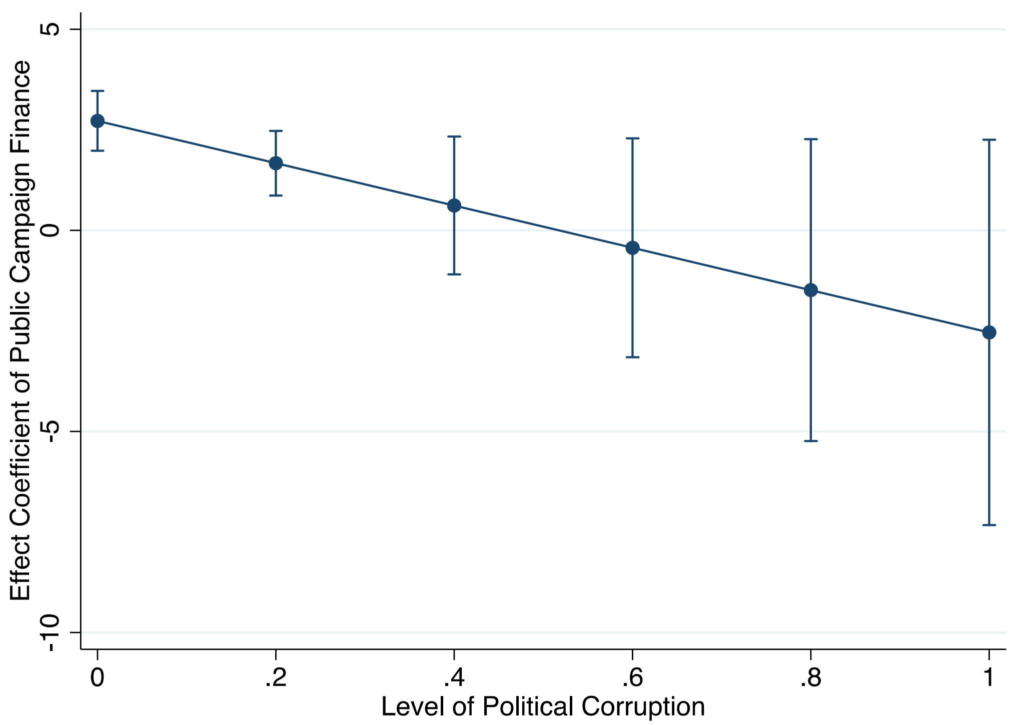
	Pooled OLS (w/o controls)	Pooled OLS (all controls)	Year FE	Two-way FE
Corruption	-9.952	10.313	-0.274	21.438
	(11.29)	(10.05)	(9.42)	(13.26)
Public Campaign Finance	2.338***	3.263***	2.720***	1.263*
	(0.47)	(0.4)	(0.38)	(0.75)
Interaction	-1.189	-8.014***	-5.259**	-7.625*
	(3.29)	(2.85)	(2.67)	(4.07)
Left Majority		0.055	0.36	0.375
		(0.58)	(0.54)	(0.36)
Democracy		1.060***	1.536***	-0.393
		(0.3)	(0.28)	(0.43)
GDP		13.350***	5.703***	-1.534
		(1.07)	(1.38)	(2.37)
Energy Imports		0.005**	0.005**	0
		(0)	(0)	(-0.01)
Population		-2.013***	-1.293***	-29.712***
		(0.31)	(0.3)	(5.3)
Electricity Consumption		-12.184***	-7.608***	-11.409***
		(0.96)	(1.05)	(2.66)
Surface Area		1.449***	0.705***	-18.585***
		(0.26)	(0.26)	(5.85)
Alternatives		-0.023**	-0.035***	-0.127***
		(0.01)	(0.01)	(0.02)
Year Fixed Effects	No	No	Yes	Yes
Country Fixed Effects	No	No	No	Yes
Constant	1.571	-24.357***	6.435	833.988***
	(1.57)	(8.53)	(8.82)	(115.12)
R-sqr	0.129	0.441	0.533	0.672
Observations	557	546	531	497

Note: the table displays coefficients with robust standard errors in parentheses.
*p < .10, ** p <.05, ***p < .01

Consistent with Hypothesis 4, the positive effect of public campaign finance is diminished as the level of political corruption increases. The interaction coefficient is negative and significant in all models except the most rudimentary specification, which includes neither controls nor fixed effects. All models demonstrate that the effect of campaign finance is positive and significant when corruption is 0. According to three out of the four models, when corruption is at its maximum possible value of 1, the effect of public campaign finance is negative. However, the highest level of corruption observed in the dataset is .772 and the median value is very low at .074. Unlike GDP, for which a value close to 0 is implausible, a majority of political corruption observations are close to 0; the coefficient for public campaign finance therefore remains meaningful.

Figure 5 illustrates the effect of public campaign finance on renewable energy production as the prevalence of corruption increases.

Figure 5: Effect Coefficient of Public Campaign Finance Across Political Corruption



The dramatic increase in the width of the 95% confidence interval as corruption increases is due to the low average corruption score within the sample; most observations are between 0 and .1. In completely clean governments, a one-point increase in the public campaign finance variable is associated with an approximately three percent increase in renewable energy share. In countries with a corruption score is greater than .5, the estimated effect of public campaign finance is negative. 0 remains within the 95% confidence interval, however, for all negative coefficient estimates. Due to low levels of corruption throughout of the sample, conclusions cannot be drawn about whether public campaign finance actually has a negative effect on renewable energy in corrupt political systems. However, in countries with a corruption score between 0 and .25, effects are positive and significant, suggesting that public campaign finance has a positive impact in low-corruption systems.

Table 4: Heterogeneous effect of public campaign finance across polity

	Pooled OLS (w/o controls)	Pooled OLS (all controls)	Year FE	Two-way FE
Polity	-0.893	-2.449**	-1.305	-0.571
	(1.26)	(1.15)	(1.08)	(1.82)
Public Campaign Finance	-6.451*	-7.610**	-5.966**	-0.167
	(3.56)	(3.22)	(2.99)	(4.56)
Interaction	0.901**	1.077***	0.871***	0.083
	(0.38)	(0.34)	(0.32)	(0.51)
Left Majority		0.208	0.499	0.311
		(0.58)	(0.54)	(0.37)
Democracy		-16.161***	-17.476***	-1.11
		(2.22)	(2.07)	(5.65)
GDP		13.202***	5.678***	-2.201
		(1.05)	(1.35)	(2.35)
Energy Imports		0.006**	0.005**	0.001
		(0)	(0)	(0.01)
Population		-1.815***	-1.124***	-28.207***
		(0.32)	(0.3)	(5.28)
Electricity Consumption		-11.737***	-7.271***	-12.542***
		(0.96)	(1.04)	(2.68)
Surface Area		1.299***	0.592**	-18.409***
		(0.26)	(0.26)	(5.88)
Alternatives		-0.023**	-0.035***	-0.124***
		(0.01)	(0.01)	(0.02)
Year Fixed Effects	No	No	Yes	Yes
Country Fixed Effects	No	No	No	Yes

Constant	8.731	7.176	30.568***	827.077***
	(11.84)	(10.5)	(10.13)	(115.68)
R-sqr	0.123	0.443	0.536	0.669
Observations	557	546	531	497

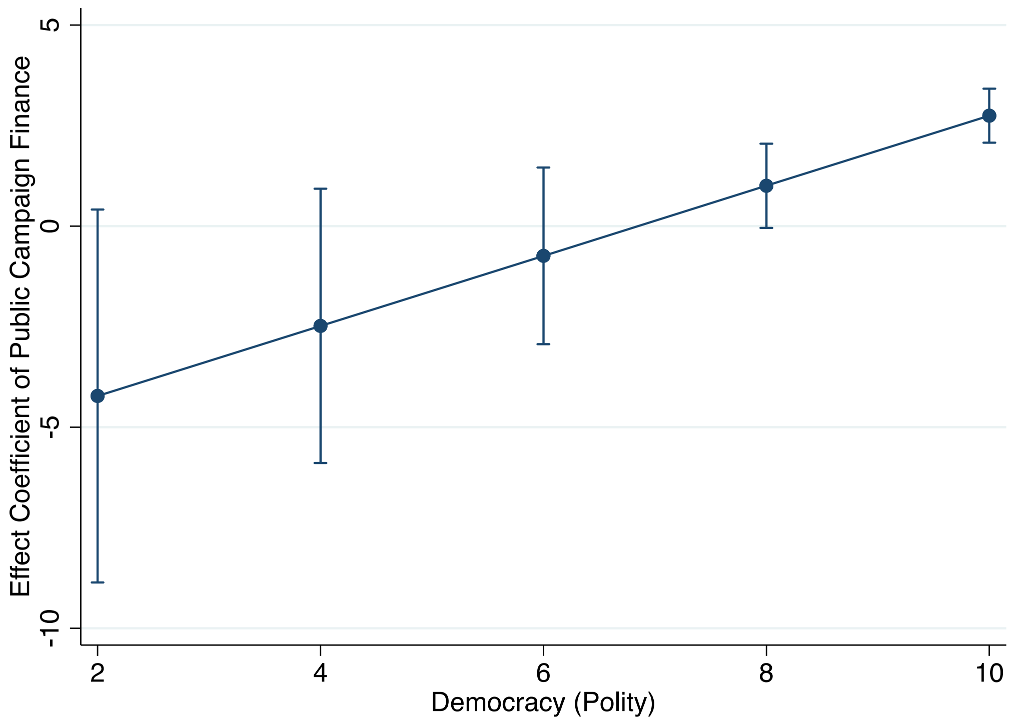
Note: the table displays coefficients with robust standard errors in parentheses.
*p < .10, ** p <.05, ***p < .01

The positive interaction effect coefficients indicate that, as predicted by H5, the impact of campaign finance is positively associated with democracy. The interaction effect is highly significant in three out of the four models; it loses significance when country fixed effects are added. The significant, negative coefficients for the public finance variable represent its estimated effects when a country's polity score is zero. In my sample, the lowest recorded score is three, and even this value is an outlier[7]. Conclusions about the role of public campaign finance based on linear estimations cannot be drawn at polity values that do not exist in the dataset. Thus, further research on samples that include anocracies and autocracies is necessary to understand the full range of its effect across regime types.

Figure 6 illustrates the estimated effect coefficient of public campaign finance on renewable energy production across democracy. In countries with a polity score of below 8 or below (which constitute 10 percent of observations in the sample), campaign finance has an insignificant impact on renewable energy share. In countries with a polity score of 10 (which constitute over half of observations in the sample) a one-point increase in campaign finance is associated with a 2.5 to 3.5 percent increase in renewable energy share.

[7] Turkey's polity score dropped precipitously from nine in 2013 to three in 2014 and 2015. The lowest polity score in the sample aside from these two observations is six.

Figure 6: Effect Coefficient of Public Campaign Finance Across Polity



6. Conclusion

This thesis sought to explain variation in recent renewable energy deployment among OECD countries by examining the role of campaign finance, a previously unaddressed political factor. I quantitatively measure its association with the adoption of renewable energy through panel data analysis techniques including pooled OLS and fixed effects regressions.

The results of these analyses suggest that public campaign finance is a statistically significant and quantitatively important determinant of renewable energy adoption. They support not only the predicted main effect of campaign finance on renewable energy share, but also my hypotheses regarding how its effects change over time and interact with other variables. The increased size and robustness of the effect in the more recent half of the time period indicates that as climate concern heightens and renewable energy poses an increasingly serious threat to fossil fuel interests, public funding becomes increasingly important. The heterogeneous effects of campaign finance across GDP, corruption, and democracy reveal the institutional contexts in which it is most critical and provide further support for my theoretical conceptualization of its role, which may be summarized as follows: reliance on private campaign contributions allows entrenched interests to obtain access and favors from politicians, thus disproportionately influencing political decision making on renewable energy. When public financing plays a major role in elections, politicians are less reliant on private contributions and therefore less likely to sacrifice policy utility or constituent preferences on consequential issues like energy policy and climate change mitigation.

This theoretical framework suggests that improved representation of constituents due to public campaign finance has a greater impact on renewable energy policy in wealthy nations because their citizens prioritize post-materialistic concerns such as environmental quality.

Decreasing reliance on private donations is more critical in strong democracies because elections are consequential and competitive. Furthermore, politicians in democratic systems can suffer electorally from sacrificing constituent preferences and are thus likely to choose policies that address their concerns when they no longer find it necessary to sell access or favors to secure sufficient campaign funding. Finally, campaign finance is a less relevant factor when corruption is prevalent because entrenched interests have other, more expedient monetary channels through which to influence policy outcomes.

A number of OECD members including Slovenia, Israel, South Korea, Mexico, and Turkey offer robust public campaign finance, but their levels on one of more of these moderator variables prevent public financing from facilitating government promotion of renewables. Slovenia falls in the bottom half of OECD countries in terms of GDP per capita, and fluctuates between the 75th and 90th percentiles in terms of political corruption. Israel's polity score is below the 5th percentile throughout the analysis period. South Korea has somewhat disadvantageous scores on all three moderator variables, particularly polity. Mexico and Turkey are both highly corrupt and well below the OECD average in terms of wealth and polity. All of these countries experienced only a one to five percent increase in electricity share from renewables between 2000 and 2015 (World Bank, 2020).

At first glance, cases like these seem to contradict the hypothesis that public campaign finance increases the adoption rate of renewables, but they are in fact consistent with the more nuanced relationship predicted by my theory and identified in my quantitative analysis. Campaign finance is a key explanatory variable, but its relevance is limited to countries with certain characteristics. It appears to be a crucial factor in explaining why some affluent, clean democracies such as Germany, Denmark, and Spain have become world leaders in renewable energy while others, like Japan, Switzerland, and the United States, have made minimal progress in transitioning their energy systems.

While they present promising results, the regression analyses do not rule out issues of endogeneity, omitted variable bias, or reverse causality. Rigorous statistical analysis, additional investigation into the correlates of campaign finance and renewable energy, and more granular evidence on effect mechanisms are necessary to overcome these limitations. I am also limited by the availability of data on key variables. The primary independent variable of interest in my analysis, V-Dem's public campaign finance index, is based on qualitative judgements by country experts. A similar analysis that includes, for example, public funding as the percentage of total campaign funding, would reveal whether its effect is robust across measures. Due to a lack of widespread, reliable data on sources of campaign funding, such research would likely be constrained to a more limited sample of countries over a shorter time period.

The theoretical framework and initial evidence presented in this thesis suggest several avenues for future research. My quantitative approach may be built upon through qualitative, country-level study illuminating how organized interests utilize campaign finance to influence energy policy in various contexts. Country-level work examining campaign finance reform and the subsequent changes in renewable energy policy could also provide more applied evidence of within-country effects. Analysis using data on the dependent variable and its correlates after 2015 could provide more concrete insight into how the relationship between renewable energy and public campaign finance continues to evolve over time. Finally, other components of campaign finance systems such as total campaign cost should be evaluated as they may have independent effects and interact with public campaign finance to shape renewable energy policy.

While further study is needed to corroborate its findings, this thesis provides novel insight into variation in renewable energy deployment among developed democracies and the value of public campaign finance within them. Rapid growth of renewable energy and reduction in fossil fuel use are critical to mitigate severe environmental, social, and political consequences of climate change. Thus, the positive relationship between public campaign finance and renewable energy growth should be considered in policy debates regarding the provision of public funding in democratic elections.

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