Renewable Energy Transitions in Hydrocarbon-Rich Countries: The Effects of Political Institutions (Various Types of Democracy and Autocracy) and State Hydrocarbon Rent on Renewable Energy Policies

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Amirhossein Najafi Marghmaleki, declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Arts and Social Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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ABSTRACT

Hydrocarbon resource wealth often leads to overreliance on hydrocarbon resource revenues (state hydrocarbon rents) and/or an unhealthy dependence on hydrocarbon-intensive industries, detrimental political and economic outcome of which are known as the resource curse. While the impact of democracy on the provision of environmental public goods is well studied, the link between democracy and renewable energy (RE) policy outcomes, such as RE deployment and its share in the energy mix, remains relatively unexplored. Additionally, there is a significant gap in understanding the interrelationships between hydrocarbon richness, and state hydrocarbon rents, and RE development. Transitioning towards a low-carbon future necessitates the meaningful involvement of hydrocarbon-rich countries. Therefore, it is crucial for academics and policy practitioners to comprehend the interconnections between different dimensions of democracy, the political and economic consequences of hydrocarbon wealth, state hydrocarbon rents, and RE development.

This study adopted a mixed-method approach, combining quantitative regression modelling and qualitative case studies. The quantitative analysis utilized regression models, including the linear mixed model and 'within-between' estimations, to thoroughly investigate the effects and likely interactions of various independent variables on the share of solar and wind electricity in the electricity generation capacity and consumption. The independent variables included a novel measure of hydrocarbon richness, measures of different dimensions of democracy, state hydrocarbon rents, and other political, social, and economic factors. The qualitative component of the study comprised illustrative case studies of Algeria, Morocco, and Tunisia.

The study broadly found empirical support for the long-term positive relationship between democracy and RE development, as well as a negative association between oil richness, state oil rent, and RE development. It also identified a strong Environmental Kuznets Effect (EKC) and highlighted the moderating effect of institutional qualities such as the rule of law and quality of government on the relationship between state oil rent and RE development. However, the study did not find a robust link between a country's vulnerability to climate risks and its RE potential or development. The findings demonstrate considerable robustness when modifying the sample composition and size, as well as when utilizing alternative measures of RE development. The case study analysis, re-examining the links between the independent variables and RE development in the context of the three countries, identified the positive effect of political stability and detrimental effect of hydrocarbon resource wealth—through energy subsidies—on RE development. The findings of the case study analysis broadly corroborate those of the quantitative analysis.

1. Introduction to the Thesis

Sustainable energy transitions require large-scale development of renewable energy (RE). Recent progress in RE generation—which includes solar, wind, biomass and waste, wave and tidal energy, geothermal and small hydro—has been substantial. According to Ajadi et al. (2020), the cost of RE resources, or in technical parlance the levelized cost of energy (LCOE)[1], has dropped significantly in the past decade—83%, 49%, and 51% for solar photovoltaics, on-shore, and off-shore wind respectively—all thanks to advancement in RE technologies, economies of scale, and the adoption of more and better RE policies. In 2019 total RE investments (US$302 billion) and capacity generation (184 gigawatts) far outpaced those of conventional electricity generation sources, resulting in a 78% share of renewables in the added electricity generation capacity in that year. In 2020, utility scale prices fell well below the cost of coal, gas and nuclear (Macacci, 2020).

Although the COVID-19 pandemic hampered investment in renewables in 2020, it might have had unwanted positive consequences for RE demand. Data reveal that the demand for fossil fuels declined in the first quarter of 2020, while renewables were the only source of electricity to record an increase in demand (Murdock et al., 2020). Despite solid progress in the use of renewables for electricity production, RE penetration in other sectors has not been promising. In the heating/cooling and transport sectors, which account for 83% of total final energy consumption (TFEC), renewables' gains have been relatively dismal. Renewables have a modest 11% share in TFEC. Overall, current and projected future developments in RE are still insufficient to keep the increase in the average global temperature under 2ºC (Murdock et al., 2018; Murdock et al., 2020).[2] Furthermore, there is a significant disparity in renewable energy development among countries. Many nations have negligible or zero renewable energy in their electricity mix, while a few others have achieved higher shares.

[1] The levelized costs account for not just the expense of buying the equipment and constructing the plant but also developing it through the permitting stage, financing it and operating and maintaining it (Ajadi et al., 2020).

[2] It is worth noting that while conventional research considers RE investment as an effective way of mitigating or avoiding environmental crises, the degrowth literature contends that any increased investment would most likely expedite environmental degradation as more efficient technologies only speed up growth consumption and pollution (Dasgupta & De Cian, 2018).

This thesis describes a country-level empirical study of the outcomes of the development, adoption, and implementation of environmental policies that directly and indirectly promote RE. The key objective of this study has been to discover and investigate the mechanisms through which democracy, hydrocarbon-richness, and state hydrocarbon rents affect RE development within country and across countries.[3]

1.1. Role of Politics and State Policies in Renewable Energy Development

Although Bayulgen and Ladewig (2017) argue that landscape factors affect RE development, examples being natural endowments—including but not limited to a country's hydrocarbon and non-hydrocarbon resource endowments—land area, length of coastline, river systems, exposure to sun radiation, along with national wealth, industrial and technological capacities, and international energy prices, mere possession of such natural endowments or wealth and benefitting from favorable technological factors by no means guarantee RE development in a country.

Additionally, there exists a near consensus among RE academics and policy communities regarding the critical role of state policy in RE development (Bayulgen & Ladewig, 2017; Cadoret & Padovano, 2016; Edenhofer et al., 2011; Gavin, 2020; IEA, 2020; Murdock et al., 2018; Murdock et al., 2020; Stokes, 2020).[4] Engagement and interaction between four key groups of actors—governments, investors, producers, and end-users—also influence RE development (Murdock et al., 2018). The first of these groups, governments, and hence politics and policies, is of interest in the current study.

[3] It is important to acknowledge that a single factor such as a country's level of hydrocarbon-richness or democracy is unable to explain why a substantial variance in RE investment and development exists among countries. A wide range of economic, social, and political factors such as geography, income per capita, fossil fuel prices, natural resource endowment, corruption, quality of governance, industrialization, energy intensity, energy dependency, population, urbanization, and public opinion are believed to be influential on RE development.

[4] For example, IEA (2020) reported that expiry of a number of critical RE policies and consequent policy uncertainties particularly in US, China, India, and Latin America would most likely result in a drop in RE capacity addition in 2022.

Governments influence RE development through policies, rules and regulations that can support or hinder renewables. Adoption of environmental policies such as climate mitigation—such as fossil fuel phase-out policies, greenhouse gas reduction policies, 'net zero' commitments, carbon pricing, and emission trading—pollution mitigation, and energy security policies, along with specific RE policy instruments, has contributed to an increase in RE penetration, especially in the power generation sector. Effective government policies play a critical role in tackling the economic, technical and institutional barriers to RE development by contributing to cost reduction, market creation, investment risk mitigation, and technology development, which increases the competitiveness of RE technologies (Murdock et al., 2018; Murdock et al., 2020). They also provide a more stable environment for future investment in renewables.

Nevertheless, investment in RE still faces political, regulatory and policy barriers (Gavin, 2020). Promoting RE often turns into a political debate. Governments decide to finance or facilitate the financing of RE projects through policy in response to political factors (Cadoret & Padovano, 2016). Bayulgen and Ladewig (2017) argue that policy support for RE transition is not only an economic choice, but also a social and political choice involving the interplay between the winners and losers of RE policies. For example, under the Trump administration, the US Federal Energy Regulatory Commission basically tilted the energy market in favor of more costly and environmentally harmful coal (Stokes, 2020). Another example is the sizeable fossil fuel subsidies in many hydrocarbon-rich countries. It is apparent that despite the economic feasibility of RE alternatives compared to fossil fuels, political factors still can be decisive in promoting the latter.

Policy support for renewables includes institutional creation and strategic planning to promote RE investment and development. It can be direct, such as through mandates, financial incentives, and production and capacity targets, or indirect through facilitation of effective operating conditions and the integration of renewables and enabling technologies into energy systems and markets (Murdock et al., 2020).[5] RE policies can be adopted at

[5] One of the most comprehensive classifications of RE policies is provided by the International Energy Agency (IEA) in cooperation with International Renewable Energy Agency (IRENA) (IEA, 2023). It classifies RE policies and measures into seven aggregate policy measures and several subcategories or policy instruments. The seven aggregate policy measures are: i) fiscal and financial, ii) market-based, iii) direct investment, iv) policy support,

various levels of governance: municipal, state/provincial, national, regional and international.

1.2. Gaps in the Literature

The relationship between democracy and environmental outcomes is well-established. Research has consistently shown that democracy tends to have a positive impact on various environmental outcomes, contributing to a cleaner and more sustainable environment. Numerous empirical and theoretical studies in the fields of economics and political science have investigated international environmental agreements, the passing of environmental and climate legislation and regulations, environmental policy stringency, and environmental and climate policy outcomes such as greenhouse gas emission reductions, clean air, alleviation of environmental degradation, water sanitation, and clean energy transition measures. Over the past few decades, the literature on environmental policy outcomes and performance has mostly focused on the relationship between democracy and physical environmental performance measures such as air and water pollution and greenhouse gas emissions. There appear to be gaps in the literature regarding the impact of democracy on green energy transitions.

Dasgupta and De Cian's (2018) comprehensive review of the literature on political institutions and environmental policy outputs and outcomes revealed that investigations into the links between democracies and green investment and development[6] such as RE investment and development are sparse and limited. Several studies have explored the factors that contribute to the adoption of RE, but most of them cover only a small number of

v) regulatory, vi) information and education, and vii) research development and deployment (RD&D). Some of these aggregate measures contain specific policy instruments. The fiscal and financial category includes fiscal and financial incentives such as Feed-In Tariff (FIT), grants and subsidies, loans, taxes, and tax reductions. Greenhouse gas allowances and green certificates are the two main market-based instruments. Direct investment in renewables is broken down into infrastructure investments and funds to subnational governments. Regulatory instruments include codes and standards, obligation schemes such as renewable portfolio standards, and other mandatory requirements.

[6] It is worth noting that the link between democracy and RE development is not a one-way causal pathway. For example, the literature of energy democracy elaborates on the link between the mostly decentralizing nature of RE systems and reinforcement of democracy and public participation.

countries and have limited sample sizes (Apergis & Payne, 2010; Pfeiffer & Mulder, 2013; Sadorsky, 2009; Salim & Rafiq, 2012; Uzar, 2020). Bayer and Urpelainen (2016) examined the effect of democracy on the adoption of a specific type of RE policy, the feed-in tariff (FIT), and Cadoret and Padovano (2016) investigated the effect of right/left politics and governance quality on the share of renewables in the energy mix in EU countries. Researchers with a broader scope, such as Bayulgen and Ladewig (2017) and Sequeira and Santos (2018), investigated only the effects of political constraints and regime types on the share of renewables in a relatively larger sample of countries. Overall, there is a lack of adequate scholarship on the link between democracy and RE development.

In the context of this study, hydrocarbon richness is defined as the level of hydrocarbon resource production in a country relative to the domestic consumption of the three major hydrocarbon resources: crude oil, coal, and natural gas. Hydrocarbon-rich countries generally have high levels of fossil fuel dependency, with a small number of them accounting for the majority of the world's fossil fuel production and consumption.[7] Furthermore, a country's hydrocarbon richness often leads to governmental overreliance on hydrocarbon resource revenues—also known as state hydrocarbon rents—with the detrimental political and economic consequences that are commonly known as the 'resource curse'. Although the theoretical foundations of the political and economic resource curse are quite strong, and the empirical evidence for the causal links is robust, the theoretical and empirical literature on the resource curse and RE outcomes is scarce and nascent. Only a small number of studies (Ahmad et al., 2020; Badeeb et al., 2020; Baloch et al., 2019; Balsalobre-Lorente et al., 2018; Bekun et al., 2019; Cooper et al., 2018) have looked beyond the typical resource curse consequences and investigated the links between natural resources and a broader range of public policy outputs and outcomes, such as those of environmental and climate policies. Among these, perhaps only Cooper et al. (2018) employed a robust conceptual framework and a sufficiently sophisticated empirical model to test its hypotheses. It seems that scholarly effort has not been rigorous enough to bridge the gap

[7] The US, China, Russia, Brazil, Iran and Mexico account for almost half of the global crude oil consumption according to Petroleum (2020). Similarly, a group of countries consisting of the US, China, Russia, Iran, Saudi Arabia, and Mexico burns around half of the world's natural gas, while China accounts for about half of the coal the world consumes each year.

between the empirical resource curse literature and environmental policy outputs and outcomes—within the context of the environmental politics literature. This is the case despite the two bodies of literature sharing several key concepts and components in their conceptual/theoretical frameworks, namely, quality of government, corruption, political regime (democracy), income, population, and state hydrocarbon rents.

1.3. Research Questions and Key Contributions

This study disentangles and investigates the complex web of interrelationships and causal links between democracy, hydrocarbon resources, and RE development. It also thoroughly elaborates and empirically examines how several causal pathways impact environmental policy outputs and outcomes. In summary, the key research questions of this study are:

- Are more democratic political systems more conducive to RE development?
- Is the effect of democracy on RE development, conditional on institutional qualities such as corruption, rule of law, and quality of government?
- Does a country's level of hydrocarbon richness affect its RE development?
- Does a country's state hydrocarbon rent impact its RE development?
- Are the effects of hydrocarbon richness and state hydrocarbon rents on RE development conditional on the level of democracy or institutional qualities?

This study makes five substantial contributions to the empirical literature of environmental politics, much of which is limited to environmental and climate policy outputs and outcomes such as GHG emissions, environmental degradation, and environmental commitments. First, it specifically investigated RE development. Second, it has gone beyond using a single aggregate measure of democracy to compare and contrast the effects of various dimensions and qualities of democracy on RE development. Third, it distinguishes between hydrocarbon richness and state hydrocarbon rents, and it has included both variables to capture different aspects of hydrocarbon wealth in a country: hydrocarbon richness is used as a measure of the relative size and importance of hydrocarbon sector in a country, and state hydrocarbon rent is used to capture the relative importance of hydrocarbon revenues to the country's state. Fourth, this study seems to be the only investigation into the effect of the key independent variables on RE development that constructs and includes country-level measures of RE potentials and vulnerability to climate risk. Fifth, this study is part of a growing body of empirical literature on environmental politics that employs the 'linear mixed model', and 'within-between' estimations. The within-between estimations produced extra material for causal inference, and hence generated additional information and insight.

1.4. Scope of Study

This thesis contributes to the literature within the positivist worldview. This worldview is characterized by examining the validity of a theory through measurement and empirical work (Dasgupta & De Cian, 2016, 2018). Positivism centers on the determinism of causality and the critical role of evidence and data in creating knowledge (Phillips et al., 2000). This study examines the relationships between democracy, hydrocarbon richness and state hydrocarbon rent and RE, from a political economy perspective. It adopted a mixed-methods approach that includes a quantitative analysis in the form of a regression analysis and a qualitative analysis in the form of illustrative case studies. The regression analysis employed linear mixed models (LMM) and within-between estimation, which is a relatively novel and very capable panel data specification. By introducing a new measure of hydrocarbon richness and by using existing measures of the various dimensions of democracy, state hydrocarbon rents, and several other key political, social, and economic factors, the regression analysis investigated the effects of these variables and their likely interactions on RE development measured as the share of wind and solar energy in a country's electricity mix. The qualitative part of the study included case studies of Algeria, Morocco, and Tunisia to examine in depth the proposed causal mechanisms through which the independent variables of interest affected RE development.

1.5. Outline and Structure of the Thesis

This empirical study is organized into 10 chapters, including this introduction. Chapters 2 and 3 provide thorough reviews of the literature on democracy and its environmental policy outputs and outcomes and on resource curse and its environmental policy outputs and outcomes. The division of the literature review into two separate chapters is primarily driven by the core rationale that the key research questions addressed in this study are closely intertwined with two distinct bodies of literature, seemingly disparate at first glance. By adopting this approach, the study effectively delves into the interconnectedness of these fields and sheds light on their relevance to this study. These literature review chapters play a pivotal role in establishing the underpinnings of the theoretical frameworks of this study, offering a solid groundwork for the subsequent analysis and contributing to a comprehensive and well-rounded exploration of the research hypotheses.

Chapter 4, the theoretical framework chapter, proposes causal pathways from democracy, hydrocarbon richness, and state hydrocarbon rent to RE development. Chapter 5, the methodology chapter, elaborates the mixed-methods approach of using both quantitative and qualitative analyses in this study. Chapter 6 reports on the data and regression models that are used in this study. The results of the quantitative analysis are presented and discussed in Chapter 7 (the simple linear mixed model estimation) and Chapter 8 (the within-between estimation). The case studies of Algeria, Morocco, and Tunisia, which constitute the qualitative part of this thesis, are discussed in Chapter 9. The final chapter, Chapter 10, concludes the thesis with a discussion of the key findings, policy implications, and suggestions for future research.

2. Literature Review—Part One: Democracy and Environmental Policy Outcomes

This study's literature review has two main parts. The first part, this chapter, examines the connection between democracy and the results of environmental policies. It starts by discussing the theories that link democracy with the outcomes of environmental policies. Then, it provides an overview of the existing empirical research that deals with this connection. The review also looks at the limitations of the current empirical research and suggests potential areas where new research can make contributions. Importantly, this study aims to address some of the shortcomings found in the reviewed literature.

Furthermore, the arguments presented in this chapter play a crucial role in establishing the theoretical framework of the study. These arguments, which both support and, in some cases, challenge the idea of a positive link between democracy and environmental policy outcomes, serve as building blocks of the theoretical framework of this study.

2.1. Introduction

The theoretical arguments for the link between democracy and environment, as Dasgupta and De Cian (2016, 2018) notes, are mostly based on the assumption that environmental protection is of a public good nature. Private agents have no incentive to price in negative externalities resulting from their economic activities (Stavins, 2004). The goal of any environmental and climate policy is environmental quality and a cleaner environment that are to a large extent public goods (Bayer & Urpelainen, 2016; Farzin & Bond, 2006; von Stein, 2020; Winslow, 2005). Most environmental public goods cannot be traded in the market (Winslow, 2005) and in most cases the capital, infrastructure, and more importantly coordination required to procure them are beyond the capacity of individuals and private players alone (Farzin & Bond, 2006). When it comes to environmental quality improvement, clean energy transition, and climate mitigation, the role of the state and state policy cannot be more pivotal. That a government decides to develop and implement an environmental policy is to a great extent a political and economic question, in that allocation of public resources to policies depends on the political dynamics between those that benefit from such policies and those that have something to lose (Bayulgen & Ladewig, 2017). The fossil fuel sector—either in the form of multinational oil, gas, and coal corporations or national fossil fuel companies—utility companies, car manufacturers, heavy industries such as mining companies and metal producers, and communities and constituencies that are heavily dependent on these industries are those that would bear most the costs of environmental and climate policies and regulations (Lamb & Minx, 2020). Therefore, a government's environmental intervention would ultimately be in the form of policies that are influenced by several societal, political, and economic factors that have political, social, and economic consequences (Dasgupta & De Cian, 2018).

In the past few decades, a body of the literature on democracy and the environment, or to be more specific environmental policy outputs and outcomes, has grown rapidly. The key common research questions in the literature are if and how the level, form, or qualities of democracy affects environmental policy outputs and outcomes (Dasgupta & De Cian, 2016, 2018). Cao et al. (2013) contends that a proper investigation of the impact of democracy, on environmental policy outputs and outcomes should include a theoretical framework and empirical investigation. The theoretical work should elaborate why some factors are expected to influence environmental policy outputs and outcomes. The empirical work should investigate if there is any empirical support for the theoretical propositions. Causal relationship between democracy and environmental policy outputs and outcomes is investigated usually through running reduced-form models specified based on a number of hypotheses drawn from a theoretical or conceptual framework (Dasgupta & De Cian, 2016, 2018).

In summary, as we will see in the following sections, a large part of the literature on democracy and environmental policy outputs and outcomes supports a positive link between democracy and environmental policy outputs and outcomes. An extensive review of the empirical literature by Dasgupta and De Cian (2018) on democracy as a key determinant of a country's environmental policy outputs and outcome reports that greater democracy and democratic capital, and more civil liberties generally results in provision of more environmental public goods. A closer look, however, reveals that democracies might not always be performing significantly better than their nondemocratic rivals (Wurster, 2011).[8]

In this part of the literature review, first the distinction between environmental policy outputs and outcomes is elaborated. Then, arguments in support of a positive association between democracy and environmental policy outputs and outcomes is reviewed. It is then followed by several caveats concerning the robustness of some of the arguments. Next, a few studies that examine variation in environmental policy outputs and outcomes in different forms of democracies and non-democracies are presented. Also, a few other key determinants of environmental policy outputs and outcomes are discussed. It is then followed by a review of the outcome of empirical works on democracy and environmental policy outcomes.

2.2. Environmental Policy Outputs vs. Environmental Policy Outcomes

Provision of environmental public goods refers to either environmental policy outputs or outcomes. Environmental policy outputs consist of environmental and climate rules, regulations, and commitments, while environmental policy outcomes are defined as the consequences—either favorable, unfavorable, intended, or unintended—of adopting and implementing those rules, regulations, and commitments. Theoretical and empirical studies investigating the effect of democracy on provision of environmental public goods can be classified, based on this distinction (Lamb & Minx, 2020; Li & Reuveny, 2006). One group examines the effect of democracy on environmental policy outputs such as joining international environmental agreements, passing environmental and climate legislation and regulations and environmental policy stringency. The second group focuses on environmental and climate policy outcomes such as reduction in greenhouse gas emissions, clean air, alleviating environmental degradation, water sanitation, and very rarely green and

[8] For example, Mathews (1995) claims that the nature of environmental concerns is against the foundations of liberal democracy, that are civil liberties, autonomy, and free markets.

clean energy transition measures—e.g., RE transitions and development. There is a third group that investigates the effect of democracy on both environmental policy outputs and outcomes.

Reporting a weak or ambiguous link between democracy and environmental policy outcomes in the literature, Neumayer (2002) and Fredriksson and Neumayer (2013) argue that focusing on environmental policy outcomes could be misleading as democracy or basically any political system needs time to produce a meaningful effect on environmental policy outcomes such as soil degradation or greenhouse gas emissions. As Bättig and Bernauer (2009) puts it, in democracies, the causal chain from environmental problems and concerns to environmental awareness and public demand for action and consequent policy outputs is much shorter than the one that also includes tangible environmental policy outcomes. Furthermore, there are other key drivers than state policies at play—such as a country's level of economic development, wealth and industrialization—when it comes to a country's environmental performance (Bättig & Bernauer, 2009; Neumayer, 2002). Neumayer (2002) argues that a strong link between democracy and environmental policy outputs is expected due to democratic systems' greater involvement in environmental and climate mitigation policy discourse. Neumayer (2002) argues that environmental commitments in democracies are stronger because in democracies people have more freedom to express their environmental concerns, and officeholders and policymakers would pay more attention to such concerns. Such commitments however would not necessarily translate into better environmental outcomes immediately. Fredriksson and Neumayer (2013) and Ward and Cao (2012) contend that environmental policy outputs are more useful and informative dependent variables than policy outcomes for the empirical study of democracy and the environment.

Though using policy outputs might result in a more clear distinction between different political systems (Cao & Ward, 2015), international and domestic policy commitments can be undemanding, and as Li and Reuveny (2006) put it, can include "cheap talk" and paying lip service to environmental causes merely to appease environmental interest groups. Adoption of environmental and climate policies does not necessarily mean such policies would be implemented efficiently and effectively. International negotiations and bargaining may result in policies and decisions unsuitable for a particular country (Li & Reuveny, 2006). Furthermore, domestic environmental policies may not go beyond political symbolism or be properly implemented (Cao & Ward, 2015). Bayulgen and Ladewig (2017) contend that including policy outcomes in empirical studies indeed provides a more stringent test for the hypothesized causal link between democracy and environmental outcomes, as policy outcomes are also influenced by several other factors. A better solution, however, is not replacing policy outcomes with policy outputs, but properly controlling for and capturing the partial effect of other key drivers of policy outcomes in empirical models (Bayulgen & Ladewig, 2017). Furthermore, in response to critiques of using policy outcomes such as the level of pollution or water sanitation, Murdoch and Sandler (1997) proposes using variables that measure changes in such policy outcomes. Bättig and Bernauer (2009) are critical of the literature that focuses on either policy outputs or outcomes and recommends inclusion of both environmental policy outputs and outcomes in any empirical study.

2.3. Arguments for Positive Link between Democracy and Environmental Policy Outcomes

Some prominent conservationist and green scholars of 1960s and 1970s were quite critical of democracy as the best political system for addressing environmental problems (Ehrlich et al., 1971; Hardin, 1968; Heilbroner, 1974). However, the poor environmental performance of almost all communist regimes and many military dictatorships in Latin America, Africa, and Asia that became evident in late 20th century, encouraged scholars to reexamine the link between democratic systems and environmental outcomes (Midlarsky, 1998; Payne, 1995; Pellegrini & Gerlagh, 2006). Since the 1980s, numerous studies in the areas of economics and political science have contributed to what is now a rich literature of environmental politics and environmental political economy. In this line of research, democracy, income (economic development), and population are three key determinants of environmental performance, along with a host of other important control variables. Arguments in favor of a positive impact of democracy on environmental policy outputs and outcomes abound. A higher level of political rights, civil liberties, freedom of information, freedom of expression, electoral accountability, political contestability, political inclusiveness, political participation, and respect for rule of law, along with maximizing the utility of the median voter, longer time horizon, more meaningful international collaboration and involvement among democracies and more recently distinct dimensions of democracy such as deliberation, egalitarianism, and participation are elaborated as reasons why democratic systems are expected to perform better than nondemocracies when it comes to environmental policy outputs and outcomes.

2.3.1. Freedom Inclusiveness and Contestation

Young (2000) mentions inclusiveness and participation as two key democratic norms and argues that the normative legitimacy of a democratic decision is determined by how much those impacted by it have been involved in the decision-making processes and given the chance to shape the results. Inclusiveness and contestation are also the two most relevant dimensions of a democratic system, according to Dahl (1989). Inclusiveness denotes the proportion of a society able to involve itself in public policy debates or as Dahl (1989) puts it "controlling and contesting the conduct of the government." Contestation refers to citizens' freedom to express, publicize and more importantly debate their various preferences in the public arena (Böhmelt et al., 2016; Dahl, 1989). Democratic qualities such as political rights, freedom of information, and freedom of expression makes democracies more inclusive than autocracies. Long-term environmental sustainability indeed requires extensive involvement of the citizens in policy debates (Böhmelt et al., 2016). Furthermore, more participation of the citizens in policy debates virtually means more voices would be heard. Theoretically, contestability, along with higher levels of political constraint in democracies (von Stein, 2020), put a limit on state or special interest groups' capacity to shape and promote policy narratives unilaterally.[9]

[9] Nevertheless, one needs to acknowledge that the risk of disinformation campaigns by established or rich interest groups and political players, affecting policy narratives, always exists in any political system including democratic ones.

In democracies, political and individual rights along with freedom of press, speech and association could help turn a society's environmental concerns into effective environmental legislation (Gemmill & Bamidele-Izu, 2002; Midlarsky, 1998; Payne, 1995; von Stein, 2020). Information flows more freely, and political and individual rights are better guarded in democracies than in autocracies (Li & Reuveny, 2006). This allows environmental interest groups to inform the public of environmental issues more effectively and efficiently (Li & Reuveny, 2006; McBeath & Rosenberg, 2006). Such groups, in the form of environmental NGOs, have a stronger presence in democracies mostly due to civil society protections (Sonnenfeld & Taylor, 2018; von Stein, 2020; Winslow, 2005). Also, free flow of information increases a society's learning capacity. For example, it is argued that in democratic systems, scientific views can be more freely discussed and shared with the public (McBeath & Rosenberg, 2006; Midlarsky, 1998; von Stein, 2020). The information provided by environmental interest groups regarding environmental problems and concerns frequently can play a major role in shaping public opinion on the environment (Midlarsky, 1998; Payne, 1995). Concerned citizens of democratic systems in turn can influence policy through a variety of channels such as civil litigation, pressure groups, social movements and ballot box (Ward, 2008; Winslow, 2005). This consequently can result in more effective environmental legislation. Overall, political rights and civil liberties along with freedom of information, speech and press allow citizens of a democratic society, to have more awareness regarding environmental problems, to better express their concerns in public arena, and to put more pressure on politicians and policymakers for real environmental actions (Escher & Walter-Rogg, 2018; Neumayer, 2002). Further involvement of the public increases the chances of environmental problems being identified and addressed (Winslow, 2005).

This virtuous cycle is relatively weak or absent in nondemocratic systems. In such systems, the government inhibits free flow of information, organization of interests and NGO activities and do their best to isolate those interests from people's preferences (Li & Reuveny, 2006; McBeath & Rosenberg, 2006; Neumayer, 2002; Payne, 1995). The environmental concerns that conflict with state development plans could be easily suppressed and censored (Neumayer, 2002). Also, in non-democracies, the decision making is more autonomous than in democracies (Li & Reuveny, 2006). Therefore, environmental issues, concentrated in geographical areas populated by powerless or ordinary citizens, could be easily disregarded (Chadwick, 1995; Neumayer, 2002). The bottom line is that in non-democracies, it is less likely that the public becomes fully aware of environmental problems, that awareness transforms into people's concerns, and that those concerns and preferences have a chance to shape public policies and yield meaningful policy outcomes.

2.3.2. Political Competition Political Representation and Electoral Accountability

A second set of arguments in favor of democracy is that political competition and electoral accountability in democracies generally force leaders to listen to the public. Leaders are incentivized to constantly look for better policy options and penalized for not doing so (Wurster, 2011). The electoral accountability mainly arises from the practice of free and fair election and/or reelection concerns of officeholders in democracies (McBeath & Rosenberg, 2006; Midlarsky, 1998; Payne, 1995). Political competition can force the incumbent to adopt more stringent environmental policies to avoid losing the electorate votes, especially where environmental concerns are of high priority for the society (Wilson & Damania, 2005). Political competition for the electorate's vote, as Wilson and Damania (2005) shows through a game theory model, raise the costs of adopting suboptimal environmental policies. Electoral accountability makes democratic systems more responsive than non-democracies to environmental needs of the society (Kotov & Nikitina, 1995; McBeath & Rosenberg, 2006; Midlarsky, 1998; Payne, 1995; von Stein, 2020; Winslow, 2005). Electoral accountability also makes it less likely for leaders to personally benefit from activities that yields further environmental degradation (Winslow, 2005). Leaders in democracies are much more constrained by interests and preferences of parties and political actors outside of power—preferences and interests usually not consistent with the incumbent's optimal rent seeking position (Ward et al., 2014). In democracies, groups with various agendas or preferences have a chance to influence public policies through social mobilization and political representation (Li & Reuveny, 2006). Political representation is achieved through regular, free and fair elections, which are widespread in democracies. Non-democracies hold a lower level of accountability to the public opinion, since free and fair elections are rare or non-existent and political power is concentrated in a few hands (Li & Reuveny, 2006). Therefore, groups with environmental preferences or agendas have a better chance to gain political power or be heard in democratic societies. Due to a lower level of bottom-up accountability and political participation than democracies, autocracies are expected to perform worse on environmental policy issues (Kneuer, 2012).

2.3.3. Institutional and Ideational Features of Democracy

Respect for the rule of law and human life are stated as features of democracy that lead to a better environmental performance (Gleditsch & Sverdrup, 2002; Li & Reuveny, 2006). Gleditsch and Sverdrup (2002) argues that democracies are more responsive to hazardous environmental problems because they hold a higher regard for human life. Also, respect for the rule of law is believed to be stronger and more prevalent in democracies. Therefore, democratic systems are expected to comply more with environmental agreements (Li & Reuveny, 2006). Ward (2008) and Congleton (1992) also argue that nondemocratic systems generally focus more on economic growth to improve their legitimacy and boost their national security. Such overemphasis on material growth inevitably has detrimental impacts on the environment. Furthermore, non-democracies usually have less institutional stability than democracies especially when it comes to power transition. Such instability and rupture can impair environmental policies (Wurster, 2011).

It is also argued that among democracies, political learning due to mutual identification and tendency toward international cooperation leads to more meaningful involvement in international environmental efforts (Midlarsky, 1998; Payne, 1995; Winslow, 2005). Democracies in the context of international institutions could identify with each other and learn from each other’s experience more effortlessly (Midlarsky, 1998). Here, the arguments are similar to the ones explaining the rarity of war between democracies. Repeated and smooth interactions between democracies, dealing with common environmental problems, could increase the chances of finding common solutions to those common problems through sharing information, technologies, and knowhow (Midlarsky, 1998; Winslow, 2005)[10]. Furthermore, Midlarsky (1998) claims that international environmental groups in general have had more success in influencing environmental policy outputs and outcomes in democracies than in non-democracies.

2.3.4. Elites vs. Median Voter

One of the key arguments in favor of democracy is centered around the concept of elites in non-democracies versus the median voter in democratic systems. Congleton (1992) explains that, in a utility maximization setting, democratic and non-democratic decision-making processes are fundamentally similar in terms of maximizing the welfare of a single pivotal individual given several political and economic constraints. That single individual in a non-democracy is the dictator, ruler, or the pivotal member of the elite. In democracies the equivalent of that single individual is called the median voter. The difference between the optimal outcomes of the utility maximization function in the two contexts is merely the result of different single pivotal individual they hypothetically serve (Congleton, 1992). Elites in non-democracies generally control a larger share of the national economy than ordinary citizens in a democratic system (Li & Reuveny, 2006) while at the same time have a disproportionately bigger say in policy setting. On the other hand, given current production technologies and raw material consumption patterns, environmental policies and laws are expected to put some forms of restriction on production and consumption in a national economy. Consequently, elites in non-democracies incur disproportionately higher opportunity costs associated with such restrictive policies and regulations (Bättig & Bernauer, 2009; Congleton, 1992; Li & Reuveny, 2006; Ward, 2008). Therefore, they are expected to be less pro-environment than ordinary citizens in democracies even if the pivotal member of the elite is greener—in terms of personal preferences—than the median voter in a democracy (Bättig & Bernauer, 2009; Congleton, 1992; Li & Reuveny, 2006). Actually, in most societies the elite disproportionately profit from economic activities that

[10] It is also argued that international cooperation can also be a function of geographical proximity or various forms of network membership (Cao et al., 2013).

are usually harmful to the environment while the environmental costs are spread among all citizens (Winslow, 2005). McGuire and Olson (1996) argues that in non-democracies, as the size of elite—which could be considered a measure of democracy (Pellegrini & Gerlagh, 2006)—increases, more environmental policy outputs and outcomes are produced. Similarly, the Selectorate theory (Bueno de Mesquita et al., 2003), predicts that political systems with a small size of winning coalition do not particularly benefit from provision of environmental public goods for survival while have a clear incentive to offer private benefits to the elite mostly through exclusive opportunities for further exploitation of national economy. Such exploitations would most likely lead to further environmental degradation.

Bättig and Bernauer (2009) presents further arguments in support of the idea that the median voter in democracies has greener preferences than the median elite member in non-democracies. First democracies are on average richer and there's a positive correlation between income level and political participation in democracies. The median voter could be as rich or richer than the median elite member in an autocracy.[11] Therefore, assuming environmental public goods are normal goods, on average there's a higher demand for such goods in democracies. Bättig and Bernauer (2009) also argues that the median elite member in a non-democracy enjoys more political influence and has more and better options than the median voter or average citizens in a democracy, to insulate themselves from negative effects of environmental degradation. For example, they can relocate to less polluted regions or leave the country or buy themselves out of the exposure to various aspects of environmental degradation (Fredriksson & Neumayer, 2013). The availability of such options to the elite dampens the demand for environmental public goods in autocracies. Bättig and Bernauer (2009) concludes that demand for environmental public goods is at least as strong or most likely stronger in democracies than autocracies, plus democracies are expected to provide more of them at any given level of public demand.

[11] Bättig and Bernauer (2009) present this as a counter argument against the idea that the median elite member in a non-democracy is wealthier and better educated than the median voter in a democracy. On one hand, the fact that the elite hold a large share of the economy makes them less friendly towards stricter environmental policies that usually put a limit on economic activities. On the other hand, a higher income level is expected to increase the demand for environmental public goods. Therefore, the net effect, as Congleton (1992) argues, is at least theoretically ambiguous.

2.3.5. Longer Time Horizon

This argument is based on the assumptions that environmental problems develop slowly, and democratic leaders generally have a longer time horizon that their nondemocratic peers—though it doesn't necessarily imply that all democratic systems have a longer time horizon than their non-democratic peers. It also presumes that people in democracies have much less to lose than the elite in non-democracies if the regime collapses (Li & Reuveny, 2006). Congleton (1992) explains that in non-democracies elites try to prolong the regime they benefit from through diversion of more resources to oppression. If overthrow of the regime is eminent, the elite will try to maximize their consumption and economic exploitation. Both scenarios, as Congleton (1992) argues, result in a shorter time horizon of the regime. It creates a vicious cycle in which inevitable diversion of resources from environmental causes to oppression and further economic exploitation only worsen environmental degradation. The elite basically ignore long-term environmental damages and interests of future generations (Congleton, 1992; Li & Reuveny, 2006; Ward, 2008). Overall, Congleton (1992) predicts a better environmental performance for democracies due to a longer time horizon.

2.4. Democracy and Environmental Policy Outputs and Outcomes: Several Caveats

While theoretical support for a positive link between democracy and environmental policy outputs and outcomes has been generally strong in the literature, several past and recent studies cast doubt on such association. Green scholars of 1960s and 1970s such as Hardin (1968) and Heilbroner (1974) cast doubt on the capacity of liberal democracy to address environmental degradation of that era. Defining features of liberal democracy such as political and individual rights and free market were criticized as drivers of further environmental degradation, mostly in Western democracies (Midlarsky, 1998). Winslow (2005) argues even if we presume that democracies perform better in mitigation of environmental issues with immediate and clear effects on a large portion of the population, there would be no guarantee that environmental problems with long-term, incremental, and somehow uncertain impact on future generations or smaller disenfranchised communities within a society would be addressed more decisively in a democratic system. As recently as today, the environmental performance of liberal democracies has been criticized for its close ties with private interest groups and it short-termism (Böhmelt et al., 2016). Some scholars even have gone one step further and give support to a Hobbesian approach to environmental problems—i.e. giving the state and its technocracy absolute power to unilaterally make quite hard environmental decisions that create winners and losers (Pellegrini & Gerlagh, 2006). A new breed of scholars (Beeson, 2010, 2018; Gilley, 2012; Shearman & Smith, 2007) have coined a new concept called 'eco-authoritarianism', or 'authoritarian environmentalism'. This concept has recently gained support mainly due to China's decisive environmental actions in the past decade (von Stein, 2020).[12] Overall, there are a number of arguments casting doubt on robust and positive association between democracy and environmental performance.

Li and Reuveny (2006) and Neumayer (2002) explain that an autocratic system might be more effective in battling environmental problems and adopting decisive environmental policies simply because it does not need to be as accountable to the public will and respectful of its citizens' civil and political rights as a democratic system is typically mandated to do. Bättig and Bernauer (2009) discuss how democracies struggle to curtail emission from transportation through putting restriction on a fundamental form of personal freedom, the mobility rights. von Stein (2020) argues that the mere existence of electoral accountability does not guarantee better environmental performance. For it to be effective, the public has to be aware of environmental challenges, demand change, and make that demand electorally critical (von Stein, 2020). More importantly, provision of environmental public goods also may depend on how much and in what ways it contributes to distribution

[12] Another fringe green political theory stand, called eco-radicalism or radical environmentalism, exists that mostly disregards democracy and primarily focuses on environmental outcomes (Iwińska et al., 2019). it mainly argues that under capitalism the imperatives for ecological destruction overwhelm existing democratic processes.

or redistribution of economic benefits to important and pivotal constituencies (Bayer & Urpelainen, 2016).[13]

While environmental problems are mostly of a global nature, any political system including democracies, deals with them as local or national problems (Paehlke, 1996). They, therefore, may not be addressed in a timely manner even in a democratic system (Li & Reuveny, 2006). Midlarsky (1998) brings up the case of acidification of lakes in Sweden as a result of British industrial activities to show how some forms of environmental degradation can be externalized upon future generations or citizens of other polities. This example also illustrates the challenge of internalizing the spillover of environmental problems even among democracies.

The prevalence of capitalist interest groups and the market economy especially in the context of liberal democracies, as Dryzek (1987) argues, makes it harder for environmental groups to have a voice in policy setting. The problem arises when leaders pay disproportionately more attention to business interest groups whose priority is not environmental concerns but profit maximization (Li & Reuveny, 2006; Povitkina, 2018). This is the result of business interest groups being better organized and funded and having better access to critical information (Dryzek, 1992; Eckersley, 1995). Midlarsky (1998) identifies corporatism as a major threat to democracy as a whole and discusses how it degrades a democracy's ability to respond to environmental challenges. Other scholars point to the presence of powerful lobbies and infrequent elections—associated with the most common form of democracy, the representative democracy—along with the unchecked power of markets and bureaucratic machine in democracies and argues that such political systems are incapable of handling long-term environmental challenges (Lafferty & Meadowcroft, 1996; Norgaard, 2006).

Moreover, in a democratic system, the leadership, for political survival, must attend to incompatible demands of various interest groups, competing for political influence. This

[13] Bayer and Urpelainen (2016) argues that the ultimate objective of a leader is political survival. When it comes to environmental policies, the incumbent adopts policies that yield electoral advantage and political support. The study reveals that feed-in Tariff (FIT) policies have advantage over other types of RE policies such as renewable portfolio standards (RPS) and are preferred by democratic governments simply because such policies promote rural development and redistribute electricity generation profits from large utilities to independent producers in rural areas. Policies such as RPS do not induce such favorable distributional effects for electorally pivotal constituencies.

could result in a policy gridlock, where environmental groups and other interest groups just can't accommodate each other's opposing preferences (Midlarsky, 1998). Environmental policies are expected to impact different interest groups differently (Lafferty & Meadowcroft, 1996; Midlarsky, 1998). In other words, usually there would be winners and losers when any new set of policies are implemented. Striking a delicate balance between all parties is not an easy feat. When quick and decisive decision-making is necessary, allowing all stakeholders to have a voice or participate in policy development and implementation by no means guarantee that an optimal outcome would be achieved in a timely manner (von Stein, 2020).[14] In such scenarios, especially when the required actions are unpopular[15], autocratic rulers, who do not usually feel under pressure and threatened by myopic voters and frequent and fair elections, might perform better (Bernauer & Koubi, 2009; von Stein, 2020). Democratic systems, which normally are more accountable to the public than nondemocratic ones, may become more reluctant to make hard decisions (Li & Reuveny, 2006).

Another argument against democracy revolves around an underlying feature of democracy, the separation of power. The separation of power, in the form of checks and balances, could actually compromise efficiency and effectiveness of decision making process in democracies, especially when unpopular reforms are necessary (Wurster, 2011). A higher number of institutional players in democracies, or as Tsebelis (2002) calls them, 'veto players', can result in protracted negotiations and outcomes that are not necessarily optimal (Scharpf, 2018; Wurster, 2011). Also, some scholars claim that short-termism is more prevalent in democracies and results in weaker commitment to long-term environmental solutions (Haggard & Kaufman, 1990; Keefer, 2007; Povitkina, 2018). Environmental problems require consistent and long-term policy development and implementation in a certain direction for an extended period of time. Democratic politicians, in pursuit of election and/or reelection, might focus on providing their constituencies with visible, tangible and quick outcomes than long-term solutions for environmental problems (Dryzek,

[14] Gilley (2012) discusses how restricting individual rights in the form of limiting driving to once per week in some Chinese cities helped alleviate air pollution.

[15] Citizens might have preferences that are environmentally harmful and leaving democratic leaders no choice but to follow suit (Jamieson, 2014).

1992; Eckersley, 1995; Povitkina, 2018). In other words, there is a tendency to discount any future benefits of environmental public goods (Bättig & Bernauer, 2009).

2.5. Going Beyond a Single Measure of Democracy

According to Robert A. Dahl, democracy is a political system where there is meaningful competition (contestation) among individuals and groups for political power, and all adult members of the political community have the right to participate in the decision-making process (inclusiveness), ensuring both a competitive and inclusive governance structure (Dahl, 1989). This definition is one of the most theoretically and conceptually coherent definitions of democracy. It clearly implies at least two essential dimensions or qualities required for a political system to be considered a democracy: contestation and inclusiveness. This study is part of a growing body of the empirical literature that advocates in favor of disentangling various dimensions and qualities of democracy. Since the 2000s empirical researchers have started moving away from employing a single measure of democracy and become more interested in various subcomponents, attributes, or as some call it, qualities of democracy (Giebler et al., 2018). The more nuanced theoretical frameworks ditch democracy as a single measure in favor of specific forms of democracy—e.g., presidential vs. parliamentary, unitary vs. federal, proportional representative vs. majoritarian—specific aspects, traits, or qualities of democracy—such as political rights, civil liberties, civil society, government accountability, political constraints, etc.—and more recently dimensions of democracy—electoral, liberal, deliberative, participatory, and egalitarian dimensions.

The underlying argument of this new breed of scholarship is that specific aspects, qualities, forms, or dimensions of democracy, and not a holistic measure of democracy, offer a better explanation for variation in environmental policy outputs or outcomes among countries. There are theoretical and practical reasons behind such shift. In some cases, theoretical grounding dictates using not democracy as a single aggregate measure, but specific qualities of democracy, such as civil liberties, civil society, division of power, political constraints (veto players), various forms of government accountabilities, etc. (Vaccaro, 2021). In other cases, where inclusion of various qualities of democracy is viable, using a single measure of democracy would only result in loss of complexity and information (Boese, 2019). A new breed of studies in environmental politics and environmental policy outputs and outcomes deliberately distinguish between dimensions and qualities of democracy when empirically investigating their effect on their variables of interest (Bayulgen & Ladewig, 2017; Escher & Walter-Rogg, 2018, 2020; Povitkina & Jagers, 2021; von Stein, 2020). Unless otherwise specified, dimensions of democracy in the context of this study refers to five principles of democracy (deliberative, participatory, liberal, and egalitarian democracy principles) defined and measured by the V-Dem project. These dimensions establish a basis upon which the effect of democracy on RE development are to be investigated. This study also follows the recent trend literature and empirically examines other so-called qualities of democracy such as accountability, civil liberties, political constraints, civil society, and federalism (division of power) (Appendix A further elaborates on measurement of democracy and its dimensions and qualities).

2.5.1. Forms of Democracy and Autocracy

The reliance on a single continuous measure to gauge the level of democracy or autocracy, have limitations in empirical political science. This oversimplification overlooks the intricacies of political systems. An example is the distinctive differences between presidential vs. parliamentary systems or federal vs. unitary forms of government in democracies, in terms of both governance and policy outputs and outcomes. Various ways of classifying political regimes exist, each carrying substantial implications for empirical research. The main objective of this section is to explore the diverse methods by which political systems can be categorized and empirically studied, recognizing the need for a broader perspective. In this section, the distinctions between majoritarian vs. proportional representation systems, presidential vs. parliamentary systems, federal vs. unitary systems and multi-part (consensus) vs. two-party systems, in terms of governance and environmental policy outcomes are elaborated.

According to Midlarsky (1998), the major challenge in developing a theoretical framework for democracy and the environment lies in the tendency to view democracy as a uniform concept without considering its various distinctions. Wurster (2013) contends that the simple binary classification of democracy versus autocracy is inadequate in explaining the outcomes related to environmental performance. In the past two decades, the environmental politics literature has grown much richer in its examination of different types or institutional aspects of democratic systems such as proportional representations versus majoritarianism (Cao et al., 2013).

In a majoritarian electoral system, a party that wins a district claims that district's seat(s). A proportional representation system allocates seats according to the proportion of votes won by parties. In a majoritarian system, votes in pivotal or swing districts matter most to rival parties and politicians. Persson and Tabellini (1999) asserts that majoritarian systems may focus more on local interests and welfare of a subset of the electorate. Politicians and parties in such systems usually pay more attention to environmental concerns of constituencies in pivotal districts and may be less incentivized to adopt more stringent environmental policies in response to environmental problems of national scope and scale (Fredriksson & Wollscheid, 2007). Another consequence of such dynamics is that it provides more leeway for special interest groups, including fossil fuel and heavy industry lobbies, to influence environmental and climate policies through manipulating political processes in those pivotal districts (Fredriksson & Wollscheid, 2007). In a proportional representation system, on the other hand, parties have no choice but to heed environmental and climate concerns of the whole electorate—of course if such concerns are deemed critical by the public— to maximize their share of votes and seats across all districts. Furthermore, Katz (2007) contends that proportional representation systems overall show a higher degree of coherence, ideological foundations, and discipline that makes them more responsive to change in voters' sentiments. This responsiveness, as Rey and Ozymy (2019) note, can be a counterbalance to the influence of special interest groups.

The differences between presidential and parliamentary political systems especially in terms of policy outcomes have also been the subject of numerous studies. Fredriksson and Millimet (2004) argue that higher separation of power in presidential-congressional systems and more legislative cohesion in parliamentary systems explain why taxes, including environmental taxes, are expected to be lower in presidential systems. While voters in both political systems prefer to put a constraint on environmental taxes and rents going to politicians, a higher level of separation of power in presidential-congressional systems allow powerful minority voters to punish parties and politicians more effectively (Fredriksson & Millimet, 2004; Fredriksson & Wollscheid, 2007). More checks and balances and the prevalent practice of logrolling[16] in presidential systems can result in environmental policy outputs serving mostly powerful minorities (Ward, 2008). A lower level of separation of power, in addition to higher level of legislative cohesion in parliamentary systems may lead to higher environmental or pollution taxation and higher redistribution (Fredriksson & Wollscheid, 2007). Constraints such as the vote of confidence requirement and also re-election concerns in parliamentary systems, encourage a stable pattern of party voting in a coalition and more importantly result in paying attention to preferences and concerns of the majority (Ward, 2008). McBeath and Rosenberg (2006) argue that parliamentary systems or systems other than those with dispersed authority systems—like presidential systems—are less likely to face conflicts between executive and legislature branches. This facilitates development and implementation of environmental policies. Separation of power, as McBeath and Rosenberg (2006) argue, brings delay, stalemate, and policy gridlock especially through policy adoption process. In the case of environment policy outcomes, however, Vogel (1993) claims in some situations the opposite is true. The author argues that presidential systems, because of higher separation of power, provide diffuse interests of the public with more places and opportunities to influence policy even if one branch of the government—e.g., the executive branch—ignore them.[17]

Lower rate of taxation in presidential systems usually translate into lower environmental public goods (Ward, 2008). The Selecrorate Theory (Bueno de Mesquita et al., 2003), however, argues the opposite. The theory tries to explain variation in provision of

[16] Logrolling refers to the practice of exchanging political favors among politicians—e.g., voting for each other's proposed legislation.

[17] Vogel (1993) further elaborates that leader in parliamentary systems are more likely to face scrutiny regarding commitments for collective goods such as environmental performance and repel pressures from concentrated interests such as those of heavy industries, only if they represent diffuse interests.

public goods through the size of the winning coalition. Since in the context of the Selectorate Theory, parliamentary systems are presumed to have a smaller winning coalition size, in general, than presidential ones, they are expected to procure a lower level of environmental public goods than presidential systems. It is also argued that presidential systems are expected to adopt and execute polices of national scope and scale better because the leaders in such systems are elected by a national constituency (Persson & Tabellini, 2002). The quite dominant consensus in the literature, however, is that democratic systems that incentivizes parties and politicians to pay adequate attention to a broader range of constituencies and their environmental concerns (proportional representation systems) and possess more effective legislative cohesion and capacity (parliamentary systems) are more likely to perform better when it comes to developing and implementing environmental policies (Lachapelle & Paterson, 2013).

Recent studies also have increasingly examined the differences in environmental policy development and implementation between multi-party and two-party political systems. A few studies show that consensus democracy, prevalent in multi-party democratic systems, generally have a positive effect on environmental policy outcomes (Lijphart, 2012; McGann & Latner, 2013). Strøm et al. (2008) contends that a single-party system is more susceptible to the influence of lobbies and special interest groups than multi-party systems because of lower transaction costs. A multi-party coalition is believed to be more responsive to changes in the public preferences (McGann & Latner, 2013). It seems, however, that there is not much consensus in the literature about how consensus democracy affects environmental policy outcomes. In this line of research, political constraint and veto player are also the integral parts of the explanation why environmental policy outputs and outcomes varies in different democratic systems. As per Tsebelis (2002), veto players are individuals or groups whose consent is required to alter the existing state of affairs. Veto players could be institutional actors and/or political parties (Bayulgen & Ladewig, 2017). Bayulgen and Ladewig (2017) claims that in a multi-party or consensus democracy, the existence of multiple veto players or gatekeepers only decreases the chance of adopting new policies, as a single veto player that prefers the status quote can derail any legislative efforts.

Finally, the degree of centralization of power in political systems has been a subject of debate as a factor that can help explain variations in policy outputs and outcomes. Democratic decentralization refers to the presence of democratically elected regional and local governments that have a certain level of freedom to form and implement policies for their jurisdiction (Escher & Walter-Rogg, 2020). McBeath and Rosenberg (2006) discusses the differences between unitary systems and federal systems especially when it comes to implementation of environmental policies. It is argued that unitary systems, where the national government is the only source of sovereignty, the state would less likely face serious challenges when implementing nationwide environmental policies. But some green political theorists claim that decentralization actually boosts citizens' participation in shaping and deliberation of local and regional policies which can improve environmental performance (Dryzek, 1992; Eckersley, 1995, 2004). Also, Burnell (2012) argues that distribution of power in federal systems makes public deliberation of alternative policy issues such as environmental problems more likely. The challenges federal systems face depends on the degree of decentralization and resources and capacity the federal government can utilize to enforce nationwide environmental policies throughout its subnational units. In federal systems such as those of US and Canada, as McBeath and Rosenberg (2006) notes, environmental interest groups and fossil fuel and heavy industry interest groups are free to push their causes at different levels of government and across various branches of it. It is obvious that a strong consensus does not exist in the literature regarding the effect of decentralization of power on environmental policy outputs and outcomes. McBeath and Rosenberg (2006) concludes that the effect of federalism on environmental policy outcomes should be examined in combination with other factors such as electoral institutions, political culture, and corporatist structure.

Lastly, it is important to note that the literature on nondemocracies and environmental performance and public goods is relatively sparse. Much of literature on democracy and the environment assumes a simple democracy-autocracy divide—either as a continuum or discreet measure (Ward et al., 2014). However, various types of autocracy such as monarchy, single-party, military, and personalist can differ from each other as much as they differ from democracies (Geddes, 1999). In most empirical studies, usually a single variable measures the level of democracy for all types of political system and the underlying assumption is that more or less similar dynamics exist in democracies and nondemocracies. This assumption can be misleading. For example, Ward et al. (2014) introduce the concept of environmental investment gap and shows that unlike in democracies, higher state capacity in nondemocracies leads to further environmental degradation. The underlying argument is that in nondemocracies, infrastructure and environmental investments both grow with state capacity but the former increases at a faster rate than the latter. Overall, what is obvious is that further and more thorough investigation is needed to shed light on the environmental policy dynamics at play in nondemocratic or less democratic systems (Ward et al., 2014).

2.5.2. Dimensions and Qualities of Democracy

There is no consensus in the literature on what aspects, traits, or qualities of democracy can explain better the link between democracy and environmental performance (Burnell, 2012; Payne, 1995). Escher and Walter-Rogg (2018, 2020) emphasize the role of political rights, as the key predictor of environmental and climate policy outputs. The authors argue that among all aspects of democracy, political rights contribute most to the protection of environment and climate. Climate change mitigation entails fundamental and wholesale changes in dominant ways of life and the way national economies work today. Political rights along with an independent civil society makes such changes likelier through enabling the public to first educate itself regarding environmental challenges, and then to put adequate pressure on politicians and government for decisive actions. As for other qualities of democracy such as electoral accountability, horizontal accountability, political constraints and civil liberties, Escher and Walter-Rogg (2018, 2020) and von Stein (2020) offer more nuanced explanations that include moderating effects of other factors.

von Stein (2020) argues that electoral accountability, loosely defined as translating citizens' preferences into public polices, would be positively associated with environmental performance only if environmental demands were among the electorate's priorities. So public demand for better environmental performance plays a key moderating role on how electoral accountability affects environmental policy outputs and outcomes. More political constraints (veto players) and horizontal accountability (checks and balances) result in more diverse policy preferences being considered in public policy arenas, as agreement must be reached among a larger and usually disparate interests of veto players (Beeson, 2010; Escher & Walter-Rogg, 2020; Gilley, 2012; Wurster, 2011). But if current environmental policies are lax or ineffective, more political constraints and horizontal accountability will only make policy change—i.e., developing and implementing stringer policies—harder (von Stein, 2020). A single veto player, favoring laxer environmental policies, can block policy change (Escher & Walter-Rogg, 2020). Finally, von Stein (2020) elaborates that while civil liberties help raise environmental awareness and activism, it also guarantees that everyone, including those opposing more environmental stringency, has a voice. Therefore, the effect of higher civil liberties in a society depends on what actors are holding power in that society.

The environmental consequences of dimensions of democracy have also been the subject of theoretical debates—mostly deliberative vs. liberal democracy— especially among green political theorists (Dryzek, 1987; Dryzek, 1992; Eckersley, 1995). Since any democracy or political system can have a level of liberalism, deliberation, participation, etc., this study follows Variety of Democracy (V-Dem) Project and uses the word 'dimensions' instead. The key argument in support of a positive link between democratic deliberation and environmental outcomes is that long-term environmental policy preferences have a better chance of being discussed and considered through rational discursive political decision-making processes dominant in deliberative democracies (Dryzek, 1987; Eckersley, 1995). Smith (2001, 2003) argues that deliberative democracy allows for inclusion of a large number of stakeholders—including ordinary citizens, experts, and diverse social groups—and their respective perspectives and interests in more meaningful environmental policy debates. In this regard, the deliberative and participatory dimensions are intertwined.

The participatory democracy dimension encompasses electoral and non-electoral aspects. Electoral participation, in the forms of local and regional election or direct (non-representative) democracy, and non-electoral participation such as civil society engagement in environmental policy debates, have been discussed in the environmental politics literature[18]. When it comes to environmental policy debates, deeper and further democratic participation can move the balance of power from special interest groups towards ordinary citizens. Direct democracy, however, can be a double-edged sword, according to Stadelmann-Steffen (2011). While it can help governments to better address citizens' environmental preferences, it can also hinder generally long-term environmental solutions for collective action problems (Stadelmann-Steffen, 2011).

The literature offers a few explanations regarding the link between the egalitarian principle of democracy and the environment. First, the poor are believed to be more prone to environmental challenges, but a highly unequal society that makes galvanizing support for stringent environmental actions harder. Cushing et al. (2015) and Desai (1998) argue that reduction in inequality is a pre-requisite for improving environmental sustainability. Second, some feminist political theories link egalitarianism to the environment, in a similar vein (Escher & Walter-Rogg, 2020). Women are reported to be generally more environmentally conscious, so a more gender equal society would have a better environmental performance due to greater involvement of women in environmental policy development and implementation (Davidson & Freudenburg, 1996; McCright, 2010; McCright & Dunlap, 2011; Norgaard & York, 2005). Lastly, inequality is linked to environmental degradation through consumerism. Cushing et al. (2015) argues that inequality encourages consumerism, and consumerism in turn undermines environmental performance.

As for the liberal democracy dimension, the debate over its impact on environmental policy outputs and outcomes, is contentious. Strong association with individual liberties, property rights, and capitalism—referring to liberal democracy as being market oriented—are stated in the green political literature as the main reasons why liberal democracy underperforms in the environmental arena (Povitkina & Jagers, 2021). Dryzek (1992) contends that the balance of political power is skewed towards private business interests as they can utilize disproportionately larger economic resources. Since private business interests are usually at odds with more stringent environmental policies, such dynamic, Dryzek (1992) claims, has a detrimental impact on the environment. Also, having a shorter

[18] It is worth noting the proponents of environmental authoritarianism advocate participation of only experts and scientist in environmental policymaking (Gilley, 2012).

time horizon than the market and addiction to economic growth are mentioned as further explanations why liberal democracy's environmental underperformance (Povitkina & Jagers, 2021). These hypotheses and theories are yet to be corroborated by empirical investigations. Furthermore, Povitkina and Jagers (2021) points out that other mostly-neglected aspects of liberal democracy such as strong rule of law and constraints on the executive can induce desirable environmental outcomes. A more inclusive and richer understanding of liberal democracy, or as Povitkina and Jagers (2021) calls it social-liberal democracy, allows for inclusion of both negative and positive liberties and rights. Under this interpretation of liberal democracy, living in protected and clean environment can be regarded as a fundamental, positive right. It is obvious that guaranteeing such fundamental rights will most likely require reduction in other traditionally established rights and liberties of liberal democracy.

2.6. Other Key Drivers of Environmental Policy Outcomes

A growing body of literature focuses on economic, societal, and institutional factors other than regime type in the investigation of environmental policy outputs and outcomes. The empirical studies mostly examine partial and/or conditional effect of democracy along with other key variables of interest such as income and wealth, population, democratic capital, corruption, natural resource endowment, energy intensity, public opinion, societal demand for environmental action, state capacity, regime stability and durability, orientation of a country's market economy, and education level.

2.6.1. Income

In empirical studies, income, as Fredriksson and Ujhelyi (2006) notes, simply control for costs and benefits of environmental policies and the society's environmental preferences. Theoretically, the associations between income and environmental policy outcomes are quite complex. Inglehart (2018) argues that as a society becomes wealthier, it becomes more conscious and concerned about post-materialistic matters, among them environmental problems. Furthermore, if environmental public goods are normal goods, an increase in income will most likely translate into stronger demand for them (Fredriksson & Ujhelyi, 2006). Poorer societies on the other hand are believed to be more supportive of policies that promote economic expansion and employment more than those that merely intends to protect the environment (Farzin & Bond, 2006). Income inequality has also been studied as a potential driver of environmental demand. Farzin and Bond (2006) argue that high income groups of a society are in general more active and able politically. Therefore, they are expected to participate more in supporting and promoting environmental initiatives. This line of reasoning suggests that as the share of these groups in the national income increases—the inequality widens—stronger demand for environmental public goods is expected. Scruggs (1998) provides empirical evidence that shows higher levels of education and wealth, perhaps a crude measure of inequality, are associated with higher demand for environmental public goods. Pfeiffer and Mulder (2013) reports a significant effect of schooling levels and income per capita on RE development in developing countries between 1980 and 2010.

What makes the net effect of income on provision of environmental public goods complex is the observation of a phenomenon called the 'Environmental Kuznets Curve' (EKC) (Grossman & Krueger, 1995; Shafik & Bandyopadhyay, 1992). ECK hypothesis argues that as a poorer country starts growing it produces more pollution. This is called the scale effect (Li & Reuveny, 2006). It is often believed that environmental problems are not of high priority for poorer and developing economies (Deacon, 2003). However, as that country becomes wealthier—i.e. the income per capita increases and surpasses a certain threshold—attention towards environmental problems and climate change mitigation grows, consequently leading to stronger environmental demands from elected leaders. This behavior is called the income effect (Li & Reuveny, 2006; Payne, 1995). The net effect, it is argued, looks like an inverted U-shaped curve—or a U-shaped curve if environmental degradation is replaced by desirable environmental outcomes such as RE development—which means a positive association of income and unwanted environmental outcomes such as environmental degradation, GHG emissions, and water pollution up to a certain threshold and decoupling or a negative correlation afterwards.[19] Anecdotally, job creation and income growth are believed to be of higher priorities than air and water quality, green energy transitions, or forest protection in poorer societies. Furthermore, they are too poor to pay for a better environment even if they prioritize them (Dinda, 2004).

Li and Reuveny (2006) discusses that how EKC effect could be interpreted as an economic phenomenon, a political one or a combination of both. One economic interpretation assumes that a higher income society demands more environmental quality simply because it is a luxury good. Another economic explanation is that transformation of a country from a less developed and agrarian society to an industrial one goes hand in hand with negative environmental outcomes. Further economic progress from heavy industries towards a service economy leads to decoupling of economic development and detrimental environmental outcomes or even a reversal of the positive association between the two (Dinda, 2004). The political interpretation suggests that economic development leads to expansion of a middle class which in turn becomes more politically active on environmental issues. Cao and Ward (2015) contends that it is indeed a combination of change in a country's industrial structure—shifting from manufacturing to services—and demand factors—such as societal demand for a cleaner environment—that can explain the EKC effect.

2.6.2. Institutional Qualities

Institutional qualities such as corruption or lack thereof, rule of law, and bureaucratic quality can have a significant impact on environmental policy outputs and outcomes. Pfeiffer and Mulder (2013) argues that institutional qualities positively impact environmental outcomes through building confidence in implementation and maintenance of environmental policies,

[19] In empirical studies, the net effect of income and scale is captured through inclusion of an income per capita variable and its squared term. Empirically, as Dinda (2004) puts it neatly, Environmental Kuznets Curves are statistical representations that condense key facets of collective human behavior within a two-dimensional space.

rules, and regulations. Institutional factors such as lack of corruption, rule of law, and bureaucratic quality mitigate social political and economic risks which in turn bolster the confidence in the use of RE development as a measure to tackle environmental problems and energy security (Uzar, 2020).

Corruption has a negative effect on environmental policy outputs and outcomes. Povitkina (2018) discusses specific mechanisms through which corruption undermines environmental policy outcomes. It undermines coercive power of the government and damage trust in institutions. Through reducing trust in institutions, corruption undermines state capacity and compliance of various stakeholders—firms, citizens, etc.—with environmental policies and regulations. Corruption also hinders economic development. Through this negative impact on income, corruption can delay reaching that income threshold beyond which environmental concerns become a priority for a society according to EKC hypothesis. Last but not least, corruption, as Wilson and Damania (2005) elaborates, allows sectors responsible most for environmental degradation to bribe their way out of environmental regulations. Wilson and Damania (2005) distinguishes between two types of corruption, petty corruption, and grand corruption. Grand corruption is the type prevalent over the course of policy making and policy development while petty corruption is associated with policy implementation. Pellegrini and Gerlagh (2006) argues that since politicians' sensitivity to petty corruption is independent of political competition—and political competition is known as a distinctive feature of democracy—corruption can have its negative impact on environmental policy outcomes independent of the level of political competition.

2.6.3. Resource Endowment and Energy Intensity

A state's dependence on hydrocarbon rents and fossil fuel lobby appears to hinder development and effective implementation of environmental and energy transition policies (Bayulgen & Ladewig, 2017; Lachapelle & Paterson, 2013). The higher the level of state hydrocarbon rents, the less urgency there might be for RE transition (Bayulgen & Ladewig, 2017). Also, the fossil fuel sector, a dominant, financially powerful and itself a very polluting sector in any hydrocarbon-rich country, is likely a supporter of laxer environmental and climate policies (Böhmelt et al., 2016; Fredriksson & Neumayer, 2013; Lamb & Minx, 2020; Ward et al., 2014). Furthermore, the impact of resource endowment on certain outcomes—such as democratization and economic development—is extensively studied and examined in the rich literature of the resource curse. It is discussed separately in the following chapter. Energy intensity of an economy also has a negative effect on the environmental performance in different ways. Higher dependence on hydrocarbon resources for economic output results in a stronger carbon lock-in effect that makes transition to cleaner alternatives harder (Bättig & Bernauer, 2009). Overall, the political clout and lobbying effort of fossil fuel and energy intensive sectors, such as transportation and heavy industries, negatively affects environmental policy outputs and outcomes (Bättig & Bernauer, 2009; Cadoret & Padovano, 2016; Fredriksson & Millimet, 2004; Lachapelle & Paterson, 2013; Ward et al., 2014).

2.6.4. Public Opinion and Demand for a Better Environment

Most key drivers of provision of environmental public good discussed and theorized in the literature reflect supply side considerations. Empirical literature on democracy and environmental public goods is mostly silent about the demand side of the equation (Cao & Ward, 2015; Ward, 2008). Theoretically, democracies will provide more environmental public goods if relatively strong public support and societal demand for such public goods exists and persists (Anderson et al., 2017; Ward et al., 2014). Therefore, mere existence of democracy does not guarantee a better environmental performance. The logic, as Anderson et al. (2017) elaborate, is quite simple. Democratic leaders pursue political survival—i.e., election or reelection—mostly through provision of public goods. To increase their chances of political survival, they should introduce policies addressing preferences and concerns of the society most. Farzin and Bond (2006) argue that the level of environmental public goods a democratic system supplies depends on the weights—as the outcome of a competitive political equilibrium—officeholders assign to preferences of various stakeholders in the political arena, including environmental groups, various parts of the corporate sector, and the general public. Dasgupta and De Cian (2016, 2018), pointing to the recent rise of right-wing populist parties and factions that traditionally are not fond of environmental restrictions, argue that public opinion can be a 'double-edged sword.'

2.6.5. Other Factors

In addition to the key drivers of environmental policy outcomes discussed above, a host of other factors such as openness to trade, orientation of market economy, education, political stability, state capacity, regime durability, and population size have been included in a number of theoretical and empirical studies of democracy and environmental policy output and outcome. Some scholars argue that involvement in international trade affects the environment through its impact on economic activities (Li & Reuveny, 2006; Wurster, 2011). The net effect of trade however is not clear as trade is positively associated with economic growth and income but at the same time can lead to expansion or contraction of the industrial sector, and change in methods of production and regulations for better or worse (Böhmelt et al., 2016; Li & Reuveny, 2006). Hall (2015) classifies national economies into liberal market economies and coordinated market economies. The classification is based on the way firms interact with each other, trade unions, state, etc. Lachapelle and Paterson (2013) argue that among these two types and the developmental state, the coordinated market economy are expected to produce a better environmental performance, because more cooperation and coordination between the state and business allow the state to promote and implement environmental policies more effectively and efficiently.[20]

Environmental policies that promote renewable energy might become more successful in countries with vast territories, longer coastlines, or higher exposure to sunlight. Geographic feature and location of a country therefore matters when it comes to development and implementation of a specific type of environmental policies, such as

[20] Developmental states due to prioritizing fast economic development are expected to experience further environmental degradation in short to mid-term (Lachapelle & Paterson, 2013).

renewable ones. Bayulgen and Ladewig (2017) notes that a vast country can encourage development of renewable energy because of available area for wind and solar energy production and challenges associated with a centralized national grid. Farzin and Bond (2006) discuss a few arguments in support of positive impact of education and environmental performance. A more educated populace is expected to be more aware of environmental challenges, and more willing and able to voice its concerns, and more likely to form an environmentally progressive civil society. More education also has an indirect effect on environmental policy outputs and outcomes through its effect on income as education is positively associated with income level.

Cao and Ward (2015) define 'core democracy' as a political system with a large winning coalition, considerable state capacity and relatively long regime durability. All these three features are necessary for a democracy to perform well when it comes to provision of public goods more broadly and environmental public goods in particular. Provision of environmental public goods requires sufficient regulation and enforcement capacities (Cao & Ward, 2015; Janicke, 2002). Though a state might perform well in terms of environmental policy outputs—e.g., passing strict environmental laws—it may not be able to enforce such laws due to a lack of sufficient state capacity. In addition, it will not be economically feasible for leaders to allocate resources for provision of environmental public goods that need time to come to fruition, if they face risk of deposition or major change in the rules of the game (Cao & Ward, 2015)[21]. Wurster (2011) looks at regime age and studies how it can become as important as regime type for a country's sustainability performance. Pellegrini and Gerlagh (2006) and Fredriksson and Svensson (2003) present theoretical and empirical models that includes political instability, defined as the replacement rate for the government administration in power. High political instability is a phenomenon that is prevalent mostly in democracies. The authors show that higher political instability is associated with more stringent environmental policies. The underlying argument is that higher political instability makes bribery of polluting industries less effective.

[21] Though in democratic systems officeholders face the risk of losing office through regular elections the rules of the game remains the same (Cao & Ward, 2015).

2.7. Empirical Investigations

Empirical studies that include democracy and environmental policy outputs and/or outcomes abound and diverse. Adopting large-n quantitative methods, these studies mostly use observed cross-sectional or longitudinal data of a large number of countries. The underlying hypothesis being tested is whether factors such as democracy, corruption, public opinion, and good governance have statistically significant effects on environmental policy outputs and outcomes and if yes through what mechanisms (Dasgupta & De Cian, 2018). Type of quantitative model employed, variables that are controlled for, democracy, or regime type measures used, empirical definitions of policy performance, and country and year coverage have sizeable influence on statistical results of and consequently statistical inference from any empirical study of democracy and environmental policy outputs and outcomes (Bättig & Bernauer, 2009; Böhmelt et al., 2016; Li & Reuveny, 2006; Ward, 2008).

Several earlier studies of democracy and environmental policy outputs or commitments generally support the idea that a positive link exists between democracy and environmental policy commitment. Democracies appear to be more likely to join international environmental and climate agreements such as Kyoto Protocol, UNFCC, Montreal Protocol, Convention on Biological Diversity and the Convention on International Trade in Endangered Species (Bättig & Bernauer, 2009; Congleton, 1992; Fredriksson & Gaston, 2000; Fredriksson & Wollscheid, 2007; Neumayer, 2002; Von Stein, 2008). These studies mostly employ cross-sectional or panel data models, include a relatively large number of countries, and control for different sets of variables. For example, Congleton (1992), in one the pioneering empirical works in the area of environmental politics, controls for the effect of natural resource endowment and finds that the effect of democracy on international environmental commitment is robust and significant. The result of another study (Steves et al., 2013) regarding the effect of democracy on environmental policy stringency, which focuses on policy adoption at the domestic level, is not conclusive.

A larger body of literature is dedicated to understanding the effect of democracy on environmental policy outcomes.[22] A wide range of environmental performance indicators such as deforestation, land protection, public sanitation, air pollution, water pollution, water sanitation, greenhouse gas emissions and RE generation and penetration have been included in such studies. Congleton (1992) finds that democracies on average have higher levels of air and environmental pollutions and deforestation. A few studies report either inconclusive or mixed results regarding the effect of democracy on environmental performance (Bättig & Bernauer, 2009; Bernauer & Kuhn, 2010; Mak Arvin & Lew, 2011; Roberts & Parks, 2006; Scruggs, 1998). Murdoch and Sandler (1997), however, shows democracies, though experiencing a higher level of pollution, are more successful in emission reduction emission reduction than nondemocracies. A quite large number of more recent studies, applying simple or advanced quantitative modeling, find a robust and positive link between democracy and various indicators of environmental policy outcomes (Barrett & Graddy, 2000; Bernauer & Koubi, 2009; Bhattarai & Hammig, 2001; Buitenzorgy & Mol, 2011; Deacon, 2009; Didia, 1997; Farzin & Bond, 2006; Fredriksson et al., 2005; Gleditsch & Sverdrup, 2002; Lamb & Minx, 2020; Li & Reuveny, 2006; Povitkina & Jagers, 2021; Sequeira & Santos, 2018; Winslow, 2005). A comprehensive review of empirical literature on democracy and environmental policy outputs and outcomes—that includes some of the studies discussed above—by Dasgupta and De Cian (2016, 2018) reports important findings and provide invaluable insights.[23] Though, review of the studies that include only a single democracy measure do not indicate a statistically clear-cut advantage of democratic systems on environmental policy outcomes, some norms of democracy such as rule of law and civil and political freedom appear to be very strong predictors of environmental policy outputs and outcomes.

[22] A comprehensive review of the literature on democracy and RE development as a specific type of environmental policy outcomes by Sequeira and Santos (2018) reveals that a majority of studies—75% –applies quantitative methods.

[23] Out of 60 empirical studies included in the literature reviews, 43 investigates the effect of democracy and governance on environmental policy outcomes such as emissions, pollutants, deforestation, land degradation, etc. Only 5 of these studies include green investment and renewables as policy outcomes. The remaining 17 studies are about the effect of democracy on environmental policy outputs such as environmental policy adoption and environmental policy stringency.

A growing part of the literature goes beyond regime type or democracy-autocracy dichotomy and investigates the link between various aspects or forms of political regimes and environmental policy outputs and outcomes. Fredriksson and Wollscheid (2007) include four different forms of democratic institutions—'parliamentary', 'presidential-congressional', 'proportional electoral' and 'majoritarian electoral'—in its empirical study and reports that among the four categories only parliamentary systems fair significantly better than autocracies. The study finds that presidential-congressional systems do not perform better than autocracies when it comes to environmental performance. Ward (2008) also reports that parliamentary systems have better environmental and sustainability performance than presidential systems. Bernauer and Koubi (2009), however, report results that contradict those of Fredriksson and Wollscheid (2007) and Ward (2008), and indicate a better environmental performance for presidential systems than parliamentary ones. Fredriksson and Millimet (2004) find that presidential-congressional systems set lower environmental taxation than parliamentary systems and proportional representation rule adopt more stringent environmental policies than a majoritarian system. Bayulgen and Ladewig (2017) shows that fewer political constraints or veto players lead to faster development and adoption of environmental policies. Wurster (2011), obtaining similar results regarding the effect of veto players, also reports that among autocratic systems, monarchies perform better than military dictatorship in terms of environmental policy outcomes. A comprehensive literature review by Dasgupta and De Cian (2018) indicates that in parliamentary democracies, where energy regulators are under parliamentary authorities, governmental commitments to sustainably are more likely to come to fruition.

A few studies investigate the effect various qualities of democracy—such as political rights, civil rights, electoral accountability, and horizontal accountability a.k.a. checks and balances—on environmental policy outputs and outcomes. Some studies report a strong and positive link between political rights and civil rights/liberties and environmental policy outcomes (Barrett & Graddy, 2000; Dasgupta & Mäler, 1995; Torras & Boyce, 1998). Escher and Walter-Rogg (2018) find a strong link between political rights and environmental policy outputs. Coppedge, Gerring, Lindberg, Skaaning, Teorell, et al. (2017) and Escher and Walter-Rogg (2018) find no empirical evidence in support of a link between any of the democracy quality dimensions and environmental policy outcomes. von Stein (2020) reports a mixed effect of electoral accountability, a robust and significant effect of civil society, and an inconclusive effect of political constraint on a wide range of environmental policy outcomes. Böhmelt et al. (2016) report a positive link between inclusiveness, measured by indicators of liberal freedom and competitive political process, and environmental policy outputs and no significant positive association between the former and environmental policy outcomes. Povitkina and Jagers (2021) finds a positive link between various dimensions of democracy—liberal, social-liberal, and deliberative dimensions—and environmental policy outputs.

Finally, a number of studies theorize and empirically examine conditional effect of democracy on environmental policy outputs and outcomes. A few studies find the impact of democracy insignificant after controlling for key economic and societal factors and their interaction with democracy. Farzin and Bond (2006) find that the impact of democracy is conditional on level of income, income inequality, urbanization, and education. Findings of Lv (2017) and Kim et al. (2019) suggest that democracy contributes to better environmental performance only among wealthier economies. Laegreid and Povitkina (2018) finds support for the EKC effect and reports a significant mediating effect of democracy on the link between economic development and environmental degradation.[24] Jänicke (1996) also reports results in support of EKC hypothesis while Scruggs (1998) does not find a meaningful link between democracy and environmental performance once controlling for income inequality. Cole and Neumayer (2005), however, doesn't find empirical support for EKC hypothesis for all types of environmental policy outputs (pollution mitigation) across various types of political systems. Corruption is also reported as a strong and significant determinant of environmental policy outputs (Pellegrini & Gerlagh, 2006) and environmental policy outcomes (Iwińska et al., 2019; Povitkina, 2018)[25]. A review of the literature on corruption and environmental policies reveals that corruption is a very strong predictor of a country's environmental performance (Dasgupta & De Cian, 2018). It negatively affects a country's

[24] The results suggest that strong democracy can mitigate the environmental externalities of economic development.

[25] Povitkina (2018) and Iwińska et al. (2019) investigate the conditional effect of corruption whereas Pellegrini and Gerlagh (2006) focus on the partial effect of corruption and its impact on the explanatory power of democracy.

environmental performance through adoption of less stringent environmental and climate laws and regulation and indirectly through hindering economic and income growth.

Interest groups and lobbies, partisan ideologies, type of market economy and public opinion have also been the subject of a few empirical. Several studies have revealed that the strength of interest groups such as environmental lobbies, and left-wing and green parties has a positive effect on environmental policy outputs or outcomes, while the strength of labor unions, right-wing parties, and manufacturing industry lobby has a negative effect (Aklin & Urpelainen, 2013; Bernauer & Koubi, 2009; Cadoret & Padovano, 2016; Fredriksson et al., 2005; Fredriksson & Ujhelyi, 2006; Leinaweaver & Thomson, 2016; Neumayer, 2003)[26]. Lachapelle and Paterson (2013) finds that democracy has limited explanatory power and liberal market economies and coordinated market economies on average have a better performance than developmental states. Finally, in the context of European democracies, a favorable public opinion towards environment is shown to have a significant impact on RE policy outputs (Anderson et al., 2017).

2.8. Conclusion

The literature on the link between democracy and environmental policy outputs and outcomes is quite rich and mature. It includes studies in the areas of politics and economics. This rich literature assumes that a state has a comparative advantage in provision of public goods when markets fail, and the form of a political system has a sizeable impact on what and how much public goods are produced by the state. Overall, theoretical work in support of direct or conditional effect of democracy on environmental policy outputs abound. The arguments in support of such hypotheses are quite well-founded and strong but they are not without caveats. The empirical work generally reports statistical support for the positive link between democracy and environmental policy outputs and outcomes. However, it is

[26] Fredriksson and Ujhelyi (2006) find that more pressure from environmental interest groups result in further environmental commitment but the effect diminishes as the number of veto players grows. Fredriksson et al. (2005) reports that number of environmental interest groups and political competition will have significant impact on a specific environmental policy outcome if political participation is high enough.

important to acknowledge the sensitivity the results to factors such as sample selection, operationalization of variables especially democracy, definition of policy outcomes, control variables, and perhaps most importantly quantitative techniques and models they employ. Nonetheless, a large part of the empirical body of literature regards democracy as a key determinant of environmental policy outputs and outcomes.

Theoretical and empirical support for a positive impact of democracy or to be precise its various dimensions and qualities on environmental policy outputs, and outcomes are quite strong. However, the rich literature on the effect of democracy on environmental policy outputs and outcomes suffers from a number of shortcomings. First, as Dasgupta and De Cian (2016, 2018) promptly point out, the literature on the link between democracy and green investment and development such as RE investment and development is sparse and limited. When it comes to environmental policy outcomes and performance, the literature, over the past few decades, has mostly investigated the relationship between democracy and physical environmental performance measures such as air and water pollutions and greenhouse gas emissions. It appears immensely important to investigate the impact of democracy on performance indicators more closely related to low or zero carbon energy transitions; performance indicators such as investment in renewables, RE capacity generation, RE production and share of renewable in a country's energy mix. Second, distinguishing between various qualities of democracy such as political rights, civil liberties, electoral accountability, and more recently various dimensions of democracy such as deliberative, participatory, egalitarian, liberal and electoral dimensions, in environmental politics has gained pace only recently (Escher & Walter-Rogg, 2018, 2020; Kim et al., 2019; Povitkina, 2018; Povitkina & Jagers, 2021; von Stein, 2020). Third, widely used econometric solutions, cross-sectional OLS regression and fixed effect panel data analysis, have their own limitations and deficiencies. Cross-sectional models might reveal only an incomplete snapshot of the interconnections between a dependent variable and independent variables, in addition to being prone to endogeneity and omitted variable bias (Dasgupta & De Cian, 2018). Cross-sectional models are used mostly to tackle the problem of sample selection bias due to the environmental data gap between developed and developing countries (Dasgupta & De Cian, 2018). Fixed effect panel data models, while capable of producing a more dynamic picture of the causal links, usually produce inflated standard errors and consequently lower efficiency. More importantly such models are not able to capture the impact of some key time-invariant and rarely changing variables of interest, such as regime type, country area, etc. It is worth noting that a more capable type of panel data model called linear mixed model (LMM) and a more capable way of model specification called within-between specification—which is discussed in detail in the Methodology and Data and Modeling chapters—have shown promising results in tackling a few major shortcomings of traditional fixed-effect and random-effect models.

Finally, it seems the impact of resource endowment or to be specific hydrocarbon resource endowments on environmental policy outcomes such as RE development has not been adequately examined. A number of studies have included variables, such as fossil fuel production or exports as a share of GDP, to capture the effect of a country's hydrocarbon-richness on environmental policy outputs and outcomes. Such variables, however, fail to properly capture distinct channels through which a country's hydrocarbon-richness affects environmental policy outputs and outcomes. For example, a country like US is barely a net exporter of fossil fuels but has a sizeable and influential fossil fuel sector. Also, US economy is so large that no matter how much big its fossil fuel sector is, its share in term of percentage of GDP is relatively miniscule. Another example is countries with nationalized fossil fuel sector. No matter a net exporter of fossil fuel or not, they may behave differently than the one with a private energy industry. Overall, the need for development of better measures of hydrocarbon-richness and resource endowment is evident.

The subsequent chapter, serving as the second and final part of the literature review delves into the causal links that interconnect hydrocarbon resource abundance and environmental policy outcomes. It introduces a fresh perspective through which to study and scrutinize environmental policy outcomes. Additionally, it sheds light on the gaps and limitations prevailing in the empirical literature concerning the relationship between resource wealth and environmental outcomes.

3. Literature Review—Part Two: Resource Curse and Environmental Policy Outcomes

This chapter constitutes the second and last part of the literature review. It focuses on the resource curse literature which broadly hypothesizes a link between natural resource wealth and a wide range of detrimental social, economic, and political outcomes. Within this context, the review identifies a crucial gap in the empirical literature concerning the connection between natural resource wealth and negative environmental and climate policy outcomes. This study aims to bridge this gap in addition to addressing several methodological limitations, elaborated in the previous and this chapters. Like the preceding literature review chapter, this one plays a pivotal role in shaping the theoretical framework of the study, as the valuable insights gained here directly inform the formulation of the key hypotheses central to the research.

3.1. Introduction

The term, 'resource curse', coined first by Auty (1993), refers to the observation that ceteris paribus, countries that are endowed with and dependent on natural resources, on average perform worse than their resource-poorer peers in terms of economic growth and development outcomes. Sachs and Warner (1995) describes it as the adverse effect of natural resource wealth on a country's economic, social, and political well-being. Earlier literature on the resource curse included natural resources such as hard rock minerals, crude oil, natural gas, coal, timber, and agricultural commodities, but more recent studies find strong evidence for the adverse political and economic effects of one specific type of non-renewable natural resource, namely crude oil (Prichard et al., 2018; Ross, 2015).

Oil revenues, as Prichard et al. (2018) notes, can be channeled into government treasuries, or in other words turned into oil rents much more frictionlessly than those of natural gas or coal, and are generally larger than other resource revenues. Prichard et al. (2018) further explain that among natural resources oil is different mainly because of higher revenue per unit of production (given its market price is orders of magnitudes higher than the production costs), relative ease of extraction and the nature of the contracts governing its extraction. In some parts of the Middle East, oil extraction rents can be three to five times the production cost, while gas rents can range from 33 to 100 per cent of production costs (Aoun, 2009). Overall, oil revenues are disproportionately higher than those of natural gas and coal.[27] Ross (2015) argues oil is different because of the prevalence of state-owned oil and gas companies, relatively lower level of labor intensity of its extraction process, and its physical properties. Papyrakis (2017) distinguishes between point resources such as oil, gas and minerals that are spatially concentrated and diffuse resources such as agricultural ones. The geographical concentration of point resources, as Van der Ploeg (2011) argues, makes them more appropriable which refers to the ease of reaping benefits from such resources in a short period of time. It is argued that a government's access to the windfalls of point resources simply leads to appropriative behavior (Boschini et al., 2007).

In the context of this study, the terms 'natural resources' or 'resources' refer solely to hydrocarbon resources that are mostly in the form of crude oil, natural gas, and coal. Among the three, oil is the main focus of this study. It is worth noting that the resource curse literature does not claim that resource-rich countries would necessarily fare better without their natural wealth. It merely intends to explain why resource-rich countries generally perform poorly in terms of economic development, quality of government and measures of democracy (Badeeb et al., 2017; Karl, 2005). It is also critical to acknowledge that while some resource curse factors such as the Dutch Disease—which is discussed in detail in a following section—and volatility of commodity prices are specific to resource-rich economies, some others such as rent seeking and corruption are prevalent in less developed economies irrespective of their resource wealth (Di John, 2011). Therefore, it is safe to presume that resource-richness may exacerbate the negative impact of political and economic factors already at play in less developed economies (Badeeb et al., 2017).

From a purely theoretical perspective, resource wealth can expedite development through providing extra fiscal resources for the state to spend on public goods, including public infrastructure, education, and healthcare (Sachs, 2007). Since the time of Adam Smith

[27] For example, in 2008 the revenue generated from oil mining was significantly higher than the rents earned from gas and coal combined, which were $943 billion and $627 billion respectively, while accumulated rents from all other natural resources amounted to $452 billion (Aoun, 2009).

and David Ricardo, a commonly held belief was that natural resources can facilitate sustained economic growth (Badeeb et al., 2017). For example, in the late 19th and early 20th century the US was the largest mineral producing economy whilst simultaneously becoming the largest manufacturing economy in the world. Strong linkages and complementarities between the resource and non-resource sectors of the economy are often believed to be pivotal in the American success story (Van der Ploeg, 2011). Even as late as the 1950s, development economists such as Douglas North and Harold Innis, were still arguing that natural resource wealth could help developing states tackle their capital shortfalls (Ross, 1999). But several prominent structuralist economists (Baldwin, 1966; Hirschman, 1958; Nurkse, 1958; Prebisch, 1962; Singer, 1975) cast doubt on this commonly held belief. Their three key lines of argument were that: (i) natural resource exporters usually suffer from declining terms of trade[28]; (ii) resource exporters have difficulties handling fluctuations in international resource prices and this has an adverse effect on their state revenue and budget planning, foreign exchange rates and public and private investments; and (iii) booming resource enclaves are not strongly linked to non-resource sectors in many resource-rich economies.

Since the 1970s, the debate over the curse or blessings of natural resources, has become less ideological and more empirical which has resulted in a very rich body of literature (Ross, 1999, 2015). In the past 25 years, a number of political and economic determinants of the resource curse have been identified, discussed and examined in the literature. Ross (1999) argues that such hypothesis testing has helped create a cumulative body of knowledge of the policy failures in resource-rich economies and further refined and clarified various aspects of the theory. Factors such as the volatility of international resource prices, the Dutch Disease, resource-boom-induced deterioration of state institutions and the concept of the rentier state[29] are discussed in the earlier literature as political and economic

[28] Terms of trade is defined as the ratio of export prices to import prices and can be interpreted as the amount of import goods an economy can purchase per unit of export goods (Reinsdorf, 2009).

[29] It is worth noting that the rentier state, however, is not the only theory that intends to explain the political resource curse. For example, Mitchell (2009) claims that fossil fuels helped the birth of representative democracy, and then constrained it (through transitioning from coal to oil). Or, Malm (2016) elaborates that social and political drivers and indeed powerplay between the owners of capital and the labor were the main

explanations for the resource curse (Ross, 1999). Later studies identify corruption, armed civil conflicts, rent-seeking behavior, unsustainable government policies and insufficient spending on human capital (education) as possible explanations for the resource curse (Badeeb et al., 2017; Van der Ploeg, 2011). Also, saving, investment, and human capital formation have been examined as channels through which resource-richness hampers economic development (Gylfason, 2001). All these possible political and economic drivers of resource curse, though distinct, overlap.

The adverse effect of resource-richness is not limited to the area of economic development. As Goodman and Worth (2008) note, dependence on extractive natural resources can lead to socio-economic disadvantages such as social divisions, political disruptions such as rentier behaviors and political patronage and, last but not least, environmental degradation. In the past two and half decades, the idea of the resource curse, or the 'paradox of plenty', has been used to explain not only the prevalent economic underdevelopment but also weaker institutions, more corruption, increased susceptibility to civil conflicts and lower levels of democracy in resource-rich countries (Ross, 2015). In line with the existing literature, this research distinguishes between the economic and political dimensions of the resource curse. Both concepts are closely related and together constitute the rich resource curse literature. The political resource curse refers to three adverse political outcomes observed in many resource-rich countries, especially in oil-rich ones and specifically post 1970s (Ross, 2015). These countries are on average less democratic, more corrupt, and more susceptible to armed civil conflicts. Furthermore, this study also argues that the resource curse scholarship can be extended to a broader range of social, economic, and political outcomes, including but not limited to human development, provision of public goods, and the environmental policy outcomes. Scholars of the political resource curse literature have engaged in three discourses regarding the adverse effects of natural resources (Ross, 2015): (i) the conditions under which natural resources enable the resource curse to persist; (ii) the mechanisms through which natural resources are linked to such

drivers of transition to coal, with immense political consequences. Such hypotheses, however, have not yet been presented in testable formats—i.e., generalizable, and falsifiable, terms. They are beyond the scope of this study which particularly focuses on the empirical literature on democracy, resource curse and RE development.

political outcomes; and (iii) the robustness and validity of empirical (statistical) examination of these effects.

In empirical work, it is critical to distinguish between general tendencies and specific cases, or as Haber and Menaldo (2011) put it, between identifying one or a few cases of a common occurrence and generalizing it into lawlike statements. evidence provided through the development of empirical models that show the existence and prevalence of the resource curse through large-n studies are important for showing the generalizability for different resource curse hypotheses. This is accomplished through the construction of theories that contain testable hypotheses.

In the past 25 years, a large number of empirical studies have investigated various political and economic outcomes of the resource curse. A large part of this literature find supports for adverse economic and political effects of resource wealth (Ross, 2015). Although this project mainly focuses on the contributions of the fields of economics, political economy and political science to the resource curse literature, it still needs to acknowledge the invaluable contributions of other fields of social science to the resource curse scholarship. For example, Gilberthorpe and Rajak (2017), using an anthropological approach, investigate how the impact of resource extraction on social relations between corporate actors, state and society leads to social frictions, conflicts between various stakeholders and inequality. Or Collier (2017) tries to explain, from a social psychology perspective, how psychological biases shape public opinion, especially when an effective state communication policy is lacking, and how that itself can induce a resource curse.[30]

In this chapter, first various measures of resource-richness and resource dependence are discussed. Then, a number of key explanations for the economic consequence of resource curse are presented which are followed by a review of the empirical literature on resource curse. Next, the political resource curse is explained. The chapter also provides a review of the nascent literature on the resource curse and environment policy outcomes. The chapter concludes by identifying gaps in the literature on the link between natural

[30] Collier (2017) argues that conflicts, populism, and overconsumption are a result of psychological biases that push for allocation of windfalls from recently discovered natural resources to local communities, especially when government communication channels are malfunctioning and ineffective.

resource wealth and environmental policy outcomes, broadly, and RE development, specifically.

3.2. Measuring Natural Resources

There is no shortage of measures and indicators of natural resource wealth and natural resource rents in the empirical literature. This wide variety of variables and indicators is perhaps to some extent a product of vagueness in the theory and more importantly a lack of high quality data—specifically low quality of government revenue data (Prichard et al., 2018). The most common indicators of natural resources in empirical studies are resource income measures such as value of resource exports over GDP, value of resource exports per capita, quantity of resource exports per capita, value of resource production over GDP, value of resource production per capita, quantity of resource production per capita, and resource rents over GDP (Badeeb et al., 2017; Lucas & Richter, 2016; Ross, 2015). Furthermore, share of natural capital in national wealth, share of resource exports in total exports, value of natural resource reserves, resource discoveries, number of workers in the resource sector, and the rate of resource depletion are also used in a smaller number of resource curse studies (Badeeb et al., 2017; Ross, 2015). Recently, however, a growing number of studies include more conceptually relevant measures of state resource revenues, such as state hydrocarbon rents (Lucas & Richter, 2016; Wright & Frantz, 2017; Wright et al., 2015). As Prichard et al. (2018) correctly point out, conceptually there is a substantial difference between a country's resource income and resource rents which can vary significantly across resource-rich countries.

Several scholars distinguish between indicators of resource abundance and resource dependence and discuss how choosing one over the other in empirical studies can yield totally different results (Basedau & Lay, 2009; Pritchard, 2013; Rosser, 2006). However, the main problem is that there is no firm consensus on the definition of resource abundance and dependence. Pritchard (2013) defines resource dependence as overreliance on resource rents as part of a national economy, and resource abundance as the total value of extractable resources in a country. But, Basedau and Lay (2009) define resource abundance as the absolute amount of resource rents per capita. Even though, a majority of the empirical literature, especially recent studies, only include measures of resource dependence or reliance, the way these indicators are normalized—i.e., presented on a per capita basis, or as a share of GDP, government revenues, etc.—still has empirical implications.

The literature is quite vague about what exactly constitutes resource wealth or resource dependency or even how we would clearly distinguish between the two; dependence of a national economy on the value added produced by the resource sector; reliance of a government on windfalls from resource exports; the share of resource exports in a country's total exports or perhaps a combination of all of the above.[31] For each of these different interpretations, there are several measure that are frequently used in the literature. Perhaps a few examples can reveal the substantial challenge of operationalizing resource dependence and/or resource rent for empirical purposes. The US has a larger resource production per capita than Nigeria and lower per capita resource exports. So, it is obvious that choosing one measure over another could potentially change the outcomes of an empirical study. Furthermore, neither of the two measures captures the importance of the resource sector in a national economy and more importantly resource rents which is the central theme of the rentier state theory, itself an integral part of the resource curse literature. A second example is using total resource income per capita or other per capita indicators which Wigley (2018) claims is a better measure of resource rents than resource exports divided by GDP because it also includes resources produced and consumed domestically, plus normalizing resource rent by GDP can be technically problematic due to possible endogeneity between GDP and resource income. However his proposed measures still falls short in accounting for resource rents enjoyed by the state and capturing the relative size and importance of the resource sector in a national economy. Lucas and Richter (2016) correctly point out that using measures such as resource income or resource exports as proxies for resource rents—and not taking into account who owns and benefits from the

[31] Wiens et al. (2014) elaborates that though state resource rent is the theory's variable of interest, rough estimates of the resource value added has been used in numerous studies for reasons of simplicity and practicality.

income—fails to take into account the structural change in the global energy sector where national oil companies gradually replaced international oil companies in many resource-rich countries between 1950s and 1970s. Since the 1970s, governments have been key beneficiaries of resource windfalls or resource rents across many resource-rich countries. For example, per capita resource production for a number of resource-rich countries such as Australia, Canada and US is relatively high, which can be mistakenly interpreted as higher levels of state reliance on resource rents in comparison with well-known cases of overreliance on resource rents such as Iran, Saudi Arabia or Nigeria. Finally, one of the main critiques of using resource exports over GDP or total exports is offered by Ross (2013) and repeated by other scholars—e.g. Wigley (2018) and Lucas and Richter (2016)—is that such measures overestimate resource dependence of poorer and less developed economies that do not have enough processing and consumption capacities to absorb much of their resource production. However, this argument does not look quite convincing. Economic underdevelopment and relatively higher ratios of dependence on resource exports, go hand in hand and together form a foundation from which the resource curse hypotheses were developed in the first place.

Overall, there is a strong consensus in the literature that natural resource rents or state revenues from natural resources are what that lead to the adverse economic and political consequences known as the resource curse. Accurately estimating a government's dependence on resource revenues or in other words resource rents is anything but straightforward. Ross (2015) and Lucas and Richter (2016) elaborate how various arms of a government such as ministry of finance, ministry of energy, national oil company or local or state governments can receive resource rents in various forms such as royalties, corporate taxes from state-owned or private energy companies, transport royalties or transit fees, and direct revenues from state-owned entities. Focusing solely on non-tax state revenues disregards the possibility that primary commodity exporting entities, whether privately or state-owned, pay significant amounts of taxes, which are usually categorized as direct tax revenues (Richter & Lucas, 2016). Furthermore, government may also underreport their revenues from selling resources domestically (Ross, 2015). But recent improvements in data collection and the development of new databases on government revenues have shown promise. Government Revenue Dataset (GRD) provided by The International Center for Taxation and Development dataset (Prichard et al., 2018) and the Global State Revenues and Expenditures (GSRE) dataset (Lucas & Richter, 2016) are two examples of recent efforts to tackle the complexities of estimating state resource rents—though unfortunately the former is not being regularly updated and does not cover a large number of countries for a long period of time, while the latter does not distinguish between state revenues from hydrocarbon resources and other natural resources and the latter.

Scholars researching the resource curse have been racing to find a perfect measure of resource dependence for their empirical studies. In this Study, it is argued that a country's resource dependence cannot be adequately captured by just one indicator, but that various aspects of the resource curse can be captured by more than one indicator. One of the key indicators is without a doubt state resource rents which play a pivotal role in the rentier state and resource curse theories. Due to data limitations, this study uses the share of hydrocarbon resource revenues (from coal, natural gas, and crude oil, separately) in GDP as the indicator of hydrocarbon resource rents. Another important measure which has not been used in this context in the literature so far[32], is the share of domestically produced natural resources as a share of a country's total resource consumption. This measure is called hydrocarbon richness—calculated separately for coal, crude oil, and natural gas. Perhaps an example may reveal the usefulness of this measure better. The US has a large fossil fuel sector that is influential politically and economically. Only this indicator can capture the relative size and importance of its fossil sector compared to other nations'. Using only the share of hydrocarbon revenue in GDP cannot capture the size and importance of the American fossil fuel sector simply because first, the size of the US economy is huge therefore the fossil fuel share in its GDP is always very small, and second, its fossil fuel sector is not state-owned, therefore the US government does not directly enjoy any hydrocarbon rents.

[32] Similar measures have been used in the literature to capture a country's level of energy security.

3.3. Determinants of Economic Resource Curse

Ross (1999) lists four economic and three political explanations for the resource curse. From the economic perspective these are: Declining terms of trade for resource exporters, volatilities of international resource markets, weak linkage between resource and non-resource sectors, and the Dutch disease. The political factors include short-sightedness of policy makers (cognitive factor), empowerment of specific sectors and interest groups that support growth-impeding policies (societal factor), and resource-boom induced deterioration of state institutions along with the concept of the rentier state (state-centered factors). The focus of more recent literature on resource curse has been on the Dutch Disease, deterioration of state institutions, economic mismanagement and rent seeking behavior.

3.3.1. The Dutch Disease

The term Dutch disease was first used by *The Economist* magazine in 1977, referring to the substantial decline in export-oriented manufacturing sector in the Netherlands in the following decades after the discovery of a sizeable natural gas reserve in the late 1950s. Resource booms are believed to have a negative impact on growth-inducing sectors of an economy through a number of mechanisms (Badeeb et al., 2017; Ross, 1999; Sachs & Warner, 2001; Van der Ploeg, 2011). Historically, the tradable sector, consisting of manufacturing industries, was considered the engine of economic growth as it produces more positive spillovers and externalities—such as technological development—than the non-tradable sector, including retail, real estate, and construction (Ross, 1999, 2006, 2015; Sachs, 2007; Sachs & Warner, 1995, 1999, 2001; Van der Ploeg, 2011). First, through a sharp rise in exports, a resource boom leads to the appreciation of the real exchange rate. Such currency appreciation makes the tradable sector of the economy less competitive in international markets, where prices are set in international currencies. Second, a resource boom also boosts domestic income (wages), higher demand for goods and services, and consequently higher price levels. Since, non-tradable goods and services, labor, and raw materials are usually inputs for the tradable sector, higher input prices for that sector put even more downward pressure on its profitability. Third, higher demand for a booming non-tradable sector diverts labor and capital from the struggling tradable sector to the non-tradable sector. Forth, a prosperous resource sector also has a crowding-out effect on the supply of capital and labor to the tradable sector. A prospering resource sector, able to afford higher wages, can crowd out entrepreneurship and innovation through attracting potential entrepreneurs and innovators (Sachs & Warner, 2001). All these mechanisms make the tradable sector of the economy weaker which consequently hampers economic growth.

It is worth noting that Sachs and Warner (2001) acknowledge that there is a healthy debate over what [sector] really drives economic growth and the basic logic of crowding-out can be applied to other relevant drivers of growth. They emphasize that explaining the resource curse ultimately depends on answering the question of what really induces growth. For example, Gylfason (2001) argues that the detrimental effect of resource richness on economic development is through its negative impact on investment in human capital (education) and consequent underdevelopment in the knowledge sector of economy. Rosenberg and Tarasenko (2020), referring to the works of a number of influential economists such as Romer, North, Hall, and Acemoglu, investigate—especially in the context of autocratic regimes—how natural resource wealth undermines technological innovations as the main driver of long-term growth.

3.3.2. Deterioration of Institutional Qualities

Two main lines of argument regarding the links between natural resource richness and institutional qualities are dominant in the resource curse literature (Badeeb et al., 2017; Ross, 2015). One line argues that natural resource wealth impairs the institutional qualities such as, rule of law, lack of corruption, state capacity and government bureaucracy which in turn hinders economic development. The other one presumes an exogeneous effect of the institutional qualities and asserts that a positive or negative impact of resource abundance on economic growth depends on the institutional qualities.

Van der Ploeg (2011) argues that strong state institutions, such as lack of corruption and a higher level of rule of law, promote entrepreneurship and innovation and discourage rent-seeking behavior and weak institutions do the opposite. Therefore, when a resource boom happens in the context of a country with weak state institutions, dominant, and established rent-seeking behavior crowds out much more productive entrepreneurial activities which leads to less economic development. The resource boom in this context would likely induce reckless government spending on less productive or counterproductive activities such as excessive public employment, patronage and white elephant projects (Robinson et al., 2006). Tornell and Lane (1999) define a concept called 'voracity effect' which refers to intense fighting among powerful groups for a share of the resource windfalls in the absence of strong and robust state institutions. Overall, resource-rich economies with weaker institutions perform poorly and remain poor (Van der Ploeg, 2011).

Numerous theories and studies presume endogeneity of institutions and try to explain how natural resource abundance deteriorate the institutional qualities. Natural resource wealth can induce corruption and rent-seeking through granting protection and privileges such as export and extraction licenses to the elite and oligarchs (Van der Ploeg, 2011). Windfalls from a resource boom can encourage politicians to use them to buy political support, evade political accountability, slow modernization (Isham et al., 2005), delay urbanization, avert demand for more and better education and infrastructure that are necessary for long-term growth (Ross, 2007), buy off political challengers (Acemoglu et al., 2004), obstruct technological and institutional improvements that limit their power (Acemoglu & Robinson, 2006), and hollow out institutions governing the natural resources revenues in order to personally benefit from the available rents (Ross, 2001b). Also, the windfall would likely discourage politicians from investing in the state capacity, especially bureaucratic and tax collection capacities, that ultimately makes the state even more vulnerable to rent seeking and less able to develop and implement robust economic policies (Beblawi, 1987; Besley & Persson, 2010; Chaudhry, 1989; Karl, 1997). Furthermore, several studies argue that the effect of resource abundance on institutions itself is conditional on the political regime of a country. They suggest that natural resource abundance is more likely to increase the level of corruption in enduring nondemocracies than in democracies (Andersen & Aslaksen, 2013; Arezki & Gylfason, 2013; Bhattacharyya & Hodler, 2010). when these explanations are taken together, they provide a compelling argument for how natural resource wealth hampers economic development through the impairment of state institutions.

3.3.3. Economic Mismanagement and Rent-seeking Behavior

Arguments regarding chronic economic mismanagement and rent-seeking in resource-rich economies closely overlap with the ones regarding weak state institutions. Cognitive theories suggest that overconfidence, a false sense of security, and myopic disorder among policy makers result in adopting unproductive or counterproductive policies, laxer fiscal discipline and the neglection of growth-inducing policies and sound fiscal and financial management (Iimi, 2007; Ross, 1999; Van der Ploeg, 2011). Also, Ross (1999) notes that the wave of nationalizing natural resources that started in 1950s, flooded governments of resource-rich economies with cash which only led to further fiscal laxity and overborrowing. However, such cognitive explanations of chronic economic mismanagement in resource-rich countries have faced a fair amount of criticism. Ross (1999) offers three critiques of the cognitive approach. First, the approach assumes that politicians and policymakers are revenue satisficers[33] not maximizers. Second, the theories are not presented in the form of testable hypotheses and have not been empirically tested. Third, there is little evidence all policymakers and politicians in resource-rich economies consistently fall into the same trap. Nevertheless, one could argue that the state, in resource rich economies, generally lacks enough motivation to invest in sectors other than the natural resource sector which impedes economic diversification and consequently economic development (Atalay et al., 2016).

[33] The term satisficing was introduced by Herbert A. Simon and in the economic context refers to a decision-making strategy that demands a satisfactory solution rather than the optimal one.

Sachs and Warner (2001) argue that politicians in resource-rich countries are more prone to rent-seeking and corruption simply because natural resource revenue is generally concentrated and easily appropriable. Influential groups or the elite in a society try to utilize their political influence to enjoy benefits that are mostly in the form or resource rents (Badeeb et al., 2017). Several studies have revealed that natural resource revenues empower the elite that benefit from the windfall, disproportionately (Gylfason, 2001; Hodler, 2006; Iimi, 2007). It is argued that prevalent rent-seeking behavior in resource-rich economies hampers investment in growth-inducing infrastructure, divert resources to consumption and rent dissipation, and only exacerbates conflicts among various stakeholders such as politicians, the elite, local tribes, and ordinary citizens over resource rents (Badeeb et al., 2017; Davis & Tilton, 2005; Iimi, 2007; Sala-i-Martin & Subramanian, 2013; Tiba & Frikha, 2019). As Sachs and Warner (2001) put it, this is where a predatory state crowds out the developmental state. In this context, a predatory state simply refers to the one that advocates private interests of influential groups and the elite instead of promoting public interests (Vahabi, 2020).

3.3.4. Volatility of Natural Resource Prices

Among the four economic drivers historically identified in the literature on the resource curse, the enduring relevance of two key factors, namely the volatility of resource prices and the Dutch disease phenomenon, has become increasingly evident over time.From an economic perspective, higher uncertainty due to volatility of natural resource prices, especially in resource dependent economies, simply impairs long-term economic planning (Davis & Tilton, 2005; Frankel, 2010). For example, falling resource prices negatively affects productivity of public and private investments as it makes planning for public spending and balancing public revenues and expenditures much harder for the state (Davis & Tilton, 2005). Furthermore, Humphreys et al. (2007) and Van der Ploeg (2011) note that overborrowing at the time of boom is prevalent among resource-rich economies. Overborrowing has two detrimental effects on a national economy. First, it simply intensifies the boom. Second, it increases the chances of a debt crisis especially when resource prices fall, and resource-rich economies face further pressure to put their financial house in order.

3.4. Empirical Evidence of Economic Resource Curse

The empirical literature on the resource curse is so rich that even literature review papers on the topic abound (Badeeb et al., 2017; Frankel, 2010, 2012; Papyrakis, 2017; Ross, 2015; Van der Ploeg, 2011; Van Der Ploeg & Poelhekke, 2017). One the most recent literature surveys (Badeeb et al., 2017) referencing the most influential papers, including Karl (2005), Sachs (2007); Sachs and Warner (1995, 1999, 2001), Arezki and Gylfason (2013); Gylfason (2001); Gylfason et al. (1999); Gylfason and Zoega (2006); Nabli and Arezki (2012), concludes that a countries dependence on natural resources through generation of resource rents best explains the resource curse, not merely the abundance of resources. However, there are still studies that report a significant negative association between natural resource abundance and economic growth—for example Tiba and Frikha (2019). Dependence on resource rents is also shown to be negatively correlated with other growth factors such as schooling and public spending on schooling and education and positively associated with macroeconomic volatilities, both effects harmful to long-term growth (Van der Ploeg & Poelhekke, 2009). Finally, some studies do not find any statistical evidence for the resource curse after controlling for other factors such as debt (Manzano & Rigobon, 2001).

However, the empirical evidence is quite strong for the detrimental effects of natural resources on state institutions. Some studies find the impact of resource rents on growth conditional on the weakness of institutions such as property rights enforcement, competitive markets, legal systems, and rule of law (Auty, 2001, 2004; Gelb, 1988; Ross, 2001b). A large number of studies report a strong and negative effect of resource wealth or resource rents on various measures of institutional quality, including lack of corruption (Anthonsen et al., 2012; Beck & Laeven, 2005; Bulte et al., 2005; Frankel, 2012; Hodler, 2006; Iimi, 2007; Isham et al., 2005; Knack, 2009; Sala-i-Martin & Subramanian, 2013). However, several studies do not find a strong and negative association between resource wealth and institutional qualities. For example, Busse and Gröning (2013) finds `a statistically significant link only exists for resource wealth and corruption. Bhattacharyya and Hodler (2010) report a similar result but only in the context of enduring nondemocratic regimes, and Alexeev and Conrad (2011) and Kennedy and Tiede (2013) do not find any significant link.

In general, the main conclusions from the resource curse review literature are consistent. That is, a dependence on resource rents harms economic development directly through impairing factors of growth, or indirectly through hollowing out state institutions (Badeeb et al., 2017; Ross, 2015; Van der Ploeg, 2011). The literature shows the resource curse is based on relatively convincing theoretical foundations. As Badeeb et al. (2017) argues, the theoretical mechanisms through which resource dependence hampers economic development still look robust and valid. That some empirical studies do not support these theoretical mechanisms may indicate the need for further theoretical elaborations. Also, it can be to some extent attributed to technical deficiencies in the analytical assessments, such as endogeneity, employing unsuitable models, and/or limited sample periods.

3.5. Political Resource Curse

The detrimental effect of natural resources goes beyond economic development. The 'political resource curse' contends a causal link between natural resource reliance and democracy exists. In the context of the resource curse, economic underdevelopment, authoritarianism and prevalence of civil conflicts have been studied and empirically examined as the three main negative consequences of resource wealth (Haber & Menaldo, 2011). The main hypothesis is that higher (lower) levels of natural resource dependence is associated with lower (higher) levels of democracy or long-lasting (less durable) autocracy (Haber & Menaldo, 2011).

The change in composition of government revenues in resource-rich economies is believed to be the key determinant of adverse political effects of natural resources (Prichard et al., 2018). Accordingly, most of the explanations why this vicious link exists are centered around the theory of the rentier state. Rentier state theory was first introduced by Mahdavy and Cook (1970) to explain how petroleum revenues—especially in the Middle Eastern oil exporting countries with nationalized oil and gas resources—provide states with huge rents that ultimately make them politically unaccountable to their citizens. There are a few other explanations for the political resource curse that can be considered extensions of, or complimentary to, the original rentier state theory. For example resource windfalls can provide autocracies with enough resources to finance political repression (Cotet & Tsui, 2013; Ross, 2001a) or buy the loyalty of the military and state security apparatus (Wright et al., 2015). Also, The Selectorate Theory claims that the presence of natural resources that requires minimal labor inputs reduces the provision of public goods and increases the chances of further authoritarianism—i.e., forming smaller winning coalition—in the face of revolutionary pressures. In the absence of such rents, governments increase the provision of public goods and become more democratic when facing revolutionary threats.

The rentier state, however, is not the only theory that intends to explain the political resource curse. For example, Mitchell (2009) argues that political consequence of resource dependence—specifically in the case of crude oil—is not limited to exporting countries. He claims that the way the concept of national economy is constructed and evolved, the very modern way of life, how democracy is shaped and being practiced in oil importing and industrialized economies and why autocracy has been persistent in oil exporting ones, can be explained by properties, and the organization of supply, of the dominant source of hydrocarbon since the early 20th century, namely crude oil. Mitchell's hypotheses, however, have not been presented in a testable format—i.e., generalizable, and falsifiable, terms—yet. This section focuses on the rentier state theory which has been the central theme of the political resource curse hypothesis and has been empirically examined through numerous studies in the past two decades.

3.5.1. The Rentier State

As per Karl (2007), a rentier state is one that depends on externally generated rents instead of the surplus production of its population for its economic sustenance. According to Ross's classification, the rentier state is a state-centered explanation of the resource curse. Access to windfalls from natural resources makes governments less dependent on tax revenues which simply translates into less accountability to citizens[34]. Huntington (1991) explains that oil revenues collected by the state empowers the state bureaucracy which in turn reduces the need for taxation. It ultimately leads to less pressure on the state to behave accountably and at the same time less reason for the public to demand better representation. For example, implementing unpopular policies such as raising taxes or slashing subsidies especially by undemocratic and less democratic systems instigates public demand for more accountability. Ross (2001a) uses the term 'fiscal pacification' to refer to a government's use of its fiscal power to reduce dissent. Windfalls of natural resources make it possible for governments to avoid, delay or dilute such policies and suppress demand for more accountability (Bates & Donald Lien, 1985; Brautigam et al., 2008; Ross, 2013, 2015). Furthermore, resource rents help political leaders to stay in power even when they face challenges to their rule. They can spend the rents at their disposal to intensify repression through buying loyalty of the military and/or boosting their security and intelligence services, or to bribe their supporters' base (Badeeb et al., 2017; Wigley, 2018; Wright et al., 2015). Resource rents also discourage governments from investing in and maintaining effective bureaucratic institutions such as tax collection apparatus that create a robust link between a state and its citizens (Moore, 2004). It consequently yields obvious detrimental political and economic outcomes. Overall, the common factor in all the mechanisms elaborated above is the ability of a rentier state to survive through access to natural resource rents. It is important to acknowledge the importance of the historical context in which the rentier state theory was developed (Ross, 2013). The huge wave of nationalization of oil and gas industries in 1960s, 70s, and 80s provided leaders of major oil exporting

[34] It is worth noting that the rentier state's theory borrows substantially from fiscal sociology which contends that characteristics of a state could be defined to a great extent by the sources of government revenue (Moore, 2004; Prichard et al., 2018).

countries—mostly developing and less developed countries—with an unprecedented amount of excess funds. Analogous to the explanations for the economic resource curse, the rentier state theory is based on a government's fiscal reliance on resource revenues—and not the shear abundance of natural resources.

3.6. Empirical Examination of Political Resource Curse

Ross (2001a) pioneered the empirical examination of the theory of the political resource curse and found strong evidence supporting it. Since then, numerous studies have been conducted to investigate the link between natural resource reliance and democracy. Most of these studies use cross-country data. Most of these studies find quite strong support for the primary hypothesis of political resource theory. That is, a country with high natural resource rents is associated with lower levels of democracy and/or with a lower likelihood of transformation from autocracy to democracy (Aslaksen, 2010; Brollo et al., 2013; Goldberg et al., 2008; Jensen & Wantchekon, 2004; Lucas & Richter, 2016; Papaioannou & Siourounis, 2008; Prichard et al., 2018; Ross, 2009; Smith, 2007; Wright & Frantz, 2017; Wright et al., 2015).

A number of studies claim that the effect of resource wealth on the stability of the political system depends on regime type. For example, Jensen and Wantchekon (2004) and Ross (2013) show that oil wealth strengthens wealthy democracies with strong institutions but erodes democracy in poorer countries with weak institutions. Another group of studies finds that oil wealth makes democracies more democratic and stabilizes autocracies (Dunning, 2008; Smith, 2004; Tsui, 2011). Smith (2004) basically calls oil wealth a pro-regime stability factor. Dunning (2008) also finds that the effect of natural resource or regime type is conditional on inequality, as higher inequality counterintuitively leads to a larger positive impact of resource wealth on democracy. A number of studies distinguish between short-term and long-term effects of the resource curse on democracy. Some studies do not find any significant link between changes in oil wealth and changes in the democracy level (Brückner et al., 2012; Haber & Menaldo, 2011) interpreted as a short-term effect (Ross, 2015). It can be argued that temporary increases in resource revenue may have a negligible short-term effect on autocratic regime survival but have a significant long-term effect (Prichard et al., 2018; Ross, 2015; Wiens et al., 2014).

A well-known study of the political resource curse (Haber & Menaldo, 2011), however, does not find any statistically significant link between resource reliance and autocracy. This particular study employs times-series models with fixed effect using instrument variables to address simultaneous causality and omitted variable bias. It covers 53 resource-rich countries from 1800 to 2006. The authors argue that resource curse may be a post-1973 oil crisis phenomenon when, suddenly, oil exporters were flooded with unprecedented sums of petrodollars which helped them nationalize their energy sector and gradually became less politically accountable. They also speculate it can be a geographical phenomenon as it is mostly observed amongst the resource-rich countries of Africa and the Middle East. Also, Manzano et al. (2008) observe that most resource-rich countries historically have had weak state capacity long before becoming resource-rich and resource dependent. So, state capacity might be the key factor that determines both resource dependence and lack of democracy (Haber et al., 2003; Haber & Menaldo, 2011). In contrast, a more recent study (Prichard et al., 2018) criticizes past studies such as Haber and Menaldo (2011) for using measures of resource income instead of resource rents and calls into question the conclusions of other contrary studies. Prichard et al. (2018), employing various econometric models such as pooled OLS, fixed effect and general method of moments (GMM), reports a robust and negative association between resource rents and democracy.

Overall, a large body of literature finds strong support for the political resource curse especially in the case of oil which is the key variable in the majority of the political resource curse literature (Ross, 2015). For example , a comprehensive survey of the literature (Ross, 2015) and a large meta-analysis study (Ahmadov, 2014) covering 29 studies of the political resource curse, report a negative and significant effect of natural resources (mostly oil) on democracy. The empirical examination of the theory especially supports the idea that natural resource rents prolongs and buttresses authoritarianism (Ross, 2015). It is indeed difficult to find empirically supported alternative explanations for such strong association between resource wealth and corruption, lack of democracy and weak state institutions

(Ross, 2015). Such conclusions however do not mean that critiques of the empirical examination of the theory especially the ones concerning reverse causality and omitted variable bias, should not be taken seriously (Wigley, 2018). Better and more complete samples of countries covering longer time periods in addition to employing better and more suitable regression models would only increase the robustness of the empirical test of any theory or hypothesis.

3.7. Resource Curse and Environmental Policy Outputs and Outcomes

Goodman and Worth (2008) note that a country's reliance on extractive hydrocarbon resources can contribute to environmental degradation in three ways. First, the very process of resource extraction is resource intensive itself—consumes too much energy and other resources. In addition to being resource intensive, resource extraction and production usually include land clearance for roads, pipelines, and other necessary infrastructures. There are also risks of spills, leaks and local environmental pollutions (Rajan, 2011) – so resource extraction can be environmentally destructive. Second domestic consumption of those hydrocarbon resources has harmful environmental impact though the pollution or poisons they emit, with those effects often downplayed. Third, resource exports also lead to further environmental degradation beyond the country of origin. Resource dependence can indirectly impact the environment through impeding economic development. Given the Environmental Kuznets Curve (EKC) effect that has strong empirical support, slower growth can translate into more enduring environmental neglects. Political and state institutions have a robust and significant effect on environmental policy outputs and outcomes. So, natural resources seem likely to have an indirect impact on environmental policy outputs and outcomes through eroding democracy and state institutions.

One can add that a strong and sizable resource sector, either in the form of private multinational entities or state-owned companies, usually has incentives to hamper development and implementation of environmental and climate policies. From a political economy perspective, transitioning towards cleaner energies through state policies can be seen as competition and conflicts between various interest groups (Lockwood et al., 2017; Roberts et al., 2018). Climate and environmental policies are seen as direct threats to the standard operating practices of hydrocarbon industries and industries dependent on them such as heavy industries, car manufactures, utility companies, and the mining sector (Lamb & Minx, 2020).[35] All these industries would try to oppose or derail development and implementation of environmental and climate policies or even roll back existing policies through different channels such as lobbying, neutralizing state bodies in charge of those policies, and shaping public environmental and climate discourses (Lamb & Minx, 2020). They may give up direct opposition to the policies but try to blunt them to minimize their compliance costs through policy exemptions and special arrangements (Lamb & Minx, 2020). The carbon tax repeal in Australia (Crowley, 2017), and opposition to coal regulation in South Africa (Baker et al., 2014) are two examples of how fossil fuel sector pushes to derail or blunt environmental policies.

Though the link between resource wealth and the environment looks obvious, the theoretical and empirical literature on the resource curse and environment is very scarce and nascent. There are limited studies that attempt to bridge the gap between the resource curse and the environment—though the two bodies of literature share several key concepts and elements such as quality of government, corruption, democracy, income, population state hydrocarbon rents, etc.—in their conceptual frameworks. A handful of country-level or state-level studies (Ahmad et al., 2020; Badeeb et al., 2020; Baloch et al., 2019; Bekun et al., 2019; Cooper et al., 2018) provide evidence in support of a negative link between natural resources and environmental policy outcomes, while Balsalobre-Lorente et al. (2018) finds a positive link. Also, Tiba and Frikha (2019) examine and find statistical support for the resource curse and EKC's hypotheses but still do not try to link natural resources to environmental outcomes. Among them, perhaps only Cooper et al. (2018) employs robust and sophisticated models to test its hypotheses. It through a quasi-experimental study of shale gas development and its impact on policy and politics in the context of US states, find that access to natural resources puts a downward pressure on environmental policy outputs

[35] These industries, and constituencies that are heavily dependent on these industries generally lobby against passing and implementation of environmental rules, regulations, and measures because of the compliance costs.

and leads to under-provision of environmental policies. It happens through buttressing the political position of anti-environmental stakeholders, consisting of interest groups and a sizable portion of the society that directly benefits from a resource boom and environmental deregulation.

3.8. Conclusion

The theoretical foundations for a political *and* economic resource curse are quite strong. The empirical evidence supports the theory and finds a robust causal link between resource rents and negative political and economic outcomes. These conclusions do not come without caveats. Papyrakis (2017) points out that the adverse effect of natural resources is largely conditional on a number of socio-political factors, that are both context and resource specific. As Van der Ploeg (2011) put it, the effect of natural resources varies from case to case and across different periods in history. Furthermore, the resource curse is observed at multiple levels, such as country, region, state or local levels (Papyrakis, 2017). A majority of the empirical studies of the resource curse, especially earlier ones, employ simple cross-sectional models. Overall, from a methodological perspective, in the context of the empirical resource curse literature, there is still a need for further theoretical elaboration and empirical investigation. Furthermore, there is a complex interconnection between economic and political development. Indeed, the economic and political dimensions of the resource curse are not independent from each other. There is a very rich debate in the literature on the causal direction between economic development and democratization. This topic is beyond the scope of this study that focuses on the adverse effects of hydrocarbon wealth on RE development.

More importantly, the literature investigating the link between natural resource dependence and environmental policy outputs and outcomes is truly sparse. The environmental impact of natural resources through their impact on institutions—including democracy—and economic development seems obvious and plausible. While there is no shortage of explanations for a negative impact of natural resources on environmental policy outcomes, the current literature on this topic is truly sparse and lacks empirical, theoretical, and technical rigor. Even more scarce is the empirical literature on the link between natural resource wealth and RE development.

Throughout this and previous chapters, significant gaps in the literature have been brought to light, specifically concerning the causal relationship between democracy and hydrocarbon resources on one hand, and renewable energy (RE) development on the other. This study stands out as one of the few endeavors seeking to directly address these existing limitations and fill the research void. Building upon the insights gleaned from this comprehensive literature review, the subsequent chapter formulates a set of testable hypotheses. These hypotheses are then subjected to rigorous quantitative and qualitative analysis to empirically investigate and shed light on the intricate connections between democracy, hydrocarbon resources, and RE development.

4. Theoretical Framework and Hypotheses

This study intends to investigate causal links between democracy, hydrocarbon richness, and state hydrocarbon rents on one hand, and RE policy outcomes on the other, employing regression analysis in the form of panel data modelling. The data and models used in the regression analysis are discussed in the following chapter.

This chapter presents a compilation of hypotheses that will be rigorously tested in this empirical study. These hypotheses have been carefully formulated, drawing from the insights garnered through the extensive literature review. As a result, they represent a well-informed and systematic approach to investigating the research questions at hand. Through empirical analysis, the study aims to validate, refute, or refine these hypotheses, ultimately contributing to a deeper understanding of the complex dynamics between the variables under examination.

4.1. Introduction

Hydrocarbon richness, state hydrocarbon rents, and democracy impact environmental policy outputs and outcomes broadly and RE development in particular, through a number of suggested causal pathways. As for democracy, electoral, liberal, deliberative, egalitarian, and participatory dimensions, and several other democracy components such as civil liberties core civil society, political accountability, constraints, federalism, etc. are included in this study.

A hydrocarbon rich country can become resource dependent. ‘Resource dependence’ refers to a state’s reliance on hydrocarbon resources as a source of state revenue, a national economy’s dependence on the hydrocarbon resource sector, or both. ‘Hydrocarbon richness’ and ‘state hydrocarbon rents’ can be captured separately using two distinct categories of indicators. ‘Hydrocarbon richness’ indices measure the level of hydrocarbon resource production in a country relative to its domestic hydrocarbon resource consumption regardless of who—the state, private fossil fuel sector, or both—directly receives the resource revenue. ‘State hydrocarbon rent’ indices capture state dependence on hydrocarbon revenues. The *Data and Modelling* chapter elaborates on how all these indices are constructed and calculated.

Modelling and testing the complex web of causal links and interactions at once, is very challenging if not impossible for obvious reasons. This complex web first needs to be broken down into simple unidirectional causal pathways that can be examined through testable hypotheses. In this theoretical framework, as justified by the literature review, the key drivers of RE development seem to be hydrocarbon richness, state hydrocarbon rents and level of democracy. What follows are a number of hypotheses that predict the positive, negative, or conditional effect of these factors on RE development. As for various dimensions, attributes and components of democracy, this study mostly adopts an exploratory approach. It means exploring whether various dimensions, attributes, and components of democracy have any significant effect on RE development, and if yes, whether their effects on RE policy outcomes are of disparate magnitude. Therefore, they come with no need for a priori hypotheses.

4.2. Level of Democracy and Renewable Energy Development

In the context of this study provision of environmental public goods refers to environmental and climate policy outputs and outcomes. Environmental *policy outputs* include environmental and climate rules, regulations, and commitments. Environmental *policy outcomes* are defined as the intended and unintended consequences of adopting and implementing those rules, regulations, and commitments. The main focus of this empirical study is on RE policy outcomes, which are a specific type of environmental policy outcome—measured as the share of renewables in a country’s electricity consumption and production capacity. As shown in Chapter 2, the scholarship on democracy and the provision of environmental public goods offers plausible explanations for how democracy influences a country’s environmental policy outputs and outcomes. Such explanations can be utilized to elucidate the positive impact of democracy on RE policy outcomes. It is necessary to acknowledge that hydrocarbon richness, state hydrocarbon rents and the level of economic development (income per capita) themselves influence the level of democracy.

The explanations for why a higher level of democracy is expected to yield more environmental policy outputs and outcomes in general, and RE policy outcomes in particular, include:

- Higher levels of democracy are associated with higher levels of political competition, political representation and political accountability which translate into lower costs of participation and the possible removal from power of officeholders. Democratic constraints on the state's monopoly of power and exploitative capacity, along with more responsiveness to public concerns and demands, is likely to result in more environmental policy outputs and outcomes.
- Higher levels of political and individual rights, and freedom of expression and the strength of an independent civil society in democracies, facilitates the translation of the environmental concerns of the public into environmental policy outputs and outcomes.
- Free flow of information, as a result freedom of expression in democracies, makes undersupply of environmental public goods more noticeable. Therefore, it is positively associated with environmental policy outputs and outcomes. This is despite, possible elite ownership and control of information and its distribution.
- A larger size of the winning coalition associated with democracies—according to the Selectorate Theory—makes provision of more environmental public goods more likely, as leaders/officeholders need to buy support from the winning coalition in order to survive.
- The greener preferences of the median voter in democracies—relative to less environmentally friendly preferences of the elite in less democratic or autocratic systems—can lead to provision of more environmental public goods.

Given these lines of reasoning in support of a positive link between democracy and environmental policy outputs and outcomes, the first hypothesis to be tested empirically, is presented as follows:

Hypothesis One: *All else being equal, more democratic political systems are on average more conducive to RE development.*

As shown above, a number of arguments point to a conditional effect of democracy on provision of environmental public goods. The key line of reasoning is that the overall effect of democracy on environmental policy outputs and outcomes also depends on institutional factors such as effectiveness and efficiency of the public administration apparatus (quality of government), the level of corruption and rule of law. Institutional factors are necessary for development and implementation of and long-term commitment to any public policy.

The second hypothesis of this empirical study, therefore, investigates a conditional effect of democracy on RE policy outcomes:

Hypothesis Two: *The positive effect of democracy on RE development is moderated by institutional factors such as quality of government, level of corruption, and rule of law.*

4.3. Hydrocarbon Richness State Hydrocarbon Rent and Renewable Energy Development

Hydrocarbon richness seems likely to influence a country's RE policy outputs and outcomes through a number of distinct but interconnected channels. A state's hydrocarbon resource sector can be nationalized, privatized or somewhere in between. It can be a relatively small or large sector, when considered in terms of a country's resource production relative to its resource consumption. The hydrocarbon sector itself can have a direct detrimental effect provision of environmental public goods. Revenues from hydrocarbon resources, if directly received by the state, constitute state hydrocarbon rents. As extensively discussed in Chapter 3, State hydrocarbon rents in turn can induce political and economic resource curses which hamper economic development and harm democracy and institutional factors such as rule of law. Furthermore, there is a robust and strong association between economic development and democracy themselves and of each with provision of environmental public goods. This section explores and examines causal pathways through which hydrocarbon richness and state hydrocarbon rents affect RE development.

4.3.1. Fossil Fuel Sector and Renewable Energy Development

There are a number of channels through which the presence of a sizeable private hydrocarbon sector can negatively affect environmental policy outputs and outcomes. Environmental policies, including RE policies, threaten the dominant position and standard practices of the fossil fuel sector and increases their cost of compliance, and the users of fossil fuel's costs. Therefore, users and providers both may try to oppose or derail the development and implementation of environmental and climate policies, blunt them, or even roll back existing policies. Extraction, production, and transfer of hydrocarbon resources are resource intensive and environmentally damaging. The hydrocarbon sector is therefore one of the main sectors in an economy that bears the cost of stricter environmental policies and regulations. Hence, this sector has clear political and financial incentives to oppose both passing policies and the effective implementation of policies aimed at climate protection and/or mitigation.

Furthermore, the hydrocarbon sector is the main beneficiary of carbon lock-in. Higher levels of fossil fuel energy consumption per capita and/or per unit of GDP (energy intensity) means more prosperity for fossil fuel industries. Therefore, the sector has a vested interest in maintaining the status quo or promoting more production and consumption of hydrocarbon resources. Fossil fuel industries historically have seen competition from alternative renewable sources as a major threat to their business model, deeply entrenched in the status quo. Therefore, the larger and more powerful the fossil fuel industries in a country, the stronger and fiercer the opposition to passing and implement environmental policies, such as RE polices, and consequently less development of renewable energy:

Hypothesis Three: *All else being equal, a country's level of hydrocarbon richness is negatively associated with RE development in that country.*

4.3.2. Economic Resource Curse, EKC, and Renewable Energy Development

The hydrocarbon sector can be state-owned, such as national oil/gas companies (NOCs). They can also be private, such as large multinational energy companies, or somewhere in between, such as Chinese oil, gas, and petrochemical giants. A state-owned hydrocarbon resource sector can induce even more detrimental effects on environmental policy outputs and outcomes due to conflict of interests. In this case, the state is the entity that directly benefits from resources revenues and at the same time is the one in charge of developing and implementing environmental and climate policies. Furthermore, state hydrocarbon revenues are also a root cause of the resource curse—generating economic and political ramifications which are detrimental to environmental policy outcomes. These causal links with RE development are elaborated in this and the following sections.

Dependence on hydrocarbon resource revenues is relatively prevalent in a large number of hydrocarbon-rich economies. Such dependence can be specifically more severe in countries with a nationalized fossil fuel sector where the state enjoys unhindered access to resource windfalls. The idea of the 'economic resource curse' refers to mechanisms that explain how a state's dependence on resource revenues leads to economic underdevelopment. As elaborated in the earlier review of resource curse literature, such detrimental impact can be attributed to the effect of resource dependence on economic development through its deleterious impact on institutional factors—such as rule of law, level of corruption, and quality of government. It also can be attributed to the moderating effect of the quality institutions on the causal link between state hydrocarbon rents and economic development. Either way, the level of dependence on hydrocarbon resource revenues in a country is negatively associated with that country's level of economic development.

A few causal pathways can explain how a lower level of economic development (income per capita) induced by economic resource curse has a negative effect on environmental policy outputs and outcomes. First, it is safe to assume that all else being equal, the state in less wealthy economies has less resources at hand to spend on public goods in general and on environmental public goods in particular. Second, the volatility of resource prices makes public expenditure-planning difficult in a resource dependent economy where state resource revenues constitute the lion's share of public expenditures. Effective provision of public goods requires consistency in policy planning, implementation, and evaluation. The price volatility has a detrimental impact on public goods provision through disrupting or undermining policy continuity. Third, the Environmental Kuznets Curve (EKC) hypothesis tries to explain why provision of environmental public goods may not be of a high priority in less developed economies. According to the EKC hypothesis, there is a certain income level after which a country's concerns for environment issues grow substantially. Resource dependence therefore can reinforce the duration and magnitude of the EKC effect. Last but not least, the level of economic development can have an indirect impact on the provision of environmental public goods through its association with the level of democracy. It is argued that urbanization, education, and industrialization are the key drivers of democratization, according to modernization theory. Overall, state dependence on hydrocarbon resource revenues can have a negative impact on RE policy outcomes through its negative impact on economic development (income level).

4.3.3. Political Resource Curse and Renewable Energy Development

As discussed in Chapter 2, provision of public goods in general depends on institutional factors and the level of democracy. The deleterious impact of state dependence on hydrocarbon revenues on the provision of environmental public goods can be explained through its negative association with the level of democracy and institutional factors such as quality of government, rule of law and corruption or lack thereof. Hydrocarbon resource dependence undermines provision of public goods through eroding state institutions and democracy. Hydrocarbon resource rents make the state less politically accountable to their citizens and provides resources to finance political repression or buy loyalty of the military and state security apparatus. Furthermore, the fiscal link between the state and society is a strong driver of government accountability which in turn affects the level and composition of public spending. Hydrocarbon resource revenues have significant contribution to state finances in many hydrocarbon-rich countries which makes genuine organizational and political interactions with citizens less critical for the state. State accountability is one of the key dimensions of democracy and has a significant and positive effect on provision of public goods. Overall, dependence on hydrocarbon resource revenues is expected to result in a lower level of democracy or a more enduring autocracy. As already discussed in a previous section, the level of democracy in a society seems directly associated with the provision of environmental public goods. Therefore, it appears safe to hypothesize that dependence on hydrocarbon resource revenues has a negative impact on RE policy outcomes.

The level of democracy also can affect income level through its negative impact on institutional factors such as the level of corruption and rule of law. As discussed in the literature review, a democratic system is more likely to promote economic reforms necessary for long-term growth, on average raises more taxes to be invested in growth-inducing public goods such as education and healthcare and can manage and handle social conflicts and unrests better than an autocracy. Income level and institutional factors in turn have a direct effect on provision of public goods in general, and environmental policy outcomes in particular. Therefore, the level of democracy can also indirectly influence the provision of environmental public goods through its moderating effect on economic development and institutional factors.

In sum, all direct and indirect links between state hydrocarbon resource dependence and RE development through democracy and economic development indicates a negative causal effect which is summarized in the following hypothesis:

Hypothesis Four: *All else being equal, the higher the state dependence on hydrocarbon resource revenues, the lower the level of RE development.*

Finally, it is argued that the effect of hydrocarbon resource rents on economic development and consequently on provision of environmental public goods also depends on the level of democracy and institutional qualities such as corruption and rule of law. The hypotheses that follow aim to test the validity of such propositions:

Hypothesis Five: *The negative effect of state hydrocarbon rents on RE development is moderated by the level of democracy.*

Hypothesis Six: *The negative effect of state hydrocarbon rents on RE development is moderated by institutional factors such as the level of corruption, quality of government, and rule of law.*

The six hypotheses outlined above represent the primary hypotheses to be examined in this empirical study. The following chapter delves into the methods employed to investigate these hypotheses.

5. Methodology

In the political economy scholarship, the positivist worldview, embraced by this empirical study, is characterized by examining the validity of a theory through measurement and empirical analysis (Dasgupta & De Cian, 2016, 2018). As asserted by Rich et al. (2018), the examination of factual realities is referred to as empirical analysis, which is about developing and applying an objective quantitative and/or qualitative language to describe and explain the observed reality. The positivist worldview has the elements of being deterministic, logical and reductionistic (Cresswell, 2007), and assumes the objectivity in the outside world, where a researcher is an objective observer and reporter of facts (Vanderstoep & Johnson, 2008). It is centered around the determinism of causality, the critical role of evidence, data, and empirical analysis in creating knowledge (Phillips et al., 2000).

It is however critical to acknowledge that almost any subject of investigation in the field of political science—or any field of science—is too complicated to model comprehensively and coherently all at once. Bueno de Mesquita (2016) characterizes the modest purpose of an empirical model—as "an abstraction and simplification" of a real-world phenomenon or problem—is to reveal and investigate some insightful general patterns or principles. It can be done through isolating a few key aspects of that problem or phenomenon so that a researcher can scrutinize it thoroughly and without distraction (Bueno de Mesquita, 2016).[36]

This study intends to look at the dynamics between democracy—and its various dimensions, forms, and qualities—hydrocarbon richness and state hydrocarbon rents on one hand and RE development on the other, from a political economy perspective. Though this study adopts this perspective, it important to acknowledge other perspectives through which such dynamics can be examined. For example, socio-technical transition frameworks apply a broader definition of state and institutions. Such frameworks encompass a wide

[36] Bueno de Mesquita (2016) further elaborates that a model cannot be a merely abstract object and its key element must correspond to key features of the problem or phenomenon under investigation. According to Roland Giere, a philosopher of science, models are carefully crafted representations that are designed in a way that allows elements of the model to be linked or coordinated with features of the actual world (Giere, 2010). A model, as an abstraction, is considered useful if it can be related to the problem or phenomenon under investigation in a meaningful and convincing way and more importantly can provide extra insight about it (Bueno de Mesquita, 2016).

range of actors such as national and state governments, organizations, structures, networks and relationships to explain how they impact societal processes and decision-making (Dasgupta & De Cian, 2018; Turnheim et al., 2015). Vasstrøm and Lysgård (2021) discusses the critical importance of understanding the interplay between state policies, technology, market investments, and social acceptance, and Sovacool et al. (2020) and Lysgård (2019) emphasize discovering what forces shape energy transition policies and in what ways and whose concerns are addressed or ignored. Another perspective is based on the concept of complex adaptive systems which sees the web of links between governance, institutions, and environment complex as interactive and evolving (Axelrod et al., 2001; Cherp et al., 2011; Dasgupta & De Cian, 2018).

5.1. Introduction

This project is an empirical study that adopts a mixed method approach. This approach includes quantitative analysis in the form of regression modelling and qualitative analysis in the form of case study analysis. An empirical study indeed can include quantitative analysis, qualitative analysis, or a combination of both. Both types offer observational evidence though the use of experimental and quasi-experimental research designs have recently been growing in popularity in political science (Crasnow, 2012). Quantitative methods, tools, and techniques, such as formal models, simulation, statistical methods, and more recently machine learning, have become increasingly prevalent and dominant in the political science scholarship in the past few decades. A considerable shift in methodological emphasis from qualitative methods to quantitative ones in political science emerged in early 20th century (Crasnow, 2012).[37] Box-Steffensmeier et al. (2008) argues that such development was a

[37] By most accounts, the current dominance of quantitative methods in the political science scholarship especially in the US owes a great deal to the early and earnest efforts of Charles Merriam and his disciples at the University of Chicago in the 1920s (Sylvan, 1991). It is worth noting that in a recent review of methods in the political science literature, Lewis-Beck and Bélanger (2015) reports a sharp contrast between US and France in employing quantitative methods in political science. They call it an epistemological difference which denotes problems, solutions and interpretations are seen through fundamentally different lenses in US and France [and most likely the rest of the continental Europe]. While the American political science scholarship is overwhelmingly

result of the rise of causal thinking in political science at the turn of the 20th century.[38] Brady (2003) elaborates on four distinct approaches to causal thinking—namely the 'neo-Humean' regularity, counterfactual, manipulation, and causation—and argues that the neo-Humean regularity and causation approaches correspond closely to regression analysis and case study, respectively. The neo-Humean regularity approach enquires about causation through investigating correlations and associations between variables of interest, while the focus of the causation approach is mostly mechanism(s) through which a cause-and-effect process or processes can be explained (Bennett & Elman, 2006). It is important to acknowledge that various disciplines of social science practice, and different research traditions frame their research questions and approach them differently (Byrne, 2017). It appears safe to claim that quantitative empirical analysis in political science and its subdisciplines is a longstanding tradition.

Quantitative analysis, simply put, entails specifying numerical assignments to concepts, constructs, objects and events under study, then comparing and analyzing their mathematical characteristics (Rich et al., 2018; Vanderstoep & Johnson, 2008). Quantitative analysis mostly revolves around the concept of generalization, or the average effect of one or a set of factors on one or a set of variables of interest (Vanderstoep & Johnson, 2008). Quantitative methods can provide important insights about the magnitude and range of various factors that explain a phenomenon and also the strength of linkages among them (Box-Steffensmeier et al., 2008). It is critically important to understand that solid causal inference requires solid conceptualization and measurement of the phenomena under investigation (Box-Steffensmeier et al., 2008). Causal inference refers to the process of determining cause-and-effect relationships between variables or events based on empirical evidence and rigorous analysis.

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quantitative, its French counterpart is mostly qualitative. Bennett et al. (2003) also reports the steep decline of the case study approach, as the most prevalent qualitative method in political science and international relations, in US between 1970s and 2000s.

[38] Box-Steffensmeier et al. (2008) offers three possible explanations for the rise of causal thinking: (i) A shared scientific value attributed to causal thinking by political scientists and acceptance of causal thinking as a common standard for evaluating academic scholarship; (ii) invention and advancement of statistical tools such as regression analysis; and (iii) a behavioral revolution emphasizing development of testable causal theories/hypotheses.

On the other hand, qualitative analysis—in the case of this study, case study analysis—includes textual description of a phenomenon and intends to shed light on the causal mechanism that explains why and how one or a set of factors affect the researcher's variables of interest (Box-Steffensmeier et al., 2008; Vanderstoep & Johnson, 2008). Qualitative methods including case studies are generally described as inductive which denotes a flow of reasoning from observation to theory/hypotheses to interpretations (Vanderstoep & Johnson, 2008). Within a mixed method framework, they can complement quantitative methods that are generally characterized as being deductive. Indeed, there is a growing popularity of inclusion of cases or illustrative examples in the quantitative political science literature (Ruffa, 2020). The objective is mainly to further investigate the plausibility of the causal links discovered by quantitative analysis. Overall, from the positivist perspective, the ultimate goal of using mixed method approaches is causal and/or descriptive inference through employing methods in a manner that is rigorous, systematic, and capable of being replicated (Ruffa, 2020). [39]

In the context of this study, regression analysis has unique properties that allow for inclusion of many countries, investigation of those countries for a relatively long period of time, and estimation of the average effect of the hydrocarbon-richness state hydrocarbon rents, and democracy—and its dimensions forms and models—along with several other independent variables of interest on RE development. Case study methods, on the other hand, are very capable tools for further investigation of presumed causal mechanisms through which the independent variables affect the dependent variable of interest.

In this chapter, first a key distinction between quantitative and qualitative analyses particularly in the political science scholarship is explained. Then regression analysis, case study analysis and the mixed method approach along with their advantages and limitations are elaborated.

[39] In this empirical study, the concept of inference is derived from Brady and Collier (2010), where it is defined as the process of utilizing data to make more extensive conclusions about the concepts and hypotheses that are the primary focus of the research.

5.2. Causes of Effects vs. Effects of Causes

Proponents of quantitative and qualitative methods in political science engaged in a battle of criticizing each other's methods for a long time—critiques such as small sample size and lack of generalizability of qualitative studies and reduction of a complex reality to an oversimplified equation in quantitative studies (Vanderstoep & Johnson, 2008).[40]

A quantitative analysis usually begins with development of one or a set of testable hypotheses based on a theoretical framework. Measurement of the phenomenon or phenomena under investigation, including operationalization of variables of interest, is the next step. The phenomenon or phenomena therefore have to be quantifiable in one way or another (Sylvan, 1991). Finally, the outcome of quantitative methods such as regression analysis provides estimates for the average effect of the factors that define or shape the phenomena according to the theoretical framework. Quantitative analysis is to some extent silent about the causal mechanism(s) yielding such effects (Crasnow, 2012; Gerring, 2004, 2009). On the other hand, qualitative methods generally presume that a phenomenon is more complex than a one-way causal relationship that a regression analysis might suggest. Such a complex reality can be characterized by path dependence, tipping points, two-directional causality, equifinality or multi-finality (Bennett & Elman, 2006). In short, identifying and verifying a cause or causes of an effect is the key concern of qualitative methods such as a case study analysis. This distinction has been widely acknowledged by methodologists in the fields of political science (Bennett & Elman, 2006; Crasnow, 2012; Gerring, 2004, 2009; Thelen & Mahoney, 2015).[41]

Choosing between causes-of-effects and effects-of-causes approaches—which have been mostly associated with case study and statistical analysis respectively—depends mostly on the research objectives (Mahoney & Goertz, 2006). However, recent methodology

[40] Ross (1999) argues that in a qualitative analysis a lack of framing causal links in a testable falsifiable and generalizable format can lead to underspecified and vague arguments with ambiguous variables and fuzzy causal mechanisms. It also may not result in accumulation of replicable findings or in other words a body of empirical knowledge.

[41] It is worth noting that the causes-of-effects/effects-of-cause distinction is not a new concept. It was indeed identified and discussed in the work of John Stuart Mill as early as 1850s (Bennett & Elman, 2006).

scholarship, particularly in political science, emphasizes on complementarity of quantitative and qualitative methods. For example, Bennett and Elman (2006) argues that qualitative methods such as case study analysis can provide additional and complementary inferential insights even when quantitative analysis is feasible. For example, an in-depth case study can help examine spuriousness or endogeneity of statistical links between variables of a regression analysis. As Thelen and Mahoney (2015) notes, the aim of a case study is not generalization of effects of various factors on an outcome of interest in a large population but identification, tracing and verification of causal links between them.

5.3. Regression Analysis: Panel Data Modelling

Given the nature of the inquiry, this study employs regression analysis in the form of panel data modeling. Any regression model will include a dependent variable and several independent variables. Changes in the independent variables are expected to explain variation in the dependent variable. The goal of regression analysis is to identify and examine patterns of association and relationships between the independent variables and the dependent variable in a large enough sample. The relationships are then generalized to a whole population (Fearon & Laitin, 2008). But since association and correlation does not necessarily mean causation, such statistical patterns need to be accompanied by one or a set of convincing arguments elucidating the possible causal links between the variables of interest (Fearon & Laitin, 2008). Such arguments are basically the building blocks of the theoretical framework, based on which, the regression model was constructed in the first place. To ascertain that the variation in the dependent variable is not the result of other factors, control variables—technically extra independent variables—are added to the regression equation (Fearon & Laitin, 2008). Regression analysis, however, is not without limitations and shortcomings. Selection bias, endogeneity, omitted variable bias, and insufficient theoretical underpinning are considered key limitations of regression analysis (Box-Steffensmeier et al., 2008).

This study employs time-series cross-section (TSCS) or panel data modeling. Panel data consists of observations of 'units'—in the context of this study, countries—at different points in time—in this study, different years[42]. In this sense, Troeger (2019) explains two clear advantages of panel data analysis over the analysis of time series or cross-sectional data. First, higher degrees of freedom as a result of a larger number of observations allow for testing more complex hypotheses by employing more complex estimation methods and specifying more complex models. Second, many theories in political science offer predictions over space and time—e.g., theories concerning the relatively long process of democratization in different polities. The panel data structure, containing repeated measurements of variables for each unit of analysis, allows for proper examination of such theories and hypotheses.

Panel data models have become dominant in empirical studies in the field of political science, especially in comparative politics and comparative political economy (Beck, 2008; Bell & Jones, 2015; Leszczensky & Wolbring, 2022). Two kinds of Panel data models have become commonly used; random effect (RE) and fixed effect (FE) models. Both have their advantages and limitations. FE models have been the go-to tool in economics, and political science. When the unit of analysis is country, a country-fixed effect model basically controls for all idiosyncratic characteristics of each country—such as each country's specific political, social and historical factors not included in the model—through the inclusion of a country-fixed effect term in the panel data model. They are a useful tool for dealing with omitted variable bias which is presumably a big concern in panel data analysis. But, controlling for time-invariant variables and a country's idiosyncrasies does not come without costs. FE models, focus exclusively on within-country variation and cannot make any statistical inference regarding between-country variance, and more importantly time-invariant variables—such as a country's climate change vulnerability or RE potentials. Additionally, they have difficulty in estimating the effect of variables with little within-country variation

[42] In the context of this study panel data and TSCS data are used interchangeably. However, they sometimes refer to different types of data structure. Panel data can refer to a structure with a relatively large number of units and small number of observations per unit. This distinction can become critical, as some statistical tools and procedures that work well for TSCS might not work properly for panel data (Beck, 2008). This project uses a dataset that includes numerous countries observed for a relatively long period of time—to be precise, an unbalanced panel data of more than 130 countries with observations for 30 years.

that might be of particular interest (Bell et al., 2019; Bell & Jones, 2015; Schurer & Yong, 2012). This can specifically become problematic when time-invariant and slow-moving (sluggish) variables are of particular interest in an empirical study such as this one. By controlling out time-invariant or slow moving variable, such models may produce results that are incomplete, and hence fail to explain country heterogeneity and sometimes answer important research and policy questions (Bell & Jones, 2015). Furthermore, they are less efficient, and consume more degrees of freedom than RE models. [43] More importantly, two-way FE models which control for country and year fixed effects, produce results that might be quite uninterpretable (Imai & Kim, 2021; Kropko & Kubinec, 2020). The latter point is further elaborated in the following chapter.

RE models are more flexible and do not have the shortcomings of country-fixed effect models (Dieleman & Templin, 2014). They use the feasible generalized least square (FGLS) estimator. Two-way RE models do not have the uninterpretability problem of FE models. But they are premised on the assumption that no significant between-country heterogeneity exists. It basically presumes that variation across countries is random and uncorrelated with the independent variables. But country-specific characteristics such as culture and history can have a substantial impact on the independent variables. Moreover, the risk of omitted variable bias is higher in RE models, as they may not be able to control for all likely predictors of the dependent variable—although it is argued that researchers should not place undue emphasis on minimizing bias at the expense of efficiency and interesting information (Bell & Jones, 2015; Clark & Linzer, 2015).[44] Finally, RE models need to deal with serious robustness issues due to heteroskedastic and serially and cross-sectionally (contemporaneous) correlated error terms. Such issues complicate statistical inference and

[43] Generally, a more efficient estimator requires a lower number of observations to achieve a specific level of estimation precision.

[44] Clark and Linzer (2015) through interesting simulations shows that under many realistic conditions, gains from higher efficiency of RE models and their ability to estimate time-invariant and sluggish variables far outweighs losses due to omitted variable bias. The study reveals that the mere presence of correlation between independent variables and unit effects in an RE model is simply not a sufficient condition for ruling out the RE model altogether.

requires robust standard error estimations which in most cases jeopardizes statistical inference.

A third type of panel data model, called the linear mixed model (LMM), hierarchical model, or multilevel model, has been gaining popularity recently in political science—e.g., Bayulgen and Ladewig (2017), Shor et al. (2007), and von Stein (2020). It uses the maximum likelihood estimator, has fixed effect and random effect parts—not to be confused with econometric FE and RE models elaborated above—and can control for more than two random effects—e.g., country, region, and year random effects. In terms of structure, it is similar to traditional random effect models. Recent studies and simulations have shown quite strong robustness of LMMs to bias, and type-I error due to violations of distributional assumptions such as heteroskedasticity and serial correlation (LeBeau, 2016; Schielzeth et al., 2020).

The LMM also can incorporate the within-between specification, which is similar to random effect within-between (REWB) specification in econometric models. It is a novel way of model specification with striking capabilities. The within-between specification has become popular recently, especially after the work of Bell and Jones (2015). It was originally introduced to tackle the limitations of fixed effect models. This specification method allows for estimation of the effect of variables within units and across units separately (Bell et al., 2019; Bell & Jones, 2015).[45] The within-between specification has its origins in the work of Mundlak (1978). The specification can capture within-country and between-country effects of independent variables separately while controlling for any country-specific time-invariant factor. It is basically an RE model with additional time-invariant variables (Bell & Jones, 2015). Dieleman and Templin (2014) and Bell and Jones (2015) show that within-group (within-country when the unit of analysis is country) estimates in an FE model and the within-between model are asymptotically identical while the within-between specification produces additional information regarding across-unit effects (time-invariant variables). It basically means producing estimations identical to those of the FE model and more, using a

[45] For example, the within-between specification distinguishes between the effect of GDP per capita on democracy as GDP per capita grows in a country from $1,000 to $1,200 (within effect) and the same effect as GDP per capita changes from country A with average GDP per capita of $1,000 to country B with average GDP per capita of $1,200 (between effect).

fraction of the degrees of freedom an FE model consumes. It also means avoiding less flexibility, less efficiency, and less precision (high variance) of FE models and to an acceptable degree tackling bias of RE models simultaneously (Bell et al., 2019).

In the LMM, the within-between specification can tackle confounding by cluster—discussed in the following chapter—in addition to providing more information from same data. This study is among a few but growing number of studies in political science and environmental politics that employs the LMM and perhaps the first one to incorporate the within-between specification into the LMM. Full details of the modelling, specifications, and data that are employed in this study are discussed in the following chapter.

5.4. Case Study Analysis

According to George and Bennett (2005), a case study is the comprehensive investigation of a particular aspect of a historical event to formulate or test historical explanations that could be applicable to other occurrences. Levy (2008) characterizes a case study as an effort to comprehend and interpret a defined collection of events within specific spatial and temporal boundaries. Collier et al. (2004) discusses the case study method as an analysis involving rich and dense information concerning one or several specific cases. It is worth noting that in the context of a case study, that "rich and dense information" can be completely qualitative, include quantitative components such as historical data and numerical information in the form of tables, graphs, etc., or a mix of both (Crasnow, 2012; Mills et al., 2009). Gerring (2009) refers to a case as a spatially demarcated unit—e.g., country in the context this project—observed once or over an extended period.

Historically the case study approach has been a prevalent method in comparative politics and comparative political economy fields (Gerring, 2004, 2009; Mills et al., 2009). Gerring (2009) elaborates how a recent epistemological shift has boosted the popularity of the case study method in political science. He explains that it is a result of a recent push by realists for more emphasis on identification and elaboration of causal mechanisms as a complement to statistical inference and as an integral part of any causal analysis.[46] From the positivist perspective, the aim of a case study can be generalization of a causal relation beyond a case or cases under investigation through identification and elaboration of patterns of behavior using observational data (Ruffa, 2020). In this regard, no fundamental difference exists between the objective of a large-n quantitative analysis and a case study analysis.

Gerring (2004, 2009) and Ruffa (2020) enumerate the advantages of the case study method over the large-n quantitative method. Gerring (2009) argues that the subjectivity of case studies allows for identification, and examination, of a larger number of possible hypotheses and insights than in large-n quantitative analyses—which have to have more determinate definitions of factors and variables. Depth of analysis or contextual sensitivity, which refers to details, richness, and comprehensiveness of an analysis, is another key advantage of the case study method. Furthermore, Gerring (2009) elaborates that some challenges regarding operationalization and measurement of variables in a large-n study—such as measurement bias, measurement errors, and aggregation and conceptualization problems—can be avoided in a case study. He argues that the case study method that includes one or a small number of cases allows for evaluating consistency of a case's recorded data, identifying sources of measurement bias and errors, and rectifying them. The final objective of a case study is generally theory testing, theory development or both (Ruffa, 2020). Not surprisingly, the objective of employing the case study method in this empirical study is theory testing or in other words, testing the validity of the set of hypotheses elaborated in the theoretical framework chapter (Chapter 4).

5.4.1. Single Case Study vs. Multiple Case Studies

Methodologists distinguish between single-case study—also called single-sited study or within-case study—and multiple-case study—also called comparative case study analysis,

[46] Even in economics discipline, the case study method has become a popular tools to examine theoretical predications and causal mechanisms associated with a formal economic model (Gerring, 2004, 2009).

multi-sited study, or cross-case study. A single case study focuses on within-case variation, while a multiple case study deals with cross-case variation (Gerring, 2009). Single case studies and comparative case studies have their own advantages and disadvantages. When it comes to choosing the number of cases in a case study there is a spectrum between the single-case approach and cross-case approach.[47] Gerring (2009) does not distinguish between the two sides of the spectrum when it comes to investigation of the causal mechanism, though believes that a fewer number of cases allows for a deeper and more comprehensive analysis. Mills et al. (2009) on the other hand, contend that research design and research objective of a single case study and a multiple-case study are different. While a comparative case study focuses more on covariation across cases, a single-case study mostly tries to examine the validity of the theory through identifying theory-driven expectations in the context of the single case (Mills et al., 2009). Ragin and Becker (1992) believe that comparative case studies are still a capable tool for identifying and examining causal relationships, in addition to deep contextual understanding in the context of more than one case. Ruffa (2020) argues that single case studies generally have a higher level of conceptual validity as they allow for construction and measurement of more nuanced and complex concepts in the context of one single case. They however are more prone to the risk of case selection bias, and are not able to control for confounders (Ruffa, 2020). Comparative case studies potentially can control for confounding factors, generally enjoy a high level of external validity but still can suffer from selection bias, and the risk of missing the independence among cases or comparing apples and oranges (Ruffa, 2020). Finally, Della Porta (2008) distinguishes between case-oriented approaches and variable-oriented ones in the context of comparative case studies. According to Della Porta (2008), variable-oriented studies primarily strive to establish generalized connections between variables, whereas case-oriented research aims to gain an understanding of intricate individual units. Due to the nature of this study and its theoretical framework, the variable-oriented approach is adopted for the qualitative part of this study.

[47] As a rule of thumb, the number of cases can be between one and up to six (Mills et al., 2009).

5.4.2. Considerations for Case Selection

Seawright and Gerring (2008) argues that case study analysis and case selection are more closely interconnected in case study research compared to large-n cross-case analysis. Case selection is a very critical part of the case study method. There is no shortage of criteria based on which a case or cases can be chosen. To avoid selection bias, Fearon and Laitin (2008) recommends a random case selection. They further elaborate that stratifying based on particular variables of interest can be more useful and efficient than purely random case selection. Gerring (2004, 2009) and Seawright and Gerring (2008) identify seven distinct categories of case studies: typical, diverse, extreme, deviant, influential, most similar, and most different cases.

According to Gerring (2009), a typical case is a representative case that exemplifies a stable, cross-case relationship. A typical case approach is mostly useful when the aim is to confirm a theory's predictions and/or hypotheses (Seawright & Gerring, 2008). Diverse selection strategy requires choosing at least two cases that represent the full range of independent or dependent variables. Such a strategy may enhance representativeness or the sample. Extreme cases are the one that have their value of the dependent or independent variables far away from the mean value. A deviant case is the one that simply does not behave according to the theory's predictions. Gerring (2009) argues that such cases are useful for probing for alternative explanations. Influential cases have a disproportionate impact when included in a large-n quantitative analysis. Identifying and examining such cases allow scholars to check robustness of their regression analysis. The most similar approach includes a minimum of two cases similar on all measures—independent variables—except one. Finally, the most different approach is the opposite. While the extreme case approach is mostly suitable for exploratory purposes—exploring alternative explanations—the influential case approach is mostly confirmatory, the diverse, deviant, most similar and most different approaches can serve both confirmatory and exploratory purposes (Seawright & Gerring, 2008). Fearon and Laitin (2008) also suggests choosing a cases that are off the regression line, which is very similar to the deviant type in Gerring's typology. Each type has its own advantages, disadvantages, and limitations.

The more fundamental question that precedes case selection strategy is the purpose of a case study. Gerring (2004) and Seawright and Gerring (2008) argue that the purpose of most case studies is to identify a pattern or patterns generalizable to a larger population. Seawright and Gerring (2008) talks about a case's "heroic role" of representing a population of cases larger than the case itself. When the unit of analysis is country, the population can be countries with one or a number of specific attributes—for example, enjoying similar levels of hydrocarbon-richness or democracy. Seawright and Gerring (2008) then elaborate on the difficulties of identifying a representative enough case that also has variations across relevant dimensions of theoretical interest. There is a second camp among the methodologists that argues emphasizing case representativeness and case selection bias are to a great extent unwarranted and misplaced—though they don't entirely dismiss them—in the context of qualitative case studies (Bennett et al., 2003; Bennett & Elman, 2006; Collier et al., 2004; George & Bennett, 2005). To begin with, identification and understanding a causal pathway, and its context and scope precede examination of its generalizability (Bennett & Elman, 2006). Furthermore, the concept of selection bias does not seem applicable to a case study that concerns causal inference through process tracing (Bennett & Elman, 2006). George and Bennett (2005) point to the fact that process tracing is fundamentally different from quantitative methods which revolve around the concept of covariation. In Process tracing, the objective is simply to find and evaluate evidence in support of a causal pathway not covariation between causes and outcomes. Bennett and Elman (2006) argues that selection bias concerns arising from selection based on the dependent variable—the outcome—are overblown especially when the very purpose of a study is to identify cause or causes of that outcome. Overall, choosing cases based on their historical importance or data availability should not be considered a serious cause of concern right away (Bennett & Elman, 2006; George & Bennett, 2005).

5.5. A Mixed-Method Approach

A mixed method approach, also called multi-method or hybrid, combines more than one distinct method within the same study (Harbers & Ingram, 2020). The Journal of Mixed Method Research defines it as research in which the researcher gathers and examines data, combines the discoveries, and makes deductions by employing both qualitative and quantitative approaches or methods within a single study (Tashakkori & Creswell, 2007). The popularity and prestige of the multi-method approach in political science has been growing since the mid-1990s (Fearon & Laitin, 2008; Harbers & Ingram, 2020; Lieberman, 2005).[48] Methodologists enumerate both advantages and limitations of quantitative and quantitative approaches and point to the complementarity and synergy between them. A well-executed multi-method approach can benefit from the key advantage of the large-n quantitative method in revealing statistical patterns of interest, *and* the key strength of the case study method in identifying and assessing possible causal pathways yielding the outcomes of interest (Fearon & Laitin, 2008). Gerring (2004, 2009) uses the term 'triangulation' to refer to the application of a variety of research methods in the political sciences.

Statistical methods allow for testing hypotheses, and revealing statistical patterns in the form of average effects of the variables of interests on the dependent variable within a large population of single cases (Thelen & Mahoney, 2015). Quantitative methods are the best tools for testing generalizability of interesting ideas (hypotheses). Furthermore, the outcome of such methods are useful for forming policies that are intended to address issues across a large population of cases (Thelen & Mahoney, 2015). Quantitative methods may also identify interesting categories of cases which can be further examined through case studies (Bennett & Elman, 2006; Byrne, 2017). Case studies are very useful for assessing plausibility and internal validity of a story or hypotheses offered to explain results of an empirical statistical analysis (Fearon & Laitin, 2008; Thelen & Mahoney, 2015). Case studies also can help explore new explanations (new independent variables or causal pathways) and investigate the endogeneity and spuriousness of average effects estimated by quantitative

[48] The mixed method approach has become an integral part of the methodology literature—e.g., Gerring (2016), Goertz (2017), Seawright (2016) and Weller and Barnes (2014)—in political science.

methods (Bennett & Elman, 2006). Inputs from case studies can result in refinement and modification of the statistical models employed or even suggest using new ones (Thelen & Mahoney, 2015). Even a deviant case, as Lipset (1959) argues, has the potential to reinforce a hypothesis by revealing specific conditions that prevented the typical relationship from manifesting itself. What is obvious is that statistical analysis and case study methods do not have to appear to belong to two separate worlds. They can be linked to each other through a feedback loop so each can benefit from the constructive feedback it receives from the other one. it seems intuitively obvious that using a wider range of tools and techniques in the so-called methodological toolbox of political science can lead to a better understanding of complex social, political and economic processes (Harbers & Ingram, 2020). That is perhaps the key reason the multi-method approach has found strong support among political science methodologists in recent times.

It is however important to acknowledge the discord among political science methodologist regarding viability of a mixed method approaches. For example, Gerring (2009) later contends that case study and large-n methods have different purposes and are somehow irreconcilable. He concludes that: "Ceteris paribus, case studies are more useful when the strategy of research is exploratory rather than confirmatory/dis-confirmatory, when internal validity is given preference over external validity, when insight into causal mechanisms is prioritized over insight into causal effects, when propositional depth is prized over breadth, when the population of interest is heterogeneous rather than homogeneous, when causal relationships are strong rather than weak, when useful information about key parameters is available only for a few cases, and when the available data are concentrated rather than dispersed" (Gerring, 2009, p. 1159). Furthermore, Crasnow (2012) warns that verifying a causal pattern through a case study does not necessary provide evidence in support of average effects estimated through quantitative analysis.

Harbers and Ingram (2020) discusses the combination of different methods in the context of the mixed method approach along three key dimensions: (i) the degree of integration; (ii) the sequence of combination; and (iii) the analytic motivation of the combination. The degree of integration refers to the extent to which each method utilizes data, information or observations used by the other method. A majority of case studies in political economy and comparative politics literature uses the same sources of data and information as quantitative studies do. As for the sequence of combination, the sequence from quantitative modelling to qualitative analysis has been very popular in the field of political science, where the outcome of regression modelling can facilitate case selection process (Harbers & Ingram, 2020). It is by no means a unidirectional path though. For example, investigation of an outlier(s) of a regression model through a case study analysis may eventually lead to correction or improvement of the model itself. Finally, the analytical motivation of almost all mixed method studies in political science that adopt the positivist worldview is inference. According to Brady and Collier (2010), the process of inference involves using data to draw conclusions about "what happened" (descriptive inference) and "why it happened" (causal inference).

Given the nature of this study, a mixed-method approach is adopted that includes panel data analysis and case studies. This study applies panel data models that are constructed based on the hypotheses discussed in the theoretical framework chapter (Chapter 4). The theoretical framework of this study, as elaborated in the previous chapter, intends to investigate several causal pathways through which a country's level of democracy, state hydrocarbon rent, and hydrocarbon-richness affect RE development. The data and modeling used for the quantitative analysis, is discussed in detail in the following chapter, Data and Modeling. The objective of the panel data analysis is to check if there is statistical evidence in support of the hypothesized causal pathways in Chapter 4. The case study analysis includes the three cases of Algeria, Morocco, and Tunisia. The case selection process, elaborated in further details in Chapter 9, has been based on variation in the key independent variables of interest, namely the level of democracy and its dimensions and forms, and the level of state hydrocarbon rent and hydrocarbon-richness in the three countries. The aim is to evaluate the hypothesized causal pathways and internal validity of various components of the theoretical framework of this study.

6. Data and Modelling

This chapter elaborates on the variables included in this quantitative analysis, the sources of the data, and necessary preparations and transformations of the data prior to feeding them into models. It also discusses important technical aspects, advantages, and limitations of the linear mixed model (LMM) estimation, the model of choice in this quantitate analysis.

6.1. Data

RE development, as an outcome of RE policies, is the dependent variable of all the models tested in this quantitative analysis. It is measured by the share of renewables in a country's electricity mix. *Democracy*—along with its various dimensions, qualities, and attributes (as specified in Chapter 2 and Appendix A), *hydrocarbon richness*, and *state hydrocarbon rents* are the three key independent variables. The models also control for per capita income and its squared term, share of industry in GDP, climate change vulnerability, and wind and solar energy potentials. A few other control variables, such as quality of government, level of corruption, and rule of law, are tested separately. To prepare the data for modelling, several indices are transformed to make them consistent with and comparable to each other. The final dataset, an unbalanced panel dataset[49], includes country-year data for more than 150 countries in 9 geographical regions[50], from 1990 to 2020.[51] Table 6.1 reports descriptive statistics, required transformation, and sources of all the data included in the regression analysis.

[49] In an unbalanced panel data, the number of available observations differs from one unit (country) to another.

[50] Region data are drawn from Quality of Government' standard dataset (Hadenius & Teorell, 2007; Teorell & Wahman, 2018; Wahman et al., 2013).

[51] The share of renewables, dominated by wind and solar, in the electricity generation was zero or close to zero in most countries prior to the 1990s. RE development gained considerable momentum in several advanced economies only in the 90s. Therefore, 1990 is chosen as the start year merely to avoid inclusion of many zeros in the final dataset.

6.1.1. Renewable Energy Development

RE development, an important outcome of RE policies, is the dependent variable in this study. To measure a country's RE development, this study calculates the share of solar and wind energy in that country's total electricity consumption. Renewable energy can be used in power generation, transport, heat generation, and industrial production. When it comes to measuring the success of RE policies, for a couple reasons, the literature mainly focuses on the share of renewables in the electricity sector. First, renewable energy has penetrated most in the electricity generation sector in the past few decades. Its penetration in other sectors has been relatively minor. Therefore, more, and higher quality RE data is available for the electricity generation sector. Second, state policy matters more in highly regulated industries such as electricity generation and distribution—which are generally more regulated than transport and heat generation in many jurisdictions (Bayulgen & Ladewig, 2017). Since this study intends to measure the effectiveness of RE policies, it makes perfect sense to focus on the sector in which state policy plays a more critical role.

The literature also makes a distinction between hydroelectric renewable and non-hydro renewables. There are healthy debates about designating large-scale hydropower as a sustainable source of energy, given its adverse impacts on wildlife and human livelihood through its drastic changes in ecosystems, flooding, and forced dislocation (Bayulgen & Ladewig, 2017; IRN, 2003). Among major sources of non-hydro renewable energy—solar, wind, biofuel, biomass, geothermal and tidal energy—wind and solar account for a considerable and growing share of RE production and consumption in most jurisdictions. Geothermal, and tidal energy are nascent and still relatively limited industries, hence large scale, cross-country data are scarce. Furthermore, biomass faces serious debates regarding its carbon neutrality. Additionally, a wide range of adverse environmental extraneities are associated with biofuel projects (Ji & Long, 2016). This empirical study, therefore, follows the literature in this regard and focuses on wind and solar energy sources.

To quantify the outcome of RE policies one can calculate the share of renewables in a country's electricity consumption, and/or production capacity, or measure added renewable electricity capacity, increase in renewable electricity generation, or the amount of investment in renewable electricity. Finding reliable and extensive country-year data on RE investments is difficult and expensive[52]. This study uses the share of wind and solar energy in total electricity consumption. For a robustness check, the share of wind and solar capacity in total electricity capacity, the share of total non-hydro renewable electricity capacity in total electricity capacity, and the share of total non-hydro renewable energy in total electricity consumption are also calculated and tested through the models. To create these indices, data from the International Energy Agency, U.S. Energy Information Administration and the World Bank are used (see Table 6.1 for further details).

The dependent variable, however, contains many zeroes due to its nature. A large number of countries have had zero share of renewables in their electricity mix at some point or throughout the period of analysis. The inclusion of a large number of zeros leads to the dependent variable being heavily skewed. A heavily skewed dependent variable can pose significant challenges in statistical analysis and modelling. When the distribution of the dependent variable is skewed, with most of the data points concentrated at one end of the scale, it can lead to problems such as a violation of the assumption of normality, which many statistical methods rely on. More importantly, this skewness can result in biased parameter estimates, increased risk of type I or type II errors, and can limit the interpretability of results. Therefore, only non-zero country-year values are included in the final dataset which is a customary approach in empirical studies especially when studying renewable energy outcomes (Linders & De Groot, 2006; Pfeiffer & Mulder, 2013).[53]

The heavily skewed non-zero values are log-transformed to make their skewness less severe and their distribution closer to a Gaussian distribution—note that the descriptive statistics of the dependent variables shown in Table 6.1 are calculated before applying log-transformation.

[52] Bloomberg New Energy Finance (BNEF) maintains an extensive and very expensive dataset on renewable investments. The dataset was not available for this study.

[53] For example, Bayer and Urpelainen (2016), Bayulgen and Ladewig (2017), Cadoret and Padovano (2016), and Sequeira and Santos (2018)all studying renewable energy development, included non-zero values for their dependent variables.

6.1.2. Democracy

Aggregate measure of democracy, along with its dimensions, forms (e.g., presidential vs. parliamentary), and qualities, is one of the three key independent variables of this study. All the models that are tested in this study contain one democracy variable that can be either:

i. A continuous or dichotomous aggregate democracy index (e.g., V-Dem Electoral Democracy or Dichotomous Machine-Learning Democracy Index)
ii. One of the dimensions of democracy (e.g., Deliberative Democracy index)
iii. A quality of democracy measure (e.g., Civil Liberties or Aggregate Accountability)
iv. Or a form of democracy index (e.g., DD Presidential Index).

The Electoral Democracy index from V-Dem Project dataset, which is considered the most basic and one of the most widely used measures of democracy, is the default aggregate democracy measure used in this study. Other dimensions of democracy—deliberative, liberal, participatory, and egalitarian—from V-Dem project dataset, are also tested and examined. All these V-Dem indices are continuous and range from 0 to 1. For a robustness check, aggregate democracy indices from other sources are also included in the quantitative analysis. They include: (i) Freedom House's Democracy Index; (ii) Vanhanen Democracy Index; (iii) Polity2; and (iv) Continuous Machine-Learning Democracy Index (Gründler & Krieger, 2020). These indices are continuous, ranging from 0 to 1.[54] In addition, dichotomous aggregate democracy measures (see Table 6.1 for further details) such as the Democracy-Dictatorship Index, and Dichotomous Machine-Learning Democracy Index (Gründler & Krieger, 2020) are also tested and analyzed.

Besides the above-mentioned indices, a wide range of democracy form indices, and qualities of democracy, are also tested and reported. Most of them, such as the Federalism (Division of Power) Index, Core Civil Society, Civil Liberties, Aggregate Accountability,

[54] Freedom House, Polity2, and Vanhanen indices have different scales, so appropriate transformations are applied to them (see Table 6.1 for further details). The first one is reversed, and all of them are normalized to make them comparable to the rest of democracy indices.

Horizontal Accountability, Vertical Accountability, and Diagonal Accountability are taken from the V-Dem Project dataset. In addition, the Political Constraints Index from Henisz (2017) measures the feasibility of policy change due to a change in the policy preference of political actors. Finally, there is the Democracy-Dictatorship Presidential Index, and DPI Presidential-Parliamentary Index that indicate the form of government—e.g., presidential vs. parliamentary. All the continuous aggregate democracy indices, democracy dimensions, and democracy qualities included in the final dataset are normalized, ranging from 0 to 1 (see Table 6.1 for further details).

6.1.3. Hydrocarbon Richness

Hydrocarbon richness is defined as the share of domestically produced hydrocarbon resources in a country's total hydrocarbon resource consumption. This measure is calculated separately for coal, crude oil, and natural gas, using data from IEA's datasets. The indices range from zero for countries with no oil, gas, or coal production to relatively large values. Since they are heavily skewed, all are log-transformed before being used in model estimations. It is worth noting that among the three resources, natural gas is notably distinct. It consists of natural gas liquids (NGLs) or condensates—mostly ethane, butane, and propane—and dry natural gas—mostly methane. In the IEA's datasets and many other well-established energy databases, crude oil and NGLs are combined into one index. According to numerous well-established classifications of hydrocarbon resources—including the IEA's—the term 'natural gas' only refers to the dry part of the natural gas. Second, while shipping NGLs is relatively easy (there are even international spot and futures markets for them), shipping dry natural gas requires huge investment in liquefied natural gas (LNG)—not to be mistaken with NGLs—facilities and terminals which makes exporting it capital intensive and difficult. Unlike other point resources, dry natural gas cannot be transported, and exported easily. Third, natural gas is usually a byproduct of crude oil extraction. Major oil producers have been historically major gas producers too. The correlation between oil richness and natural gas richness is fairly strong (50%). Therefore, one needs to be very cautious when trying to disentangle the effect of crude oil and natural gas and analyze them separately in a model.

6.1.4. State Hydrocarbon Rent

The most widely used measures of hydrocarbon rent in the literature are from the World Bank's WDI dataset. It measures oil, gas, and coal rents by subtracting their value of production from their total costs of production, all as a percentage of GDP. This study uses these indices, while acknowledging their limitations. An ideal index of state hydrocarbon rents would capture the share of hydrocarbon resource revenues in total state revenues or expenditures and not GDP[55]. A comprehensive natural resource rent dataset covering a large number of countries for an extended period of time, however, still does not exist. The next best available resource rent dataset is ICTD Government Revenue Dataset. It however does not distinguish between hydrocarbon and non-hydrocarbon resources, and between hydrocarbon resources themselves. More importantly, it, too, estimates the rent as a percent of GDP. Moreover, relative to the World Bank's, it is very limited in terms of year and country coverage. Using the share of hydrocarbon resource revenues in GDP, as the indicator of hydrocarbon resource rents, minimizes the risk of sample selection bias, as it available for a large sample of countries for relatively long periods. However, using it would most likely lead to underestimation of the true effect and importance of state hydrocarbon rents especially for countries with nationalized oil/gas/coal companies, hence in and of itself can be considered a rigorous robustness test for the effect of state hydrocarbon rent variable.

[55] The World Bank assumes a country resource rich and rentier when the share of resource revenues in its gross national income (GNI) is above 5% (World Bank, 2010). This ratio however is much different than the share of resource revenues in total state revenue, which can easily exceed 50% and beyond in many major oil and gas exporters. Government's revenue from hydrocarbon resources—and not the mere share of hydrocarbon revenues in GDP—is the key ingredient of the rentier state hypothesis, itself a key component of the resource curse scholarship.

6.1.5. Climate Vulnerability and Renewable Energy Potentials

Climate change vulnerability and wind and solar potentials are the three key control variables. This empirical study, to the knowledge of its author, is the first study in environmental politics and RE policy that includes RE potentials and climate vulnerability in its modelling. Their inclusion provides yet another sterner test for key hypotheses of this empirical study, concerning the effect of democracy, hydrocarbon richness, and state hydrocarbon rents on RE development. Climate vulnerability, wind potential and solar potential are assumed time-invariant, meaning their values are fixed for each country over the course of observation (1990-2020). The climate vulnerability index is drawn from the University of Notre Dame Global Adaptation Dataset. It incorporates exposure, sensitivity, and adaptive capacity of six life-supporting sectors of a country—food, water, health, ecosystem services, human habitat and infrastructure—to climate change (Chen et al., 2015). It is normalized to be consistent with other independent variables of this study.

Data for solar energy potential comes from the Energy Sector Management Assistance Program's dataset, compiled in collaboration with the Work Bank. Solar potential is defined as the average practical photovoltaic (PV) potential in kWh per kW peak per day. It is worth noting that after the level of solar radiation, air temperature is the second most significant geographical factor in determining a country's solar energy potential. Air temperature negatively affects photovoltaic conversion efficiency. So, what a country may lose due to weaker solar radiation, it can gain from having lower temperature and vice versa. That's the key reason photovoltaic potential doesn't vary much across vastly different geographies. According to Global Solar Atlas 2.0 (2020), more than 90 percent of the world's population resides in countries where the average daily PV potential ranges between 3 and 5 kWh/kWp/day.

To quantify a country's wind potentials, this study constructs two indices. The wind energy potential index, in Giga Watt hours per square kilometer is constructed by dividing a country's sum of onshore and offshore wind energy potentials by its area. The wind power potential index, in Mega Watt per square kilometer, is constructed in the same way. Both indices are log-transformed due to severe skewness[56]. The data used to create the two indices, are from a dataset by U.S. National Renewable Energy Laboratory (NREL). To be consistent with solar energy potential, the wind energy potential index is used in the modelling—though as discussed in *Results and Discussion* chapters (Chapter 7 and 8), replacing it with wind power potential index does not make any notable changes to the results.

6.1.6. Other Control Variables

Besides the variables explained so far, there are a host of well-established control variables that are included in similar studies. To avoid unnecessary complexity, this study follows a parsimonious approach, and hence examines only the control variables whose inclusion is supported by strong theoretical/conceptual underpinnings in the literature. One of the most important control variables is income—and its squared term, together controlling for the Environmental Kuznets Curve (EKC) effect. The theoretical link between income and environmental policy outputs and outcomes is well-established. GDP per capita in constant term, the most widely used proxy for income[57], is drawn from World Bank's WDI dataset and is log-transformed to correct for its skewness. Manufacturing value added has been recently used in a number of similar studies as a proxy for the power and influence of heavy and resource intensive industries. But the total share of industry in a country's GDP that puts together the value added of the manufacturing, mining, construction, and electricity, water, and gas distribution sectors, is apparently a more comprehensive measure. The World Bank's WDI dataset contains an industry share index that is used in this study, though a manufacturing value added index from the same dataset is also used as a robustness check.

[56] To be precise, wind energy potential index is calculated by log-transforming—$\log_e(x + 1)$—the sum of onshore and offshore wind energy potentials in GWh, multiplied by 1,000,000, divided by country area in square kilometers. Wind power potential index is calculated by log-transforming the sum of onshore and offshore wind power potentials in MW, multiplied by 1,000, divided by country area.

[57] In empirical studies income per capita or GDP per capita is a proxy for economic development. But it is worth noting that higher GDP per capita does not necessarily denotes economic development, as is the case with many wealthy fossil fuel exporters in the Persian Gulf region.

This study also examines institutional factors separately, which means unlike all the variables discussed so far, they are not included in all the models, due to the parsimonious approach of this study. Quality of government, rule of law, and corruption are three institutional factors that have been prevalently included in past and recent studies. The political corruption index from the V-Dem dataset which aggregates executive, legislative, and judicial corruption in a country is used as the corruption variable. A rule of law index from the same database is also tested. This index captures how much Laws are transparently, independently predictably, impartially, and equally enforced by the state, and how much the state itself complies to the law. A pair of corruption and rule of law indices from the World Bank's Worldwide Governance Indicators (WGI) dataset are also included in the modeling for robustness checks. Though quite similar in name to their V-Dem counterparts, they conceptualize and quantify corruption and rule of law very differently (see Table 6.1 for further details). WGI indices cover a lower number of countries and years, in comparison with V-Dem's. Finally, the quality of government index from the PRS Group's International Country Risk Guide dataset is a comprehensive measure that incorporates corruption (or to be precise lack thereof), law and order, and bureaucratic quality into one index.

It is worth noting that a host of popular control variables such as area size, latitude, population, population density, urban population, share of trade in GDP, energy intensity (total energy consumption per GDP or per capita) and international energy prices (oil price) are also tested but not discussed further. The main reason for their exclusion is to avoid unnecessary complexity in the models. The second reason is that their inclusion is not supported by solid theoretical underpinnings. Furthermore, in some cases the variables already included in the modelling can control for some of these factors. For example, definitive theoretical support for a positive or negative effect of trade, population, population density, and urban population on RE policy outcomes does not exist in the literature. Due to a dramatic downward trend in the costs of renewables in the past decade, RE investments and development seem to be decoupled from international energy prices. Inclusion of wind and solar potential indices makes area size, or latitude to a great extent redundant, as does including the share of industry in GDP to energy intensity indices.

Nevertheless, their examination—as discussed in the results and discussion chapters—reveals that none of these variables have a notable explanatory power.

Table 6.1: Descriptive Statistics

Variable	Description	Observations	Min	Mean	Max	SD	Remark	Source
Wind & Solar Capacity Share	(Wind Capacity + Solar Capacity) / Total Electricity Capacity (GW)	2,377	.00%	3.93%	47.20%	6.95 %	Only non-zero values included/Log-transformed*	EIA (2021)
Wind & Solar Energy Share	(Wind Energy + Solar Energy) / Total Electricity Consumption (kilo tons of oil equivalent)	1,940	.00%	2.70%	49.60%	5.68 %	Only non-zero values included/Log-transformed*	IEA (2021b, 2021e)
Total Non-Hydro Renewable Capacity Share	Total Non-Hydro Renewable Capacity / Total Electricity Capacity (GW)	2,665	.00%	6.59%	60.40%	8.89 %	Only non-zero values included/Log-transformed*	EIA (2021)
Total Non-Hydro RE Share	Total Non-Hydro Renewable Production / Total Electricity Consumption (kilo tons of oil equivalent)	2,028	.00%	4.85%	65.40%	7.42 %	Only non-zero values included/Log-transformed*	IEA (2021e); World Bank (2021)
Oil Richness	Total Oil & NGL Production / Total Oil & NGL Consumption	4061	.00	.56	4.55	.84	Log-transformed	IEA (2021f)
Coal Richness	Total Hard Coal Production / Total Hard Coal Consumption	4,140	.00	.27	7.15	.66	Log-transformed	IEA (2021d)
Gas Richness	Total Natural Gas Production / Total Natural Gas Consumption	4,147	.00	.40	6.05	.53	Log-transformed	IEA (2021c)
State Oil Rent	Value of Oil production minus Total Costs of Production (% of GDP)	5,054	.00	.03	.58	.08	Log-transformed	World Bank (2021)
State Gas Rent	Value of Natural Gas production minus Total Costs of Production (% of GDP)	5,338	.00	.01	.52	.02	Log-transformed	World Bank (2021)
State Coal Rent	Value of Coal production minus Total Costs of Production (% of GDP)	5,248	.000	.001	.231	.007	Log-transformed	World Bank (2021)
Total Resource Revenues	Total natural Resource Revenues as % of GDP (Primarily from Oil & Mining Activities)	2,667	.00	.05	.54	.09	Log-transformed	ICTD/UNU-WIDER (2020); Teorell et al. (2021)

Electoral Democracy Index	Freedom Expression/Association Free & Fair Elections, etc.	5,062	.02	.52	.92	.27	-	Coppedge et al. (2021); Pemstein et al. (2021)
Liberal Democracy Index	Liberal Component + Electoral Democracy	5,050	.00	.40	.89	.27	-	Coppedge et al. (2021); Pemstein et al. (2021)
Liberal Component Index	Equality before Law & Individual Liberties, Judicial/Legislative Constraints on Executive	5,306	.01	.60	.99	.27	-	Coppedge et al. (2021); Pemstein et al. (2021)
Deliberative Democracy Index	Deliberative Component + Electoral Democracy	5,062	.01	.41	.90	.26	-	Coppedge et al. (2021); Pemstein et al. (2021)
Deliberative Component Index	Deliberation through Public Hearings, Citizen Panels, Consultative Bodies, etc.	5,066	.01	.63	.99	.27	-	Coppedge et al. (2021); Pemstein et al. (2021)
Participatory Democracy Index	Participatory Component + Electoral Democracy	5,062	.01	.33	.81	.21	-	Coppedge et al. (2021); Pemstein et al. (2021)
Participatory Component Index	Civil Society Participation, Direct Popular Vote, Existence of Local/Regional Governments	5,315	.02	.47	.88	.19	-	Coppedge et al. (2021); Pemstein et al. (2021)
Egalitarian democracy Index	Egalitarian Component + Electoral Democracy	5,062	.03	.40	.89	.24	-	Coppedge et al. (2021); Pemstein et al. (2021)
Egalitarian Component Index	Equal Protection, Access to Power and Treatment for and Distribution of Resources to all Citizens (Social/Ethnic/Minority Groups)	5,066	.05	.61	.98	.22	-	Coppedge et al. (2021); Pemstein et al. (2021)
Freedom House Democracy Index	Political Rights + Civil Liberties	5,907	.00	.60	.92	.33	Reversed/Normalized	Freedom House (2021)

Democracy/Dictatorship Index	Dichotomous Democracy/Dictatorship Index (Democracy = 1)	5,899	-	-	-	-	Dictatorship.: 2,489 Democracy.: 3,410	Bjørnskov and Rode (2018)
Continuous Machine-Learning Democracy Index	Continuous Democracy Index	5,466	.00	.65	.96	.37	-	Gründler and Krieger (2020)
Dichotomous Machine-Learning Democracy Index	Dichotomous Democracy-Dictatorship Index (Democracy = 1)	5,466	-	-	-	-	Dictatorship.: 1,829 Democracy.: 3,637	Gründler and Krieger (2020)
Vanhanen Democracy Index	(Competition X Participation) / 100	5,307	.00	.33	1.00	.25	Normalized	Vanhanen (2019)
Polity2 Democracy Index	Revised Combined Polity Score: Democracy Score minus Autocracy Score	4,629	.00	.66	1.00	.33	Normalized	Marshall et al. (2020); Teorell et al. (2021)
DD Presidential Index	Dichotomous Presidential /Non-Presidential Index (Presidential = 1)	5,899	-	-	-	-	Non-presidential: 2,494 Presidential: 3,405	Bjørnskov and Rode (2018)
DPI Presidential/Parliamentary Index	Trichotomous Presidential/Assembly-elected President/Parliamentary Index	4,770	-	-	-	-	Presidential: 2,728 Assembly-elected president: 421 Parliamentary: 1,621	Scartascini et al. (2018)
Political Constraints	Feasibility of Policy Change due to Change in Policy Preference of Political Actors	4,348	.00	.41	.89	.32	-	Henisz (2017); Teorell et al. (2021)
Federalism (Division of Power) Index	Elected Local & Regional Governments	5,323	.00	.46	1.00	.35	-	Coppedge et al. (2021); Pemstein et al. (2021)
Core Civil Society	Autonomy of Civil Society from State	5,327	.01	.67	.98	.28	-	Coppedge et al. (2021); Pemstein et al. (2021)
Civil Liberties	Liberal Freedom	5,327	.02	.68	.98	.26	-	Coppedge et al. (2021); Pemstein et al. (2021)
Aggregate Accountability	Constraints on the State’s Use of Political Power	5,327	.03	.68	.98	.27	-	Coppedge et al. (2021);

								Pemstein et al. (2021)
Vertical Accountability	State Accountability through Elections	5,327	.06	.70	.97	.24	-	Coppedge et al. (2021); Pemstein et al. (2021)
Diagonal Accountability	State Accountability through Civil Society Organizations & Independent Media	5,327	.02	.69	.98	.27	-	Coppedge et al. (2021); Pemstein et al. (2021)
Horizontal Accountability	Checks & Balances between Institutions (Legislative, Judiciary, etc.)	5,327	.03	.61	.99	.29	-	Coppedge et al. (2021); Pemstein et al. (2021)
Quality of Government	Lack of Corruption + Law & Order + Bureaucracy Quality	4,175	.04	.55	1.00	.21	-	PRS Group (2021); Teorell et al. (2021)
V-Dem Political Corruption Index	Executive Legislative & Judicial Corruption	5,051	.03	.47	1.00	.30	Reversed	Coppedge et al. (2021); Pemstein et al. (2021)
V-Dem Rule of Law	Laws Transparently Independently Predictably, Impartially & Equally Enforced plus State Compliance with Law	5,323	.01	.54	1.00	.31	-	Coppedge et al. (2021); Pemstein et al. (2021)
WGI Control of Corruption	Perception of Corruption	3,969	.00	.42	1.00	.23	Normalized	Kaufmann et al. (2010); Teorell et al. (2021)
WGI Rule of Law	Perceptions of Incidence of crime / Effectiveness & Predictability of Judiciary / Enforceability of Contracts	4,025	.00	.54	1.00	.21	Normalized	Kaufmann et al. (2010); Teorell et al. (2021)
Climate Vulnerability	ND-GAIN Vulnerability to Climate Disruption Index	5,611	.00	.45	1.00	.22	Normalized	Chen et al. (2015)
Solar Energy Potential	Average Practical Photovoltaic Potential (kWh/kWp/day)	5,859	2.51	4.18	5.38	.63	-	Global Solar Atlas 2.0 (2020)
Wind Energy Potential	(Onshore Wind Energy Potential + Offshore Wind	5,344	.12	2.16	7.12	1.05	Log-transformed	Sullivan (2014)

	Energy Potential) / Country Area (GWh/km²)							
Wind Power Potential	(Onshore Wind Power Potential + Offshore Wind Power Potential) / Country Area (MW/km²)	5,344	.18	1.71	6.48	.86	Log-transformed	Sullivan (2014)
Manufacturing Value Added	Value Added of Manufacturing (% of GDP)	4,791	.00	.12	.41	.06	Log-transformed	World Bank (2021)
Industry Share (%GDP)	Value Added of Mining Manufacturing Construction Electricity Water & Gas (% of GDP)	4,975	.03	.23	.63	.09	Log-transformed	Teorell et al. (2021); World Bank (2021)
GDP per capita	GDP per capita in Constant 2010 US$	5,383	5.19	8.42	12.2	1.50	Log-transformed	World Bank (2021)

* Descriptive statistic calculated based on raw values prior to log-transformation

Table 6.2: List of Countries

#	Country	#	Country	#	Country	#	Country
1	Albania	31	Dominican Republic	61	Laos	91	Portugal
2	Algeria	32	Ecuador	62	Latvia	92	Romania
3	Argentina	33	Egypt	63	Lebanon	93	Russia
4	Armenia	34	El Salvador	64	Libya	94	Saudi Arabia
5	Australia	35	Eritrea	65	Lithuania	95	Senegal
6	Austria	36	Estonia	66	Luxembourg	96	Serbia
7	Azerbaijan	37	Ethiopia	67	Malaysia	97	Singapore
8	Bangladesh	38	France	68	Malta	98	Slovakia
9	Belarus	39	Gabon	69	Mauritius	99	Slovenia
10	Belgium	40	Georgia	70	Mexico	100	South Africa
11	Benin	41	Germany	71	Moldova	101	South Korea
12	Bolivia	42	Ghana	72	Mongolia	102	Spain
13	Bosnia & Herzegovina	43	Greece	73	Morocco	103	Sri Lanka
14	Botswana	44	Guatemala	74	Mozambique	104	Suriname
15	Brazil	45	Haiti	75	Myanmar (Burma)	105	Sweden
16	Bulgaria	46	Honduras	76	Namibia	106	Switzerland
17	Cambodia	47	Hungary	77	Nepal	107	Tanzania
18	Cameroon	48	India	78	Netherlands	108	Thailand
19	Canada	49	Indonesia	79	New Zealand	109	Togo
20	Chile	50	Iran	80	Nicaragua	110	Trinidad & Tobago
21	China	51	Iraq	81	Niger	111	Tunisia
22	Colombia	52	Ireland	82	Nigeria	112	Turkey
23	Congo - Brazzaville	53	Israel	83	North Macedonia	113	Ukraine
24	Congo - Kinshasa	54	Italy	84	Norway	114	United Arab Emirates
25	Costa Rica	55	Jamaica	85	Oman	115	United Kingdom
26	Croatia	56	Japan	86	Pakistan	116	United States
27	Cuba	57	Jordan	87	Panama	117	Uruguay
28	Cyprus	58	Kazakhstan	88	Peru	118	Venezuela
29	Czechia	59	Kenya	89	Philippines	119	Vietnam
30	Denmark	60	Kuwait	90	Poland	120	Yemen

6.2. Descriptive Statistics of Data

Table 6.2 reports the Pearson correlation coefficients of the key independent variables of this study. The correlation estimation is performed after the data are transformed (see *Remark* column of Table 6.1. for further details). All correlation coefficients in the Table except that of State Oil Rent–Climate Vulnerability and Wind Potential–Solar Potential are significant at **α** < 0.01. Among the correlation coefficients, few look very interesting and not necessarily surprising: (i) negative correlation between oil richness, state oil rent, and industry share as a percentage of GDP on one hand and electoral democracy on the other; (ii) positive correlation between GDP per capita and electoral democracy (iii) and strong and positive correlation between oil richness and state oil rents. These observations are all but surprising. Democratic societies are on average more economically advanced meaning their national economy is more service oriented and less reliant on industries and natural resources. Resource rich countries are found to be less democratic on average. Furthermore, it is obvious that for a country to enjoy a high level of hydrocarbon rents, it needs to be hydrocarbon rich first.

Classifying countries into hydrocarbon rich and hydrocarbon poor, oil rentier and non-oil rentier and democratic and non-democratic, then comparing and contrasting the share of wind and solar in the electricity consumption also reveal interesting patterns. Table 6.2 contains these observations. In the table, a conservative democracy threshold score of 0.5 in Electoral Democracy Index is used and rentier threshold is very conservatively set at a State Oil Rent value above 0.03.[58] As for oil rich, it is defined as Oil Richness value of above 1, denoting a country's oil self-sufficiency. Differences between the category averages (Δ) are tested using t-test. As can be seen the table, all the differences are large in magnitude and statistically significant. Democratic countries enjoy a higher share of wind and solar in electricity consumption, so do non-rentier and hydrocarbon poor countries. Again, these findings are not surprising. Figure 6.1 essentially reports the same patterns illustratively. All the estimates in the plot are 1990-2020 country averages. 'Oil poor' corresponds to Oil

[58] Note that using more realistic (higher) democracy and rentier thresholds would result in differences (Δ) that are much larger in magnitude and statistically significant.

Richness value of zero, and ‘less oil rich’ means an Oil Richness less than or equal to 1. Oil richer and more rentier countries are mostly concentrated at the bottom left of the scatter plot meaning that they enjoy a lower level of wind and solar development and at the same time are less democratic. More democratic countries concentrated on the right half of the plot are mostly less oil rich or oil poor with relatively low levels of state oil rent. They enjoy varying degrees of RE development. These observations and patterns, though casual, are consistent with this study’s proposed hypotheses, which are statistically tested and rigorously examined in the following two chapters.

Table 6.3: Correlation Matrix of Key Independent Variables

	Elec. Dem	Oil Rent	Oil Richness	QoG	GDP percap	Industry Share	Climate Vul	Solar Potential	Wind Potential
Electoral Democracy	1	-0.463	-0.411	0.546	0.524	-0.389	-0.534	-0.425	0.203
State Oil Rent	-0.463	1	0.803	-0.226	0.020	0.739	0.116	0.217	-0.070
Oil Richness	-0.411	0.803	1	-0.197	0.038	0.654	0.089	0.084	-0.079
Quality of Government	0.546	-0.226	-0.197	1	0.758	-0.166	-0.737	-0.416	0.339
GDP per capita	0.524	0.020	0.038	0.758	1	0.082	-0.882	-0.405	0.309
Industry Share ($\%GDP$)	-0.389	0.739	0.654	-0.166	0.082	1	-0.003	0.147	-0.061
Climate Vulnerability	-0.534	0.116	0.089	-0.737	-0.882	-0.003	1	0.486	-0.290
Solar Potential	-0.425	0.217	0.084	-0.416	-0.405	0.147	0.486	1	-0.048
Wind Potential	0.203	-0.070	-0.079	0.339	0.309	-0.061	-0.290	-0.048	1

Note: All correlation coefficients except that of State Oil Rent–Climate Vulnerability and Wind Potential–Solar Potential are significant at $\boldsymbol{\alpha} < 0.01$. log-transformed data—see Table 6.1—and Pearson method are used for correlation estimation.

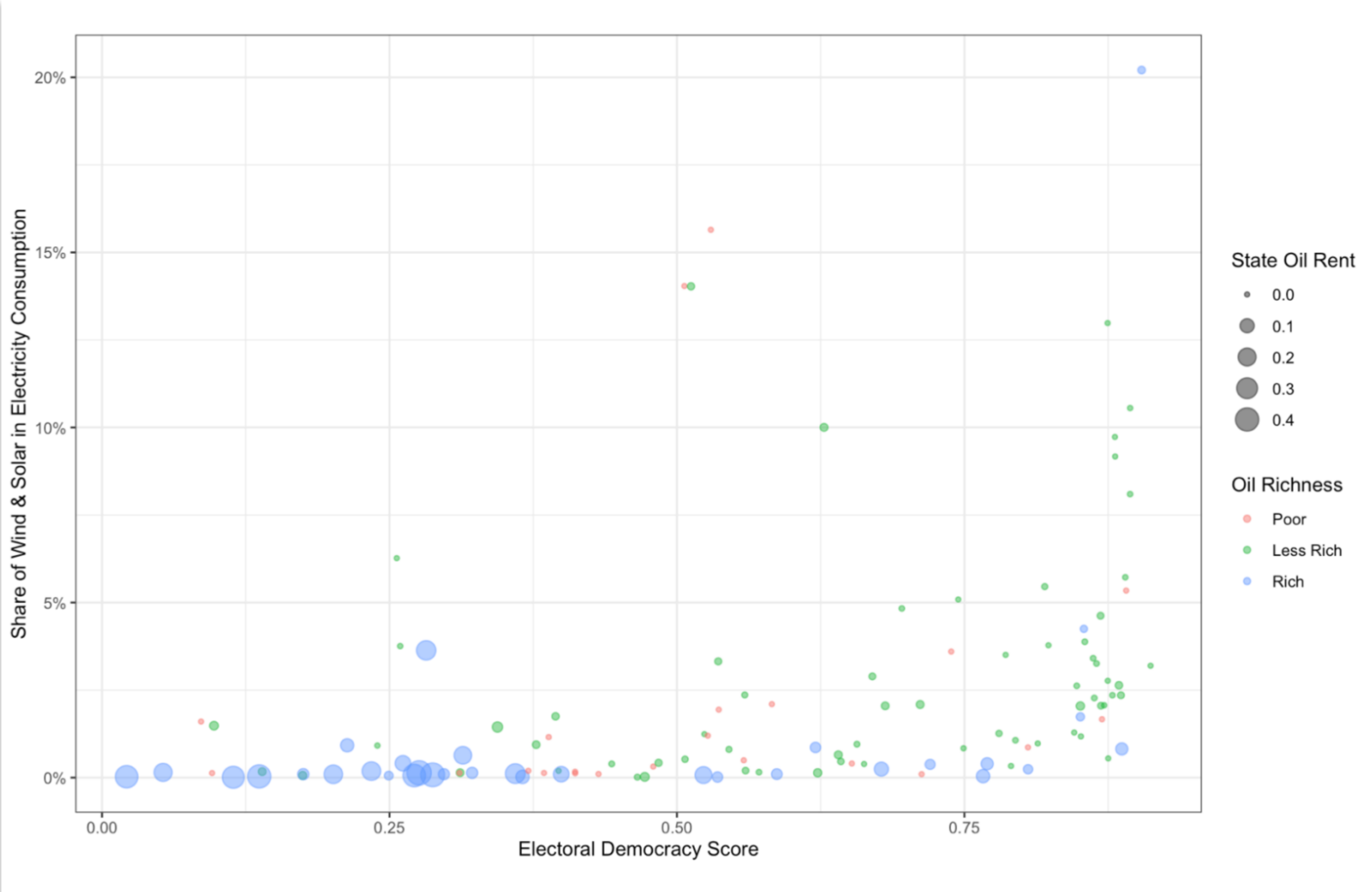
Table 6.4: Share of Wind & Solar in Electricity Consumption by Different Categories

	Share of Wind & Solar in Electricity Consumption								
	Non-Democratic	Democratic	Δ	Rentier	Non-Rentier	Δ	Oil Rich	Oil Poor	Δ
Electoral Democracy	1.32%	3.27%	**1.95%**[***]						
State Oil Rent				0.36%	3.22%	**2.86%**[***]			
Oil Richness							1.65%	2.98%	**1.33%**[***]
Observations	553	1,378		315	1,576		422	1,515	

*p<0.1; **p<0.05; ***p<0.01

Notes: State Oil Rent and Oil Richness data used for the estimations are not log-transformed. Democracy threshold is a score of above 0.5 in Electoral Democracy. Rentier threshold is set at a State Oil Rent value above 0.03. Being oil rich means an Oil Richness value > 1, denoting oil self-sufficiency. Differences between the category averages (Δ) are tested using t-test.

Figure 6.1: Scatterplot of Share of Wind & Solar in Total Electricity Consumption



Note: 1990-2020 country averages are used. Oil Poor means Oil Richness value of zero. A Less Rich country has an Oil Richness value of 1 or below. Oil Rich denotes oil self-sufficiency (Oil Richness value > 1)

6.3. Modelling

As discussed in the *Methodology* chapter, random effect (RE) and fixed effect (FE) models have been the two most popular econometric tools for panel data analysis in economics, and political science. When the unit of analysis of a study is a country, and the dataset contains country-year observations—as is the case is this study—one-way or two-way models are applied. One-way generally denotes country fixed (random) effect and two-way means country and year fixed (random) effects. The RE and FE models are least squares estimators[59]. There is another statistical tool for panel data analysis, called the linear mixed model (LMM), that has been gaining popularity in political science recently[60]. The LMM, using the maximum likelihood (ML) estimator, has both fixed effect and random effect parts—not to be confused with fixed effect and random effect models in econometrics—and overall is a very flexible and capable tool to handle panel data. It is however important to acknowledge the limitations of the LMM. Similar to the RE model, it assumes random factors—in the case of this regression analysis, year, region, and country random effects—are truly random and are uncorrelated with the independent variables. Therefore, omitted variable bias, which is discussed in the last section of this chapter, can become a concern when using the LMM.

Employing the LMM, this study also includes a novel way of specifying panel data models that allows for separate estimations of the effect of variables within countries an across countries. It is called within-between specification which is discussed in detail below. Based on the works of Mundlak (1978), it has become a popular way of specification since being revamped and reintroduced by Bell and Jones (2015). Also, in statistics, it offers a solution for confounding by the cluster problem in mixed models. This study is among a few but

[59] The RE model is a specific type of least squares estimation called the feasible generalized least squares (FGLS). The FE model is also call least squares dummy variables regression model. Discussing further technical details of the estimation methods is beyond the scope of this study.

[60] By calling it a statistical tool, the literature acknowledges the disciplinary divide between economics/political science and other disciplines such as education, epidemiology, geography, and biomedical sciences, when it comes to modelling panel data with more of less similar properties. It is worth noting that relatively strict exogeneity assumptions of the ML estimators required for estimation consistency is mentioned as the main reason for the lack of popularity of the ML estimator (mixed models) in economics/political science scholarship (Croissant & Millo, 2008).

growing number of studies in political science and environmental politics that employs the LMM and perhaps the first one that tests the within-between specification.

6.3.1. Linear Mixed Model

The LMM, also called hierarchical, or multilevel models, have a fixed effect and a random effect part that must not be confused with fixed and random effect models in econometrics. The fixed effect part of an LMM estimates the effects that are assumed to be constant and identical across all groups (countries)—like any regression—and the random effect part simply allows for clustering observations into groups (Schielzeth & Nakagawa, 2013)—e.g., regions, countries, years, etc. A random effect is a parameter with random variability around zero according to a normal distribution. The random effects simply denote random variability of the intercept (and coefficients and in random coefficient models) across clusters—between different regions, between different countries, and/or between different years. Traditional econometric fixed and random effect models are indeed special cases of LMMs (Croissant & Millo, 2008; Shor et al., 2007)[61]. For this study, a simple LMM with three random factors of country, year and region is specified as follows:

$$y_{ijt} = \beta_0 + \beta_1 x_{ijt} + \beta_2 z_i + \upsilon_{\mathrm{i}} + \upsilon_{\mathrm{j}} + \upsilon_{\mathrm{t}} + \varepsilon_{ijt} \quad (1)$$

where, β_0, β_1, and β_2 are regression estimates, the dependent variable y_{ijt} is the share of renewables in electricity for country i, in region j, at time t, x_{ijt} is the value of independent variable x (for example, democracy, hydrocarbon richness, state hydrocarbon rents, or GDP per capita) for country i, in region j, at time t, z_i is the value of time-invariant variable z (e.g.,

[61] Under the normality, homoskedasticity, and no serial correlation conditions, the least square estimator is also the ML estimator (Croissant & Millo, 2008; Williams, 2015). It means that, for example, a two-way country and year random effect model that uses the FGLS estimator produces same results as an LMM with country and year random effects that employs the ML estimator. The traditional two-way random effect however faces serious limitations when those conditions are not met, and/or research hypotheses require controlling for more than two random factors. As for the traditional fixed effect model, an LMM with no random effects and dummy variables for each cluster—e.g., country and year dummy variables—would produce the same estimates as a traditional country and year fixed effects model, if the conditions stated above are met.

RE potentials, or climate change vulnerability) for country i, υ_i is country random effect, υ_j is region random effect, υ_t is year random effect, and ε_{ijt} is the error term. In model (1), $\beta_1 x_{ijt} + \beta_2 z_i$ is the fixed effect part. $\upsilon_i + \upsilon_j + \upsilon_t$ is the random effect part whose only variances—of υ_i, υ_j, and υ_t —are estimated and reported by the model. The key underlying assumptions of this model are: that (i) υ_i, υ_j, υ_t and ε_{ijt} follow a normal distribution with zero mean; (ii) and: that the random effects and ε_{ijt} are independent. It should be noted that this model is a nested random effect model as countries are nested in regions and each country is assigned to only one region. This is an important detail when specifying a model in the software. This mixed model has a country-nested-in-region random effect, a region random effect, and a year random effect.

Traditional random effect and fixed effect models almost always require separate robust standard error estimations due to violations of distributional assumptions of residuals such as non-normality, heteroskedasticity, and serial and cross-sectional correlations[62]. One of the key advantages of LMMs over random effect and fixed effect models is its remarkable robustness to bias, and type-I error due to such violations of distributional assumptions (King & Roberts, 2015; LeBeau, 2016; Schielzeth et al., 2020) [63]. They are also robust to non-Gaussian distribution of random effects and even to missing random effect components (Schielzeth et al., 2020). These are indeed the advantages of the ML estimator over the least squares estimators (Shor et al., 2007; Steenbergen, 2020). This study employs a specific form of ML estimation, called restricted maximum likelihood (REML). It is better suited for the data of this study. The typical ML estimator, also called full information ML tends to underestimate the variance/covariance components when the number of clusters is

[62] Heteroskedasticity exists when variance of residuals changes across units (countries), serial correlation means residuals of a unit are correlation and not independent of each other and contemporaneous or cross-sectional correlation refers to correlation between residuals across units. The residuals can be serially correlated because units (countries) are measured over time, and heteroskedasticity is mostly due to unit heterogeneities left out of the model (Shor et al., 2007). Cross-sectional correlation is not uncommon in political science as economic and political shocks in one country can have spillover effects in other countries.

[63] Simulations show that when the number of clusters—e.g., number of regions, countries, and years—and repeated measurements—e.g., country-year observations—is limited, serial correlation may lead to a slight increase in the probability of type-I error—slight inflation of real α values relative to the estimated/reported ones (LeBeau, 2016).

relatively small. REML can tackle this issue. Discussing technical details of REML is beyond the scope of this study–for more information, see Steenbergen (2020).

LMMs have a few other advantages over random effect and especially fixed effect models. Unlike fixed effect models, they can estimate and not merely control out time-invariant variables. This is especially important in the context of this empirical study where estimating time-invariant variables such as a country's climate vulnerability and solar and wind energy potentials are an essential part of the modelling. Also, they don't have the uninterpretability problem of two-way fixed effect models[64], and unlike the most prevalent random effect models can control for more than two random factors. Furthermore, LMMs can accommodate a within-between specification, which estimates the effect of variables within unit (country) an across units separately.

6.3.2. Within-Between Specification

The underlying assumption of LMMs is that within-unit, and between-unit effects are equal. For example, a single coefficient of a GDP per capita variable in a model that investigates the effect of GDP per capita on democracy implies that an increase in GDP per capita from $1,000 to $1,200 in a country induces the same change in the level of democracy in that country ('within effect') as the difference between the level of democracy in country A with GDP per capita of $1,000 and country B with GDP per capita of $1,200 ('between effect'). It

[64] Imai and Kim (2021) reveals that applying a two-way time and unit fixed effect model leads to estimations that are hardly interpretable and are no answer to typical research questions in political science. The two-way time and unit fixed effect has been the default methodology in political science. It is used to supposedly control out time-specific and unit specific factors. But Imai and Kim (2021), through simulation and a novel mathematical decomposition, shows that it is impossible to control for both factors simultaneously. While a one-way time or unit fixed effect can be interpreted as the generalization of an effect that exist within a unit or at a specific point in time, a two-way fixed effect is a very complex generalization of effect of 'deviations' from the unit-means at a particular point, or equivalently, as a generalization of the effect of deviations from the time-means for each particular unit (Imai & Kim, 2021). For example, the only possible interpretation of the coefficient of GDP in a two-way fixed effect models that estimates the effect of GDP on democracy would be: "on average, relative to a country with a GDP per capita that is farther below its own over-time mean, another country with a GDP per capita that is closer to its over-time mean would have a democracy index that is farther above—or below depending on the sign of the coefficient—that other country's democracy index's over-time mean" (Imai & Kim, 2021). This interpretation apparently is not an answer to most if not any research questions in empirical political science scholarship.

is however apparent that such assumptions should not be taken for granted. If the two effects are incorrectly presumed equal, it can result in confounding by cluster (Silk et al., 2020). Confounding by cluster causes misleading estimation of the fixed effect coefficients and biased estimation of the variance components. One of the easiest and most effective solutions to this problem is within-between specification (Seaman et al., 2014). The within-between specification makes separate estimations of the 'within-unit' and 'between-unit effects' possible, hence making it possible to check if the two effects are indeed equal or not. It does so simply by mean-centering the time-varying independent variables and adding a unit-mean variable for each time-varying variable. A simple within-between LMM is specified as follows:

$$y_{ijt} = \beta_0 + \beta_{1\mathrm{W}}(x_{ijt} - \bar{x}_i) + \beta_{2\mathrm{B}}\bar{x}_i + \beta_3 z_i + \upsilon_\mathrm{i} + \upsilon_\mathrm{j} + \upsilon_\mathrm{t} + \varepsilon_{ijt} \qquad (2)$$

where $\bar{x}_i$ is the mean value of the independent variable x for country i (e.g., average level of democracy or average GDP per capita over the course of observation), $\beta_{1\mathrm{W}}$ and $\beta_{2\mathrm{B}}$ are respectively the within-country and between-country estimates for variable x. The only different between model (1) and (2) is that variable x is decomposed into a country-mean-centered part $(x_{ijt} - \bar{x}_i)$, and a country-mean part $\bar{x}_i$. All other properties of model (2), its assumptions and the estimation method, are the same as the first model's.

Model (1) and Model (2) both have their own advantages. Employing the simple specification makes it easier to examine the conditional effect of one variable on another one—through inclusion of a simple interactive term in the regression model. A within-between specification apparently can simply elicit more information and insight from same data while tackling the confounding by cluster problem. One should note that in this within-between model the country-mean part $\bar{x}_i$ is time-invariant and not fundamentally different than z_i. To increase rigor, this study tests both models and compares the results.

6.3.3. Further Technical Considerations

One of the most highly addressed topics in the literature is omitted variable bias. An LMM, like any other regression model, is prone to omitted variable bias. This bias results from leaving relevant variables out of a model which distorts the estimation of variables included in the model. To avoid such bias, scholars are tempted to include in their models as many control variables as possible. The commonly held belief is that inclusion of more control variables reduces the risk of omitted variable bias. Clarke (2005), however, shows the mathematics of the regression analysis doesn't support this assumption. Through extensive simulations, it shows that adding a new variable as likely increases bias as decreases it. One can know which is the case only if they know the true and complete model, which is an impossibility. Clarke (2005) argues that we can conclude that since omitted variable bias is unavoidable, a researcher should focus on the research design instead of overspecification. Imai and Kim (2021) argue that choosing a model that can address the research questions properly is much more critical than tackling misplaced concerns over inference (unrestrained fear of bias)[65]. Therefore, this study adopts a parsimonious approach and only includes variables whose inclusion is strongly justified by the research hypotheses and by well-established theories.

Some scholars are in favor of including a lagged dependent variable in the right hand side of a regression model for methodological and/or theoretical reasons (Beck, 2008; Williams & Whitten, 2012). The inclusion is presented as a quick and simple remedy for serial correlation of the residuals. It is also argued that the autoregressive nature of many political phenomena necessitates the inclusion. But including a lagged dependent variable in an LMM can cause severe bias due to the dependence between random effect terms and the lagged term (Allison, 2015). The bias is particularly large for datasets with a large number of units with relatively small number of observations (Leszczensky & Wolbring,

[65] Some statisticians and econometricians express strong view against overspecification. Griliches (1977) likens overspecification to a situation where our efforts to cure what might have been a relatively minor ailment could end up harming the patient instead. Breiman (1992) goes one step further and argues that in many cases models with fewer variables are more accurate and insightful that the ones that are swamped with control variables.

2022)—which is the case for the data of this study. Therefore, this study decides against the inclusion of a lagged dependent variable.

Lastly, although LMMs are generally robust to violation of distributional assumptions, residuals of all the models employed in this study are tested for heteroskedasticity, and serial correlation.

7. Results and Discussion—Part One: Simple Linear Mixed Model Estimations

The results and discussion derived from the panel data modeling in this study are presented across two chapters. This chapter presents and discusses the results of the simple linear mixed model (LMM) estimations. Moving forward, Chapter 8 centers on the within-between estimations, providing a comprehensive exploration of the empirical findings from this alternative approach. By adopting this two-chapter structure, the study ensures a thorough analysis of the panel data results, allowing for a deeper understanding of the research outcomes. Finally, the key findings from the qualitative analysis of this study are thoroughly discussed at the conclusion of Chapter 9.

7.1. Introduction

LLMs were used to estimate the effect of democracy and its dimensions, hydrocarbon richness and state hydrocarbon rents on RE development. This chapter also examines the links between a country's income, institutional factors—such as corruption, rule of law and quality of government—vulnerability to climate change and RE potentials on the one hand and the country's RE development on the other.

Overall, the LMM estimations identified a long-term and positive relationship between democracy and RE development and a negative link between oil richness, state oil rents and RE development. The analysis also revealed a robust Environmental Kuznets Curve (EKC) effect, denoting a non-linear relationship between income and RE development. Moreover, the analysis also found a moderating effect of institutional qualities on the negative link between state oil rent and RE development. These findings showed strong robustness to changes in size and composition of the sample and using different dependent variables.

Section 7.1 presents a brief review and comparison of the results of other popular models found in the research literature, highlighting the strengths and limitations of those models. In Section 7.2, a baseline LMM estimation examines the overall relationship between various factors and RE development. The effects of factors, such as democracy, oil richness, state oil rent, share of industry in GDP, income, institutional qualities, climate change vulnerability, and RE potentials, are discussed in the ensuing sections. Finally, robustness checks were conducted to ensure the reliability and validity of the results.

7.2. Model Comparison

For comparison purposes, Table 7.1 presents seven models widely used in empirical political science: (1) OLS (using cross-section data); (2) pooled OLS; (3) random effect (RE); (4) fixed effect (FE); (5) RE with cluster robust standard errors; (6) FE with cluster robust standard errors; and (7) LMM. All the models use the share of wind and solar in electricity consumption as their dependent variable. As discussed in the data and modelling chapter (Chapter 6), the dependent variable includes only non-zero values. State oil rent, oil richness, industry share of GDP, GDP per capita, and wind energy potential are log-transformed, and climate vulnerability is normalized. The electoral democracy index and all other aggregate measures of democracy, the V-Dem dimensions of democracy, and the other qualities of democracy had already been normalized or were normalized before being employed in this and next chapter's estimations. All the independent variables, except those in the OLS model, were lagged by 4 years. All the models have an intercept and, except for the OLS, include a time trend variable (year) which remains positive and significant. Both the time trend and the intercept are reported throughout this and the next chapter. Because electoral democracy is a basic measure of democracy used prevalently in recent empirical studies, it is used as the default democracy measure throughout this and next chapters and appears in the baseline and various other estimations.

Table 7.1: Various Model Estimations

	Dependent Variable: Share of Wind & Solar in Electricity Consumption						
					Cluster Robust SE		
	OLS (2010-2020 Ave.)	Pooled OLS	RE	FE	RE	FE	LMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Electoral Democracy	2.344***	1.991***	0.132	−0.093	0.132	−0.093	0.073
	(0.839)	(0.260)	(0.419)	(1.327817)	(1.327)	(0.695)	(0.429)
State Oil Rent	−1.083	1.826	−4.075**	−5.016***	−4.075	−5.016	−4.152**
	(3.613)	(1.147)	(1.591)	(1.763)	(4.304)	(3.401)	(1.646)
Oil Richness	−0.649*	−0.727***	−0.292	−0.250	−0.292	−0.250	−0.287
	(0.361)	(0.104)	(0.199)	(0.263)	(0.382)	(0.667)	(0.211)
Industry Share (*%GDP*)	−1.736	−5.674***	−5.683***	−6.400***	−5.683	−6.400*	−5.621***
	(3.122)	(0.990)	(1.298)	(1.349)	(4.021)	(2.682)	(1.301)
GDP per capita	−1.710	−4.297***	−5.193***	−7.787***	−5.193**	−7.787**	−6.227***
	(1.448)	(0.476)	(0.812)	(0.982)	(1.956)	(2.702)	(0.847)
(GDP per capita)^2	0.091	0.239***	0.348***	0.554***	0.348**	0.554***	0.423***
	(0.076)	(0.025)	(0.046)	(0.060)	(0.107)	(0.167)	(0.049)
Climate Vulnerability	−3.171*	−2.067***	0.581		2.594		2.990*
	(1.903)	(0.604)	(1.337)		(1.337)		(1.530)
Solar Potential	0.196	0.049	0.218		0.248		0.268
	(0.236)	(0.071)	(0.226)		(0.226)		(0.280)
Wind Potential	0.268*	0.496***	0.407***		0.407*		0.378*
	(0.157)	(0.051)	(0.156)		(0.202)		(0.194)
Observations	120	1,695	1,695	1,731	1,695	1,731	1,695
Log Likelihood							−2,571.929
Akaike Inf. Crit.							5,171.857
Bayesian Inf. Crit.							5,247.954
Adjusted/Pseudo R^2	0.432	0.502	0.446	0.701	0.446	0.701	0.902
F Statistic	11.073***	171.567***	3,772.252***	598.017***	28.016***	63.668***	

*p<0.1; **p<0.05; ***p<0.01

Note: All models have an intercept (not shown). All models except OLS control for time trend (not shown). Except in OLS model, independent variables are lagged by 4 years. For the OLS model, average 2010–2020 country-year values for all variables are used. Two-way 'country' and 'year' effects are estimated for RE, FE and LMM. For models (5) and (6) cluster robust standard errors and robust F Statistics are estimated. Dependent variable, Share of Wind & Solar in Electricity Consumption, only includes non-zero values. State Oil Rent, Oil Richness, Industry Share, GDP per capita and Wind Potential are log-transformed. The Climate Vulnerability variable is normalized.

The OLS Model uses 2010–2020 country averages. In the OLS estimation, the electoral democracy coefficient has the predicated positive sign and is statistically significant (at $\alpha < 0.01$). Oil richness also has the predicted negative sign and is statistically significant (at $\alpha < 0.1$). The coefficient of state oil rent is negative, as predicted by the research hypothesis, but is not significant. So is the coefficient of the industry share of GDP. Although the signs of the coefficients of GDP per capita and GDP per capita squared suggest the EKC effect, they are not statistically significant. The sign of the climate vulnerability coefficient is counterintuitively negative. This is surprising, as countries that are more vulnerable to climate change would be expected to do more in terms of RE transitions, all else being equal. Solar and wind energy potential coefficients are both positive, but only the latter is statistically significant. Overall, this cross-sectional OLS model uses only a snapshot of the countries. It has a very limited number of observations relative to other models that use panel data, and hence it gives an oversimplified picture of reality.

The Pooled OLS estimation uses the country-year panel data. It results in a substantial increase in the number of observation relative to the OLS model. In this model, the coefficient of electoral democracy is positive and significant again. Oil richness, the share of industry in GDP, GDP per capita and its squared term, and wind energy potential all have significant coefficients with predicted—according to the research hypothesis—signs. The climate vulnerability coefficient is significant but negative. Finally, state oil rent and solar energy potential are not statistically significant. Pooled OLS models have major limitations, especially when dealing with clustered data. The Country-year panel data of this study can be clustered by country, region, and year. The Pooled OLS disregards cluster structures of the data. Ignoring the cluster structure of data leads to heterogeneity estimation bias and inconsistency.[66] To put it simply, the Pooled OLS model cannot provide reliable estimates.

In Table 7.1, columns (3) and (4) report the two-way country and year REs and FEs, respectively. The key technical aspects of RE and FE models were discussed in the methodology chapter (Chapter 5) and the data and modelling chapter (Chapter 6). The RE model assumes unit (country) and time (year) heterogeneities are random. The FE model basically controls out all country specific and time-invariant factors and only captures within-country variations. In both models, state hydrocarbon rent, industry share of GDP, GDP per capita and its squared term are statistically significant with predicted signs. Oil richness in both models is negative but not significant, and the coefficient of electoral democracy is not significant. The sign of GDP per capita and its squared term indicate the strong and significant EKC effect. Among the time-invariant variables—not included in the FE model—only wind energy potential is positive and statistically significant. As already discussed in

[66] A least square estimator is considered consistent if it converges to true population parameter when sample size grows.

Chapters 5 and 6, FE models have substantial limitations that make them a less suitable choice for this empirical study. They cannot estimate the time-invariant variables—climate vulnerability, and solar and wind energy potentials—which are integral parts of this quantitative analysis. Furthermore, FE estimations generally have interpretability issues, which are discussed in Chapter 6.

Table 7.2 reports the popular Breusch-Pagan heteroskedasticity test for all the models. The test result reveals that the RE and FE models in column (3) and (4) of Table 7.1 have heteroskedastic error terms, a violation of the uniformity assumption of the error terms' variance. In econometrics and statistics, robust standard error estimation is the customary solution to homoskedasticity problem, and cluster robust standard errors estimation is specifically tailored to tackle homoscedasticity in panel data models. Column (5) and (6) report the same RE and FE estimations but with cluster robust standard errors. The inflation of standard error of estimate as a result of robust standard error estimation renders most of the key coefficient estimates insignificant. In the RE model, only GDP per capita, its squared term, and wind energy potential remain statistically significant; and in the FE model, industry share of GDP, GDP per capita and its squared term remain statistically significant. Therefore, not much statistical inference can be drawn from the RE and FE models with robust standard errors. Among all the models discussed so far, the FE model has the highest coefficient of determination, or as customarily reported in any regression result, including those in Table 7.1, R-squared estimate. R-squared or adjusted R-squared is an estimate of the proportion of the variance in the dependent variable that can be explained by a model. It is basically a measure of the model's goodness-of-fit, showing how much the data fit the regression model. At 0.701, the adjusted R-squared of the FE model is significantly higher than those of the RE, pooled OLS, and cross-sectional OLS models.

Table 7.2: Breusch-Pagan Test for Heteroskedasticity

Model	p-value*
OLS	0.16
Polled OLS	0.00
Random Effect	0.00
Fixed Effect	0.00
LMM	0.13

** Null hypothesis: residuals are homoskedastic.*

In order to make it as comparable to the RE and FE models as possible, a two-way—simple and non-nested—country and year random effect LMM was estimated (column (7) in Table 7.1). According to Table 7.2, the LMM has homoskedastic residuals, so estimation bias and type-I error were not major concerns for the LMM. In the LMM estimation, the coefficients of electoral democracy and hydrocarbon richness have the predicted sign but are not statistically significant. All the time-invariant variables have positive signs, and among them, climate vulnerability and wind energy potential are significant (at $\alpha < 0.1$). The negative and significant effect of state oil rent and industry share in GDP, along with the EKC effect, are statistically significant and indeed very robust, which is how as they emerge from almost all the LLM estimations throughout the remainder of this chapter.

Unlike the least square models, LMMs do not report an R-squared or adjusted R-squared estimate as a measure of goodness-of-fit. For LLMs, log-likelihood, Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) values are usually reported. Generally, all else—such as the number of observations and variables included in estimation—being equal, the higher the log-likelihood estimate and the lower AIC and BIC estimates, the better. Nevertheless, Nakagawa and Schielzeth (2013) have developed a method to estimate the goodness-of-fit of LMMs. This makes comparing and contrasting LMMs with their least square peers easier and more meaningful. The measure is called 'Pseudo R-squared', and it is used as the goodness-of-fit measure in this study. The method reports two values, called—perhaps misleadingly—marginal and conditional Pseudo R-squared.[67] The Marginal Pseudo R-Squared, or in short, the marginal R-squared, measures the goodness-of-fit of only the fixed effect part of the estimation (all the independent variables) and the conditional R-squared the goodness-of-fit of the whole model including the random effect components. Among all the models estimated in Table 7.1, the LMM has the highest goodness-of-fit, 0.20 higher than that of the next best model.

Before concluding this part of the chapter, it is necessary to discuss one of the main concerns that can arise when running regression models. 'Multicollinearity' can potentially undermine the reliability of statistical inference. Estimating the variance inflation factor (VIF) is perhaps the easiest way to detect potential multicollinearity in data. A high VIF generally signals presence of multicollinearity. Table 7.3 reports the VIF of the key independent and control variables of the models. An above-10 VIF estimate is regarded as a sign of serious multicollinearity. In the empirical literature, however, a cut-off threshold of 4 or 5 is usually considered adequate. Except for GDP per capita and its squared term, all other VIF estimates are well below the threshold and within the safe range. It is surprising to see that the VIF estimates of industry share, state oil rent, and oil richness are safely below the threshold, even though they are highly correlated (see Table 6.2).

Table 7.3: Multicollinearity Test

Term	VIF	Increased SE	Tolerance
Electoral Democracy	1.11	1.05	0.90
State Oil Rent	1.71	1.31	0.59
Oil Richness	1.44	1.20	0.69
Industry Share (%GDP)	1.45	1.20	0.69
Climate Vulnerability	2.08	1.44	0.48
Solar Potential	1.16	1.08	0.86
Wind Potential	1.04	1.02	0.96
Trend	1.68	1.30	0.60
High Correlation			
GDP per capita	61.20	7.82	0.02
GDP per capita-squared	62.05	7.88	0.02

[67] The technical aspects of this method are beyond the scope of this empirical study. For further technical details see (Nakagawa & Schielzeth, 2013).

As for GDP per capita and its squared term (squared GDP per capita), some studies (e.g., von Stein (2020) have tackled the issue of high VIF by mean-centering the variables with high VIF. But according to Allison (2012), this only results in unnecessary complication of a model with no clear gains, as mean-centering a variable and its squared term does not affect estimates of other variables (both the coefficients and their standard errors); it only changes the estimates of the mean-centered variables and makes them harder to interpret. Multicollinearity is a big concern when two seemingly independent variables in a model are highly correlated. However, GDP per capita and its squared term are not two different variables. They are intentionally included in the model to test the EKC hypothesis. When multicollinearity is benign, or ‘desired’ according to Allison (2012), a high VIF should not be of concern, and hence manipulating the model to tackle it would be unwarranted.

To sum up, of the models presented in Table 7.1, the LMM proved suitable for this empirical study, given the type and nature of the data and the research questions. Its residuals are homoskedastic; therefore, the risks of estimation bias and type-I error risk are minimal. It is very robust to the violation of other distribution assumptions, such as heteroskedasticity and serial correlation (see Chapter 6). More importantly, it is the only model capable of controlling for a nested effect (country-in-region) and more than two random effect factors simultaneously. It was therefore chosen for this study. In the remainder of this chapter, various LMM estimations are presented and discussed.

7.3. Baseline LMM Estimation

It is important to clarify some specific technical details of the LMM estimations of this study before proceeding with discussion of the results of various specifications and estimations. Throughout the rest of this chapter, all the LMM estimations, unless otherwise specified, are three-way nested country-in-the-region, region, and year random effect estimations. This three-way random effect specification was chosen because it would produce larger log-likelihood estimates and smaller AIC and BIC estimates, relative to two-way country and year RE and to one-way year or country random effect. It is also worth noting that, the region random effect—absent in the RE, FE and LMM specifications in Table 7.1—is an integral part of the LMM specification. Its sum of variance accounts for around 10% of the total model variance. The country random effect variance is the largest among the three. Although the year random effect is small, its inclusion still results in better log-likelihood, AIC, and BIC estimates. Furthermore, the three-way RE specification also produces the highest marginal and conditional R-squared measures.

Another model specification option was to include a time trend term and drop year RE, or vice versa. However, these control for different effects of time. The time trend captures the linear effect of time on the dependent variable, while the RE term controls for the non-linear RE of time. Excluding any of them would result in worse log-likelihood, AIC, BIC, and marginal and conditional R-squared estimates. Overall, the three-way RE with a time trend specification was the best specification, producing the best estimates. All LMM estimations in this study, unless otherwise stated, control for three-way nested country, region, and year random effects. They also include a time trend term and an intercept, coefficient estimates that are not reported in the regression tables.

The independent variables, unless otherwise stated, are lagged by 4 years. Like previous empirical studies, this study's choice to lag independent variables by 4 years was to some extent arbitrary. It is safe to say that the effects of economic, political, institutional factors, and natural endowments (hydrocarbon resources, climate vulnerability or resilience, and RE potentials) on RE development are not immediate. It takes time for a driver or factor to have a meaningful impact on an environmental and climate policy outcome such as RE electricity consumption or production capacity. One technical justification of applying a 4-year lag to the independent variables is that it results in slightly better marginal and conditional R-squared estimates.[68]

Table 7.4 reports the baseline LMM estimation of this study. Column (7) gives the full specification. Figure 7.1 also illustrates the coefficient estimates and their levels of significance. In Figure 7.1, the thick horizontal line indicates a significant coefficient at α < 0.1 and the thin line a coefficient at α < 0.05. The signs of all the coefficients are consistent

[68] Note that AIC, BIC, and log-likelihood estimates of models using independent variables with different lags are not easily comparable because of the changes in the number of observations. Therefore, R-squared measure is a more suitable criterion upon which the models can be compared and contrasted.

with the research hypotheses of this study, and some of the widely tested hypotheses in the literature. But not all the coefficients are statistically significant. The coefficient of electoral democracy and oil richness are not statistically significant. Possible explanations for this are elaborated in the following sections. State oil rent has a negative and significant coefficient, which indicates the detrimental effect of overreliance on hydrocarbon revenues on RE development. Similarly, the share of industry—including manufacturing and heavy industries, mining, and utilities sectors—in GDP is a good predictor of renewable development, or more precisely renewable underdevelopment, given the negative sign of the coefficient.

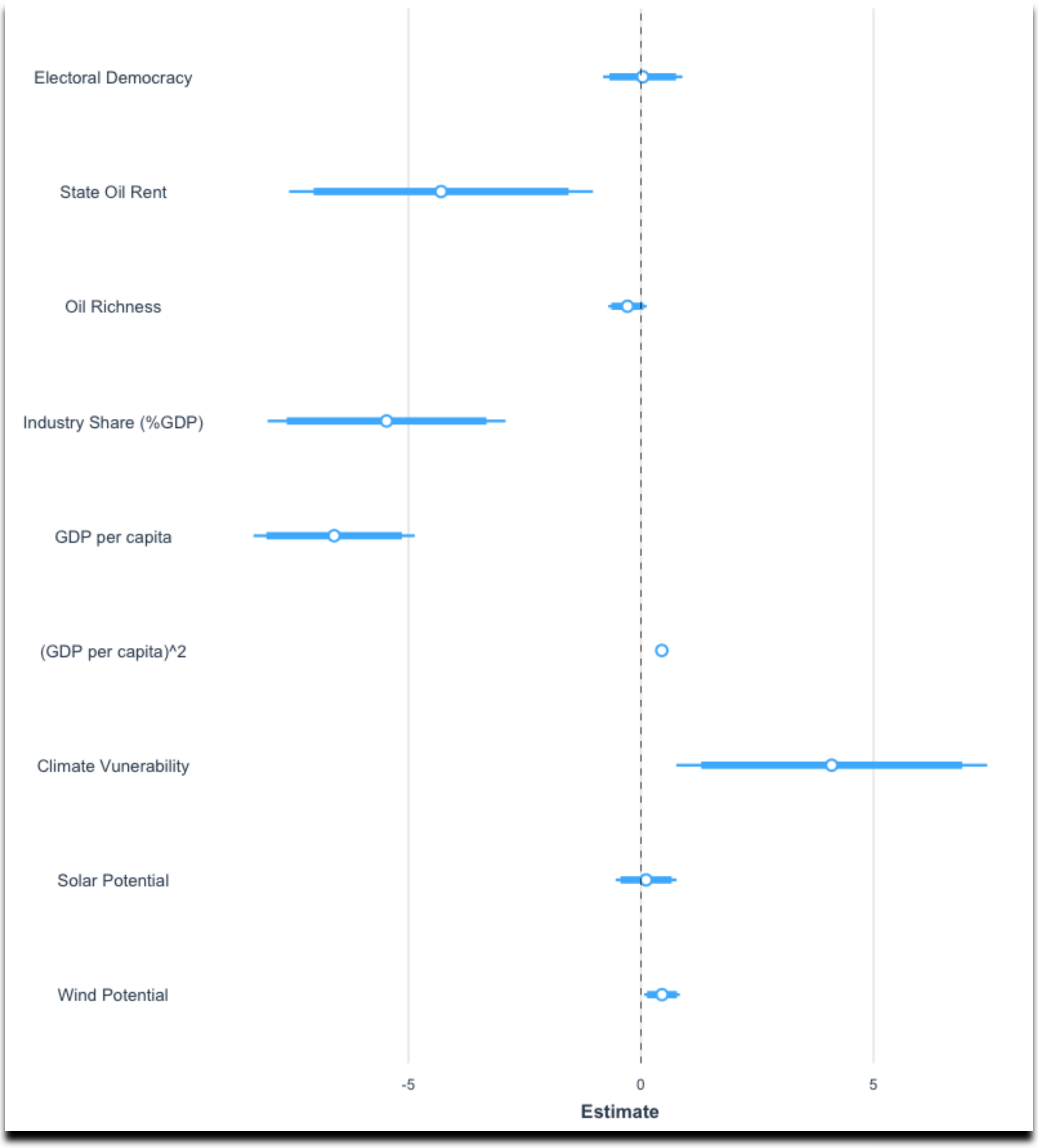
Table 7.4: Baseline LLM Estimation

	Dependent Variable: Share of Wind & Solar in Electricity Consumption						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Electoral Democracy	0.545	0.038	0.236	0.368	0.089	−0.071	0.037
	(0.413)	(0.415)	(0.420)	(0.426)	(0.431)	(0.428)	(0.435)
State Oil Rent		−7.161***	−6.375***	−3.554**	−3.235**	−3.825**	−4.299***
		(1.207)	(1.420)	(1.643)	(1.631)	(1.624)	(1.667)
Oil Richness			−0.177	−0.206	−0.261	−0.323	−0.291
			(0.201)	(0.206)	(0.208)	(0.210)	(0.210)
Industry Share (*%GDP*)				−6.148***	−7.333***	−5.398***	−5.471***
				(1.218)	(1.233)	(1.242)	(1.306)
GDP per capita					0.574***	−6.267***	−6.598***
					(0.126)	(0.856)	(0.884)
(GDP per capita)^2						0.410***	0.447***
						(0.050)	(0.052)
Climate Vulnerability							4.099**
							(1.705)
Solar Potential							0.109
							(0.334)
Wind Potential							0.451**
							(0.195)
No. of Regions/Countries	9/126	9/124	9/124	9/124	9/124	9/124	9/120
No. of Years	26	26	26	26	26	26	26
Observations	1,841	1,803	1,799	1,731	1,731	1,731	1,695
Log Likelihood	−2,857.632	−2,785.526	−2,771.630	−2,661.061	−2,653.904	−2,624.881	−2,570.337
Akaike Inf. Crit.	5,729.264	5,587.053	5,561.259	5,342.121	5,329.809	5,273.763	5,170.673
Bayesian Inf. Crit.	5,767.891	5,631.030	5,610.714	5,396.686	5,389.830	5,339.240	5,252.205
Intra-Class Correlation (ICC)	0.82	0.80	0.79	0.79	0.77	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.356/0.881	0.383/0.875	0.394/0.874	0.402/0.873	0.446/0.872	0.515/0.904	0.534/0.906

*p<0.1; **p<0.05; ***p<0.01

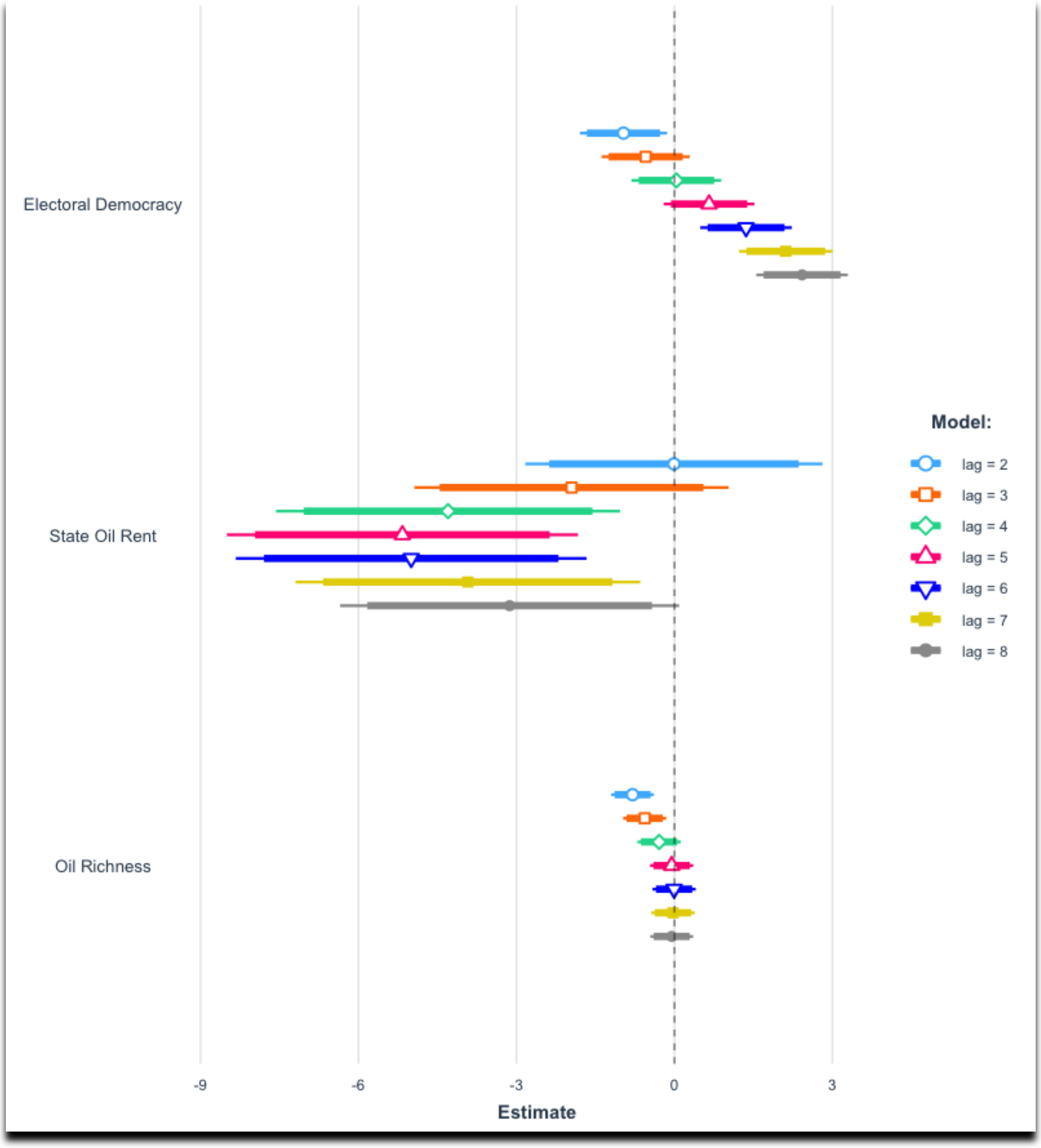
The coefficients of GDP per capita and its squared term are significant and consistent with a robust EKC effect. These provide statistical support for a non-linear, U-shaped relationship between economic development and RE development. The EKC hypothesis argues that countries at their early stages of economic development are more likely to disregard environmental and climate concerns and outcomes such as RE development until they reach a certain level of economic development. Finally, among the time-invariant variables, only solar energy potential is not statistically significant. A possible explanation for this is provided in Section 7.5.

Figure 7.1: Coefficient Estimates of Simple LMM



The independent variables in Table 7.2 are lagged by 4 years. Most empirical studies choose a specific number of lags and adhere to it. A better choice would be to identify an optimal number of lags for each independent variable separately. On the one hand, this can cause complexities without any clear or substantial gains. But on the other hand, adopting the simplistic approach of applying only one specific number for lags (i.e., 4 years) can mislead or at least unnecessarily limit the breadth of the information and insights a model can potentially provide. The impact of different independent variables can change non-negligibly as a result of different number of lags being applied to the independent variables. This change in the behavior of the independent variables can potentially provide extra invaluable information and insight. Figure 7.2 demonstrates this claim. It reports the coefficients of different lags (2-8) of the three key independent variables, with each lag estimated separately. As may be seen, while the effect of state oil rent is large in magnitude, negative, and statistically significant in most of the estimations (most of the lags), electoral democracy and oil richness variables behave quite differently. This suggests there are more nuanced effects of democracy and oil richness on RE development. These effects are discussed in Section 7.2.

Figure 7.2: Coefficient Estimates of Key Independent Variables (Different Lags)



As shown in this section, comparing and contrasting estimations that use the data (independent variables) lagged by number of years other than 4 (mostly 1-8 years) have revealed some very interesting patterns that are discussed in the rest of this chapter.

7.4. Democracy and Its Dimensions

Electoral democracy is one of the five V-Dem dimensions of democracy and the default measure of democracy in this study. So far, it has appeared in all the estimations, including the baseline LMM estimation. But empirical testing of other dimensions and comparing their effects is equally important. Also equally important is examination of other qualities and components of democracy such as government accountability, civil liberties, civil society, etc. This section examines the various aggregate measures, dimensions, and qualities of democracies.

Table 7.5 reports the estimations of all five V-Dem dimensions of democracy. The egalitarian dimension of democracy has the largest coefficient, followed by the participatory dimension. Although the coefficients of the dimensions differ in magnitude, none is statistically significant. All the estimations include the same number of observations. They are therefore comparable regarding the LMM estimation criteria, log-likelihood, BIC, AIC, and R-squared estimates. It appears that the models containing participatory democracy and egalitarian democracy variable (columns (4) and (5)) fare slightly better than the other three.[69] They have higher log-likelihood, R-squared and intra-class correlation estimates, and lower AIC and BIC estimates. The intra-class correlation (ICC) estimate—the next to the last row of the table—is the sum of all the three random effect variances divided by the total model variance—that includes residuals' variance. In a LMM estimation, an ICC value above 0.75 is considered very high, signaling that a right mix of random effect factors are selected. All the models have an ICC estimate of 0.80.

[69] Liberal, deliberative, participatory, and egalitarian dimensions of democracy in V-Dem project are constructed by combining liberal, deliberative, participatory, and egalitarian components with electoral democracy dimension (see Appendix A for further details). Using the baseline LMM model, these four V-Dem components of democracy are separately estimated and reported in Table B.5 in Appendix B. All the components have positive coefficients, but the egalitarian component is the only one that has a statistically significant coefficient. Egalitarian aspect of democracy appears to be a strong predictor of RE development in a country. A more detailed comparison of V-Dem dimensions of democracy is discussed in the following paragraphs.

Table 7.5: Dimensions of Democracy and RE Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption				
	(1)	(2)	(3)	(4)	(5)
Electoral Democracy	0.037 (0.435)				
Liberal Democracy		0.221 (0.429)			
Deliberative Democracy			0.098 (0.406)		
Participatory Democracy				0.263 (0.575)	
Egalitarian Democracy					0.831 (0.569)
State Oil Rent	−4.299*** (1.667)	−4.243** (1.668)	−4.275** (1.669)	−4.255** (1.667)	−4.159** (1.665)
Oil Richness	−0.291 (0.210)	−0.282 (0.210)	−0.289 (0.209)	−0.285 (0.209)	−0.257 (0.210)
Industry Share (*%GDP*)	−5.471*** (1.306)	−5.473*** (1.305)	−5.470*** (1.305)	−5.455*** (1.306)	−5.424*** (1.305)
GDP per capita	−6.598*** (0.884)	−6.592*** (0.884)	−6.594*** (0.884)	−6.595*** (0.884)	−6.482*** (0.886)
(GDP per capita)^2	0.447*** (0.052)	0.446*** (0.052)	0.446*** (0.052)	0.446*** (0.052)	0.438*** (0.052)
Climate Vulnerability	4.099** (1.705)	4.187** (1.706)	4.128** (1.705)	4.131** (1.697)	4.483*** (1.713)
Solar Potential	0.109 (0.334)	0.115 (0.333)	0.110 (0.333)	0.118 (0.333)	0.151 (0.333)
Wind Potential	0.451** (0.195)	0.446** (0.195)	0.449** (0.195)	0.447** (0.195)	0.432** (0.194)
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120
No. of Years	26	26	26	26	26
Observations	1,695	1,695	1,695	1,695	1,695
Log Likelihood	−2,570.337	−2,570.222	−2,570.381	−2,569.959	−2,569.011
Akaike Inf. Crit.	5,170.673	5,170.445	5,170.762	5,169.917	5,168.023
Bayesian Inf. Crit.	5,252.205	5,251.976	5,252.293	5,251.449	5,249.554
Intra-Class Correlation (ICC)	0.80	0.80	0.80	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.534/0.906	0.537/0.907	0.535/0.906	0.537/0.906	0.542/0.907

*p<0.1; **p<0.05; ***p<0.01

The picture changes when datasets with other lags are tested. Table 7.6 contains the LMM models using lags of 1-8 for the independent variables. In the estimations that use very short lags (1-2 years), the effect of electoral democracy is counterintuitively negative and significant. In columns (3), (4) and (5), corresponding to lags 3-5 years, the coefficients of electoral democracy are not statistically significant. There is, however, a rather interesting pattern emerging beyond the 5-year lag. The coefficient of electoral democracy grows in magnitude and remains strongly significant (at $\alpha < 0.01$). Possible ways democracy can positively affect public policy outputs and outcomes are elaborated in the literature review (Chapter 2) and theoretical framework chapter (Chapter 4). Democracy is associated with political competition, representation, accountability, pluralization, individual rights, and freedom of information and expression, among other things. A positive change in these factors can affect policy outcomes through development and implementation of new policies (policy outputs). Therefore, one cannot simply expect a change in a political factor such as the level of democracy to have an immediate effect on policy outcome in general and on climate and environmental policy outcomes in particular. It simply takes time for a change in the level of democracy to have a meaningful impact on RE outcomes.

All other V-Dem dimensions of democracy behave similarly. Tables B.1 to B.4 in Appendix B report LMM estimations for other V-Dem dimensions—liberal democracy, deliberative democracy, participatory democracy, and egalitarian democracy—using the data with different lags. A pattern very similar to that of electoral democracy emerges for every V-Dem dimension of democracy: a negative and significant coefficient of each democracy dimension for 1-2 year lags, insignificant coefficients for 3-5 year lags, and positive and significant coefficients for 6-8 year lags. The only difference among the dimensions is the magnitude of coefficient estimates.

Table 7.6: Baseline LMM Estimation (Different Lags)

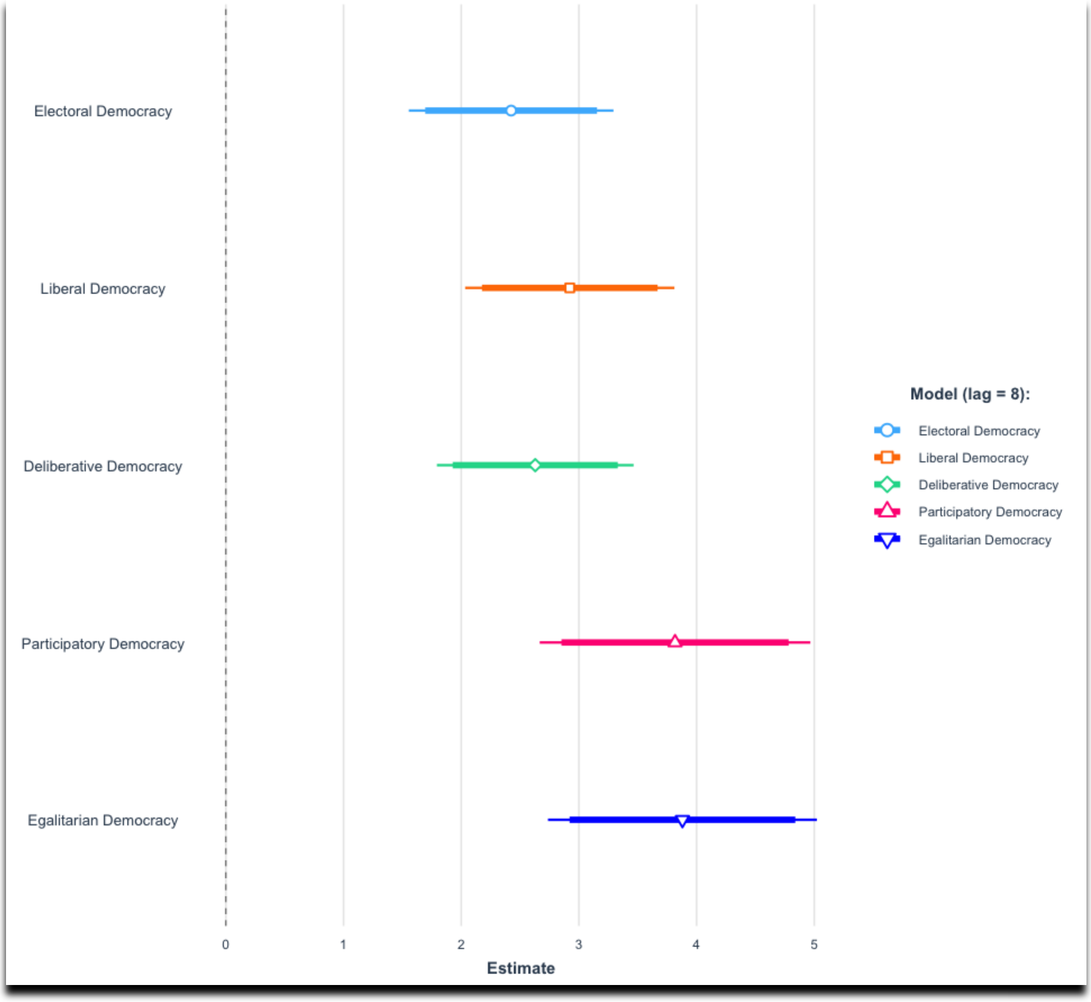
	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Electoral Democracy	−1.059**	−0.967**	−0.546	0.037	0.658	1.360***	2.115***	2.424***
State Oil Rent	0.580	−0.009	−1.954	−4.299***	−5.166***	−4.999***	−3.924**	−3.130*
Oil Richness	−0.828***	−0.795***	−0.565***	−0.291	−0.053	−0.006	−0.026	−0.051
Industry Share (*%GDP*)	−6.895***	−6.469***	−6.155***	−5.471***	−4.879***	−4.008***	−3.524***	−2.513**
GDP per capita	−6.270***	−6.371***	−6.495***	−6.598***	−6.053***	−5.075***	−3.842***	−2.744***
(GDP per capita)^2	0.399***	0.414***	0.432***	0.447***	0.415***	0.353***	0.275***	0.201***
Climate Vulnerability	0.739	1.590	2.913*	4.099**	4.410***	4.322***	4.121**	3.543**
Solar Potential	−0.048	−0.024	0.041	0.109	0.125	0.111	0.072	−0.023
Wind Potential	0.466**	0.468**	0.461**	0.451**	0.445**	0.431**	0.413**	0.414**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,708.827	−2,673.763	−2,621.495	−2,570.337	−2,521.314	−2,467.560	−2,406.649	−2,340.037
Akaike Inf. Crit.	5,447.655	5,377.525	5,272.991	5,170.673	5,072.628	4,965.120	4,843.299	4,710.074
Bayesian Inf. Crit.	5,529.819	5,459.527	5,354.777	5,252.205	5,153.883	5,046.083	4,923.899	4,790.284
Intra-Class Correlation (ICC)	0.78	0.78	0.79	0.80	0.80	0.79	0.78	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.520/0.892	0.522/0.895	0.528/0.901	0.534/0.906	0.531/0.904	0.525/0.899	0.515/0.892	0.488/0.882

*p<0.1; **p<0.05; ***p<0.01

Note: Each column reports the outcome of a separate estimation. Each estimation is run after independent variables are lagged (lagged from 1 to 8 years respectively).

Figure 7.3 shows the coefficient estimate of all the dimensions for 1-8 year lags. Of the five V-Dem dimensions of democracy, the electoral, liberal, and deliberative democracy dimensions have coefficient estimates very similar to each other, while the participatory and egalitarian ones have the largest coefficients estimates by comparison when each number of lag is applied to the data (see Tables B.1 to B.4 in Appendix B).

Figure 7.3: Coefficient Estimates of Dimensions of Democracy (Lag = 8 years)



As elaborated in Appendix A, the participatory dimension of democracy conceptually borrows from the idea of direct, non-representative democracy and measures direct rule and active participation of the citizenry in political decision making. It incorporates indices of civil society participation (non-electoral avenues of participation such as citizens' assemblies, townhall meetings, public hearings, etc.), the direct popular vote, and the power of local and regional governments. The egalitarian dimension intends to capture the level of political equality across all social strata in terms of wealth, education, ethnicity, religion, language, region, and gender. All social groups should be equally capable of participating in political processes that shape, decide, and put policies in motion. It is argued that deeper and further democratic electoral and especially non-electoral participation can move the balance of power from special interest groups towards ordinary citizens, especially when it comes to environmental and climate policies. In addition, a more egalitarian society with equality in terms of wealth distribution, economic opportunities, education, access to health care, women's and minority groups' rights, etc., can ultimately lead to meaningful improvement in environmental and climate policy outcomes. This would be achieved through channels discussed in Chapters 2. These results have provided statistical support for these arguments.[70] The participatory and egalitarian dimensions appear to be better predictors of RE development. These results also provide firm evidence in support of the claim that focusing on electoral democracy or a single aggregate measure of democracy alone when investigating the effect of democracy on environmental and climate policy outcomes would be methodologically and conceptually flawed.

One surprising finding of the estimations was the effect of the deliberative dimension of democracy, which is almost on par with that of the electoral democracy dimension and even lower than that of the liberal democracy dimension. As previously discussed, Dryzek (1992) and others have singled out democratic deliberation as a key determinant of environmental outcomes, arguing that long-term environmental policy preferences have a better chance of being discussed and considered through the rational discursive political decision-making processes dominant in deliberative democracies. Although the effect of the deliberative dimension of democracy is positive and significant in the long term, the results of this analysis indicate that deliberation is not the only important dimension or principle of democracy, at least when it comes to RE outcomes.

In addition to comparing and contrasting V-Dem dimensions of democracy, this study examined the effects of several aggregate measures of democracy and qualities of democracy. The electoral democracy dimension has become a popular aggregate measure of democracy in the empirical literature. But this study also examined other continuous aggregate democracy measures, such as the now outdated Polity2, Vanhanen index,

[70] Women are reported to be generally more environmentally conscious, so a more gender equal society would have a better environmental performance due to greater involvement of women in environmental policy development and implementation. promoting environmental sustainability necessitates reducing inequality as a prerequisite, given that the poor are considered more vulnerable to environmental challenges, and an unequal society creates obstacles in rallying support for rigorous environmental actions.

Freedom House index, the recently developed Continuous Machine-Learning Democracy Index (CMLDI), and two discrete measures of democracy, the Dichotomous Machine-Learning Democracy Index (DMLDI) and the Democracy-Dictatorship Index. Table B.6 in Appendix B reports the results of estimating the effect of these continuous and discrete democracy measures. None of these aggregate democracy measures, except the DMLDI, has a statistically significant coefficient. These measures behave differently when different lags of the independent variables are estimated separately. While the CMLDI and the Freedom House democracy index behave similarly to the V-Dem dimensions of democracy, having positive and statistically significant estimates at $\alpha < 0.05$ for 6-8 year lags, the Polity2 and the Vanhanen index do not follow any meaningful and statistically significant pattern (regression results are not reported). The two discrete measures also behave quite differently. Tables B.7 and B.8 in Appendix B report the estimation of their effects for 1-8 year lags. While the Democracy-Dictatorship Index has a positive and statistically significant coefficient beyond the 4-year lag, the DMLDI coefficient is always positive but only significant when lags 3-6 are applied to the data.

Recent empirical studies have examined the effects of some other qualities or dimensions of democracy—such as civil society, political constraints, civil liberties, accountability, federalism, etc.—on environmental and climate policy outputs and outcomes (Bayulgen & Ladewig, 2017; Escher & Walter-Rogg, 2018, 2020; Povitkina, 2018; von Stein, 2020). Table B.9 in Appendix B reports the estimation of the effect of these qualities of democracy on RE development. None of the coefficients is statistically significant. This study also tested the effect of these qualities of democracy using other lags of the independent variables (regression results are not reported) and did not find any statistical support for a positive association between these qualities of democracy and RE development. The level of these qualities of democracy does not appear to be a good predictor of RE development.

The effects of different forms of democracy on environmental and climate policy output and outcome have also been the subject of several empirical studies. As discussed in Chapter 2, it is argued in the literature that presidential and parliamentary forms of democracy perform differently when it comes to environmental policy and climate policy performance. Most studies argue in favor of non-presidential systems with regard to environmental and climate policy outputs and outcomes. [71] The current study examined the effects of democracy form on RE development, using two discrete democracy form measures, the Democracy-Dictatorship (DD) Presidential Index (dichotomous) and the DPI Presidential-Parliamentary Index (trichotomous) (see Table B.10 in Appendix B). The coefficient of the DD Presidential Index is positive but not significant, meaning neither form of democracy has any advantages over the other. On the other hand, the coefficient of the DPI Presidential-Parliamentary Index for assembly-elected president (DPI Presidential-Parliamentary Index = 1) is negative but not significant, and for parliamentary system (DPI Presidential-Parliamentary Index = 2) it is positive and significant. These results remain the same even when the data are lagged by 5-8 years (regression results are not reported).

Another way to approach the research questions of this study was to only include democratic countries in the test. One can argue that the distinction between the parliamentary and presidential systems is less clear in autocratic contexts. To that end, four subsets of data with only democratic countries were created and tested. The cut-off thresholds for democracy were arbitrarily set at electoral democracy scores of 0.5, 0.6, 0.7 and 0.8. Estimating the two democracy form indices using these four subsets of data still gave inconsistent results and did not reveal any clear or meaningful pattern (regression results are not reported). To sum up, the outcome of investigating the effect of democracy forms on RE development was inconclusive.

In conclusion, the seven key takeaway messages from using the simple LMM estimation to examine the effect of dimensions, qualities, and forms of democracy on RE are:

i. A positive and significant effect of electoral democracy on RE development exists, but it comes with a caveat. It appears that democratization or progress along dimensions of democracy does not yield immediate RE development gains. It simply takes time to take effect.

ii. When investigating the effect of democracy on RE development, distinguishing among different dimensions of democracy is conceptually and empirically warranted.

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[71] The Selectorate Theory (Bueno de Mesquita et al., 2003) argues in favor of presidential systems (see Chapter 2).

iii. Among the five dimensions of democracy, the participatory and egalitarian dimensions of democracy are better predictors of RE development.
iv. Qualities of democracy such as civil society, civil liberties, political constraints, federalism, and various forms of accountability cannot explain variation in RE development.
v. A positive and significant link between aggregate continuous and discrete measures of democracy—such Polity2, Freedom House Index, etc.—and RE development emerged, but it was not consistent across all the aggregate measures and number of lags.
vi. The form of democracy (presidential, parliamentary or hybrid) does not appear to be a good predictor of RE development.

7.5. Hydrocarbon Richness and State Hydrocarbon Rent

The baseline LMM estimation of this study includes only oil richness and state oil rents for the reasons elaborated in Chapter 6. Most of the models estimated in this chapter include these two variables—although natural gas and coal were tested separately and together with oil. Table 7.7 reports the estimation of the baseline model (3) alongside model (1), which includes only state oil rent, and model (2), which includes only oil richness. In models (1) and (2), the coefficient of state oil rent and oil richness are both negative and strongly significant. But when both are included in model (3), only the coefficient of state oil rent remains significant. A simple explanation for this pattern is the relatively strong correlation between oil richness and state oil rent (see Table 6.2). In some cases, a high correlation between two variables in a regression model leads to inflation of the standard error of one of the variable's coefficients—as seems the case for the coefficient of oil richness—making its confidence interval wider. The reason such a high correlation exists in the first place is straightforward: for a government to enjoy high state oil rent—to be a rentier state—it must be oil rich in the first place. All the governments that enjoy relatively high levels of state oil rent—e.g., all OPEC members, Russia, Kazakhstan, and Azerbaijan—are oil rich.[72] Overall, it seems that disentangling the distinctive effect of oil richness and state oil rent simultaneously is technically difficult.

Table 7.7: Separate Estimation of Oil Richness vs. State Oil Rent

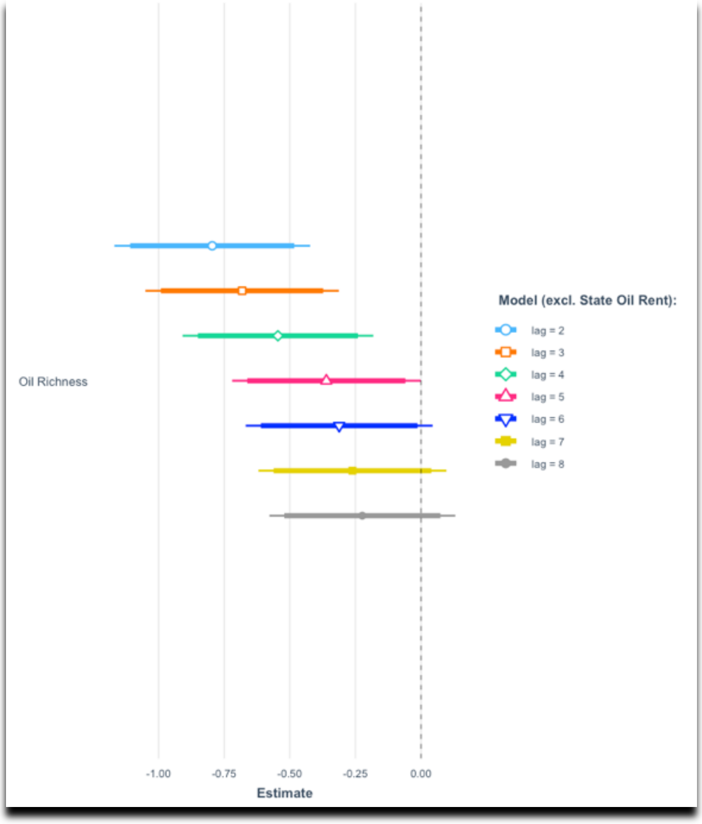
[72] The opposite is not always true, though. For example, there are several oil rich countries. such as US, Canada, Norway, and UK, where the state either does not directly receive revenue from oil production and exports, or if they receive any they do not have a free hand to spend it at as they wish due to strict fiscal rules and regulations.

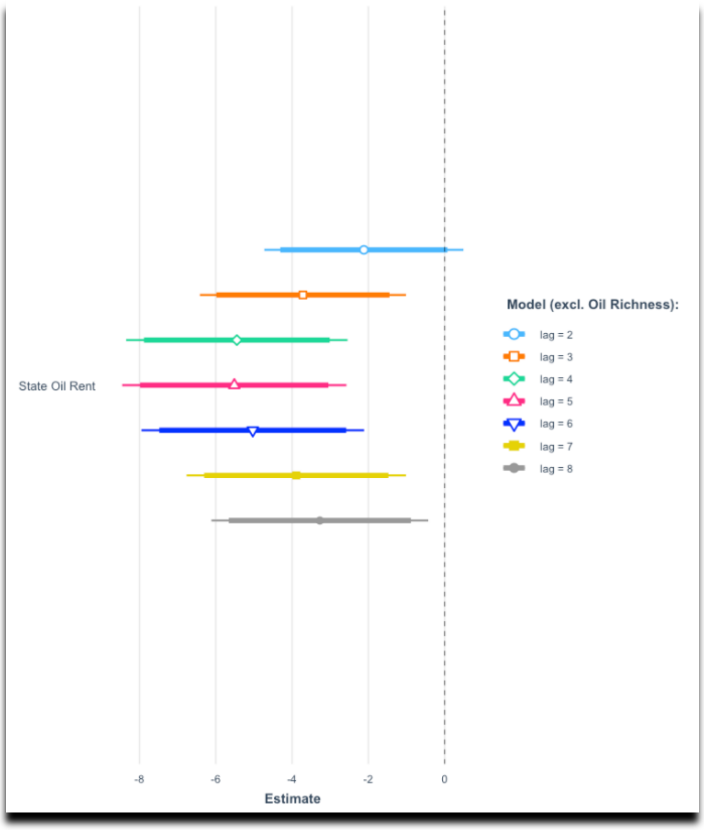
	Dependent Variable:		
	Share of Wind & Solar in Electricity Consumption		
	(1)	(2)	(3)
Electoral Democracy	−0.093	0.104	0.037
	(0.429)	(0.435)	(0.435)
State Oil Rent	−5.448***		−4.299***
	(1.481)		(1.667)
Oil Richness		−0.545***	−0.291
		(0.186)	(0.210)
Industry Share (*%GDP*)	−5.677***	−6.815***	−5.471***
	(1.309)	(1.197)	(1.306)
GDP per capita	−6.688***	−6.437***	−6.598***
	(0.889)	(0.882)	(0.884)
(GDP per capita)^2	0.456***	0.437***	0.447***
	(0.052)	(0.052)	(0.052)
Climate Vulnerability	4.642***	3.881**	4.099**
	(1.727)	(1.692)	(1.705)
Solar Potential	0.130	0.070	0.109
	(0.340)	(0.330)	(0.334)
Wind Potential	0.464**	0.444**	0.451**
	(0.198)	(0.195)	(0.195)
No. of Regions/Countries	9/120	9/120	9/120
No. of Years	26	26	26
Observations	1,699	1,695	1,695
Log Likelihood	−2,581.172	−2,575.063	−2,570.337
Akaike Inf. Crit.	5,190.344	5,178.126	5,170.673
Bayesian Inf. Crit.	5,266.473	5,254.222	5,252.205
Intra-Class Correlation (ICC)	0.81	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.526/0.908	0.536/0.906	0.534/0.906

*p<0.1; **p<0.05; ***p<0.01

A simple solution was to estimate each variable while excluding the other from the baseline LMM altogether. Figure 7.4 and Tables B.11 and B.12 in Appendix B, illustrate and report the effects of state oil rent and oil richness separately when the other variable is excluded from estimation. Figure 7.4 includes estimations for independent variables lagged by 2-8 years and estimated separately. The negative effect of state oil rent is strong and statistically significant (at $\alpha < 0.01$) for all but one model for the 2-year lag. Excluding state oil rent, the coefficients of oil richness are statistically significant in most models (at $\alpha < 0.01$ in four models and at $\alpha < 0.05$ in five models) and larger in magnitude than those of the baseline model, which estimates oil richness and state oil rent simultaneously.

Figure 7.4: Separate Effect of Oil Richness (above) vs. State Oil Rent (below)





The mechanisms through which oil richness and state oil rent affect environmental and climate policy outcomes and RE development are different (see Chapters 3 and 4). Even when the state does not directly control the oil sector in a country, a private fossil fuel sector can still undermine RE development. As one the sectors in an economy that would bear most of the cost of RE transitions, the fossil fuel industry might consider the transitioning to greener and more renewable energy a major threat to its dominant position and standard practices. Furthermore, the oil sector is the main beneficiary of carbon lock-in and is often extremely rich. Hence, the larger and more powerful the oil industries, the stronger and fiercer will be their opposition to transitioning to renewable sources of energy.

As for state oil rent, the dynamics are different, and the impact can be even stronger. Dependence on oil revenues is prevalent in many oil-rich economies. This dependence can be specifically more severe in countries with a nationalized oil sector where the state enjoys unhindered access to resource windfalls. The state directly benefits from oil revenue and at the same time is in charge of developing and implementing RE policy. This is a textbook example of conflict of interests. Furthermore, the resource curse literature links the detrimental effect of this dependence to a wide range of economic and political outcomes (see Chapters 3 and 4), which themselves are detrimental to environmental and climate policy outcomes.

Overall, these empirical tests provide statistical support for a strong, negative, and statistically significant effect of oil richness and state oil rent on RE development. The negative environmental and climate outcomes of a country's dependence on fossil fuels are hypothesized as an environmental resource curse. This study produced strong evidence supporting this hypothesis and the expansion of the negative outcomes to include RE underdevelopment. As for the two other hydrocarbon resources, natural gas and coal, the test results are inconsistent, counterintuitive, and inconclusive. Table B.13 in Appendix B reports estimations that include oil and gas variables for lags 1-8. Table B.14 compares baseline LMM estimations that include oil alone, natural gas and coal together, oil and natural gas together, and all of them together.

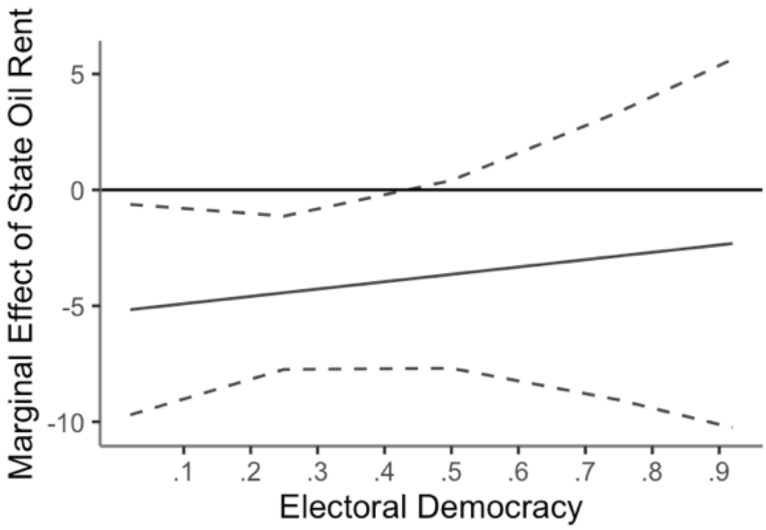
A few possible explanations for natural gas and coal not behaving according to the research hypotheses are presented in Chapter 6. In this study's dataset, natural gas only includes dry natural gas. A sizable proportion of natural gas production is in the form of natural gas liquids (NGL)—not to be confused with liquified natural gas (LNG)—or condensates. However, the natural gas data offers an incomplete picture of natural gas production, consumption, and exports, and it is thus an unreliable measure for empirical tests. NGLs or condensates are already included in crude oil statistics as barrels of oil equivalent or tons of oil equivalent by well-established databases, including the one used in this study. Furthermore, there is a relatively strong correlation (> .5) between oil and the dry part of natural gas in this study's data. Natural gas, in many cases, is merely a byproduct of oil extraction. Hence, in most countries oil data is also deemed a suitable proxy for the gas industry. As for coal, the correlation between coal richness and oil and gas richness is very low. Coal production is more labor intensive than oil and natural gas production, and it generates less revenue per unit of labor, energy, and capital inputs. It is also the dirtiest of them all. Coal is a cheaper hydrocarbon resource, and the coal industry sector is less profitable than those of crude oil and natural gas (Aoun, 2009). Simply put, coal produces less rent than the oil and gas industry per unit of input (capital, labor, etc.).

One of the hypotheses of this study is that democracy can alleviate the negative effect of state hydrocarbon rent on RE development; that is, all else being equal, the negative effect of state hydrocarbon rents on RE development is moderated by the level of democracy. A higher level of democracy is generally associated with the rule of law, better governance, more government accountability and less corruption, all of which can attenuate the negative effect of hydrocarbon rents on environmental and climate policy outcomes such as RE development.[73] To test this hypothesis, an interactive term comprising electoral democracy and state oil rent (Electoral Democracy × State Oil Rent) was added to the baseline LMM and estimated. Figure 7.5 shows the marginal effect of state oil rent on the share of wind and solar in electricity consumption (the regression table is not included). The positive slopes of the diagrams, along with the confidence intervals (dashed lines), reveal the statistically significant moderating effect of electoral democracy on the negative association between state oil rent and RE development. On average, as countries become more

[73] The moderating effect of corruption, rule of law and quality of government on the link between state hydrocarbon rent and RE development is examined separately in Section 7.4.

democratic along the electoral democracy dimension, the negative effect of oil rents on RE development diminishes in magnitude. Beyond a certain level of democracy (around electoral democracy score of 0.5) the negative effect of state oil rent on RE development becomes statistically insignificant.

Figure 7.5: Marginal Effect of State Oil Rent on RE Development



When the effects of the liberal, deliberative, participatory, and egalitarian dimensions of democracy were tested, very similar patterns appeared. As the level of democracy improves along each democracy dimension, the negative effect of state oil rent on RE development continues to shrink until it becomes statistically insignificant around the democracy score of 0.5. Testing the moderating effect of other qualities of democracy such as civil liberties, core civil society, aggregate government accountability, diagonal accountability and horizontal accountability yielded very similar results. The only surprise was the moderating effect of vertical accountability being not statistically significant.[74] Figure B.1 in Appendix B shows the moderating effect of these qualities of democracy.

In summary, the key findings of investigating the effect of hydrocarbon richness and state hydrocarbon rent on RE development, using the LMM estimation, are:

i. The statistical support for a negative effect of oil richness and state oil rent on RE development is very strong and robust. It appears that RE underdevelopment can be added to a long list of negative environmental and climate consequences of dependence on oil, which is also known as the environmental resource curse.
ii. Testing the effect of natural gas and coal yielded results that are inconsistent, counterintuitive, inconclusive or a combination of all (there are possible explanations for this).
iii. The negative association between state oil rent and RE development is moderated by V-Dem dimensions and other qualities of democracy. This moderating effect is robust and statistically significant.

7.6. Industry Share of GDP and Income

As may be seen in Table 7.4, the coefficient estimate of industry share of GDP is negative and statistically significant. Looking again at Table 7.6, it is also apparent that although the magnitude of the estimate changes in the different estimations corresponding to different lags, it always remains negative and significant (at $\alpha < 0.01$). This is the case not only for the estimations in these two tables but also for almost all the estimations throughout this empirical study, including those presented in the next chapter and Appendices B and C. The coefficient estimate of industry share of GDP is indeed one of the most robust estimates in this study.

[74] The moderating effect of political constraint and federalism on the negative link between state oil rent and RE development are also not statistically significant. These results should not be considered surprising as no firm theory or explanation exists for a moderating effect of these factors on state hydrocarbon rent-RE development relationship.

Chapter 2 discussed the arguments in support of a negative link between the share of industry in GDP and environmental and climate policy outcomes generally and in RE development particularly. The industry share of GDP encompasses the total value added produced by the manufacturing, mining, construction, and utilities (electricity, water, and gas) sectors, all of which are known to be highly energy intensive. [75] The standard practices and business models of utility companies, manufacturing and heavy industries, mining companies, and metal producers are strongly dependent on not only the availability of fossil fuels but also the reliable and uninterrupted access to them. Furthermore, these industries are the ones that would bear the highest costs of transitioning to more renewable and clear energy resources. Like the fossil fuel sector itself, they are observed to oppose rules, regulations, and initiatives—such as those promoting RE investment and development—that might jeopardize the availability of and access to fossil fuels. They do this through channels such as industry lobbying and involvement in electoral and/or media campaigns. This empirical investigation provides very strong statistical support for the hypotheses outlined in Chapter 4.

In Table 7.4, the coefficients of GDP per capita—the most widely used proxy for income and/or economic development—and its squared term are also very robust and consistent with the EKC hypothesis. The coefficients of GDP per capita is negative and significant and that of its squared term is positive and significant in the baseline LMM estimation. Although their magnitudes vary, the signs of these coefficient estimates remain the same and statistically significant (at $\alpha < 0.01$) for all lags in Table 7.6. This is the case in almost all other estimations presented in various regression tables throughout this chapter and Chapter 8, and in Appendices B and C.[76]

[75] Some empirical studies use only the share of manufacturing in GDP. For robustness, this study separately estimates the effect of manufacturing value added (results are not reported). The coefficient estimate is negative but not statistically significant. Overall, this study argues that the share of industry in GDP is simply a more complete measure and has clear advantages over manufacturing value added as percentage of GDP.

[76] A more nuanced effect of the industry share of GDP and environmental outcomes has been empirically examined in the literature. von Stein (2020) hypothesizes that the link between democracy and its qualities such as civil liberties and environmental outcomes depends on which actors within a society hold more power. The key argument is that the industry sector holding a large share of the national economy can diminish, nullify, or even reverse the supposedly positive effect of democracy and civil liberties on environmental outcomes. However, testing the moderating effect of the industry share in GDP and manufacturing share in GDP—which

As briefly discussed in Section 7.1, the EKC hypothesis argues that countries at their early stages of economic development keep caring less, in relative terms, about environmental and climate concerns and outcomes such as RE development until they reach a certain level of economic development. When trying to unravel the EKC effect, the literature mostly treats it as either an economic or a political phenomenon (see Chapter 2). From an economic perspective, a wealthier and more economically developed society is likely to ask for more environmental and climate policy outputs and outcomes (e.g., transitioning to renewable sources) simply because these are considered luxury goods. The political interpretation suggests that economic development leads to expansion of a sizeable middle class, which in turn becomes more politically active about environmental and climate demands. Another explanation put forward in Chapter 2 for the EKC effect is that economic development is indeed a combination of a change in a country's industrial structure (shifting from manufacturing to services) and demand factors such as societal demands for a cleaner environment. Although this study could not test which of these mechanisms are really at play, the statistical evidence for the effect itself is strong and robust.

In summary, this examination of the share of industry in GDP and GDP per capita along with its squared terms, using the LMM estimation, provides empirical support for:

(i) a robust, strong, and negative effect of the size of industries (manufacturing, mining, construction, and utilities sectors) in GDP on RE development, and
(ii) a robust EKC effect, linking economic development to RE development.

7.7. Institutional Qualities

This study examined the effect of quality of government, rule of law, and corruption on RE development. These three institutional factors are the most widely tested variables in the

was used in the original study instead—on the link between electoral and liberal democracy, along with civil liberties, and RE development did not provide any statistical support for this hypothesis (results are not reported).

empirical environmental politics literature. Each of the V-Dem dataset and the World Bank's Worldwide Governance Indicators (WGI) dataset has a corruption index and a rule of law index. Although the way each dataset conceptualizes and estimates corruption and rule of law is fundamentally different (see Chapter 6 for further details), data from both datasets were tested for robustness purposes. The quality of government variable aggregates its own estimation of the lack of corruption, law and order, and bureaucracy quality into one index.[77]

Environmental policy outputs and outcomes are a subset of public sector outputs (provision of public goods). A positive link between institutional factors and public sector outputs is well established in the literature. It is not contentious to hypothesize that, all else being equal, higher levels of institutional factors such as higher quality of government, less corruption and stronger rule of law generate more and better environmental and climate policy outcomes. Table 7.8 contains estimations that test these hypotheses concerning RE development. Four out of five coefficient estimates are negative and inconsistent with the hypotheses predicting a positive link between institutional factors and renewable. Among the five institutional quality variables, only the WGI rule of law and the ICRG quality of government variables have statistically significant coefficients, and only the WGI rule of law variable has a positive sign and is consistent with the hypotheses. The results are not very different when the estimations are done with other lags of the independent variables. For the quality of government variable, coefficients remain negative and significant for 1 to 8-year lags, and for all the other variables the coefficient estimates are not statistically significant, inconsistent, significant but counterintuitive, or a combination of all (regression results are not reported). The results do not reveal any meaningful or clear patterns and are indeed inconclusive.

[77] It is worth noting that these five indices are from three different datasets that vary in terms of country and year coverage. WGI dataset covers a limited number of years, in comparison with V-Dem and ICRG datasets. ICRG dataset covers a smaller number of countries than the other two. Since the country-year observations of these datasets are not the same, one needs extreme caution when trying to compare the coefficient estimates of models using them.

Table 7.8: Institutional Qualities and RE Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption				
	(1)	(2)	(3)	(4)	(5)
Electoral Democracy	0.217 (0.485)	0.317 (0.499)	−0.116 (0.490)	0.244 (0.612)	0.305 (0.451)
State Oil Rent	−5.474*** (1.717)	−4.337*** (1.667)	−5.441*** (1.714)	−4.326*** (1.668)	−4.874*** (1.675)
Oil Richness	−0.243 (0.225)	−0.298 (0.210)	−0.204 (0.224)	−0.297 (0.210)	−0.300 (0.211)
WGI Corruption (*reversed*)	−0.335 (0.730)				
V-Dem Corruption (*reversed*)		−0.546 (0.480)			
WGI Rule of Law			2.545*** (0.912)		
V-Dem Rule of Law				−0.273 (0.574)	
ICRG Quality of Government					−1.914*** (0.563)
Industry Share (*%GDP*)	−2.972* (1.530)	−5.522*** (1.306)	−2.320 (1.535)	−5.459*** (1.306)	−5.167*** (1.362)
GDP per capita	−6.687*** (1.115)	−6.699*** (0.887)	−6.149*** (1.124)	−6.581*** (0.884)	−4.909*** (0.960)
(GDP per capita)^2	0.444*** (0.064)	0.456*** (0.053)	0.397*** (0.065)	0.447*** (0.052)	0.354*** (0.056)
Climate Vulnerability	3.073* (1.792)	3.995** (1.700)	3.615** (1.813)	4.022** (1.702)	4.116** (1.788)
Solar Potential	0.130 (0.328)	0.133 (0.332)	0.075 (0.334)	0.121 (0.332)	−0.064 (0.327)
Wind Potential	0.450** (0.191)	0.458** (0.196)	0.398** (0.189)	0.452** (0.195)	0.512** (0.220)
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/111
No. of Years	17	26	17	26	26
Observations	1,389	1,695	1,389	1,695	1,614
Log Likelihood	−2,107.909	−2,569.514	−2,104.022	−2,569.862	−2,436.049
Akaike Inf. Crit.	4,247.817	5,171.028	4,240.045	5,171.724	4,904.099
Bayesian Inf. Crit.	4,331.599	5,257.995	4,323.826	5,258.691	4,990.282
Intra-Class Correlation (ICC)	0.80	0.80	0.80	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.497/0.898	0.535/0.906	0.503/0.902	0.534/0.906	0.516/0.901

*p<0.1; **p<0.05; ***p<0.01

Another way to approach the research question (What is the effect of institutional quality variables on RE development?) is to assume that disparate dynamics are at play in different contexts, for example, democratic countries vs. non-democratic ones, oil rich countries vs.

oil poor peers, and rentier economies vs. non-rentier ones. One might argue that more democratic countries have high institutional quality scores too, meaning that on average they enjoy lower levels of corruption and have stronger rules of law and better government quality. This association can potentially result in spurious coefficient estimates for institutional factors. One technical solution to tackle this issue and to empirically test this new approach was to create several new data subsets and test them using the same models, as shown in Table 7.8. For this purpose, the cut-off thresholds for democracy were arbitrarily set at country-average electoral democracy scores of 0.5, 0.6, 0.7 and 0.8. For oil richness, the cut-off threshold was an average oil richness score of 0.69, which, for a country, is equivalent to being self-sufficient in terms of satisfying its total oil demand.[78] For state oil rent, the cut-off thresholds between oil rentier countries and less rentier ones were arbitrarily set at average state oil rent values of 0.03 and 0.07.[79] Investigating the effects of institutional quality variables using all these subsets still produced inconsistent, contradictory, counterintuitive, or statistically insignificant estimates. The results remain inconclusive.

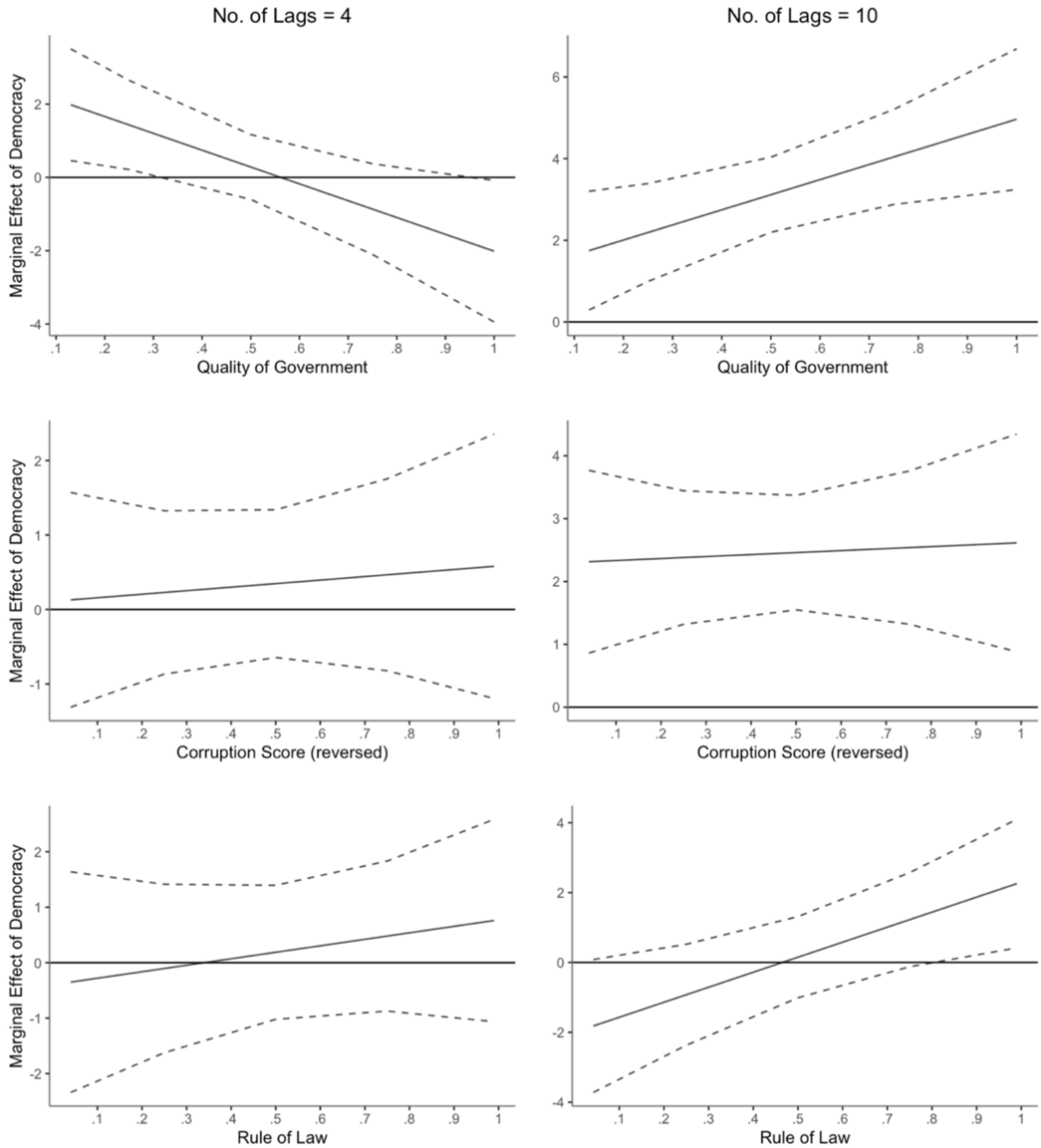
Perhaps, other, more nuanced, hypotheses can explain the moderating effects of quality of institutions on the links between other key independent variables such as democracy and environmental policy outcomes. The main argument is that a factor such as the level of democracy alone is not sufficient to explain variations in environmental and climate policy outcomes, and that its impact depends on institutional factors such as the level of corruption, rule of law, and quality of government. To test this hypothesis, which was discussed in Chapter 4, an interactive term comprising electoral democracy and each institutional quality variable was separately added to the baseline LMM and estimated. Figure 7.6 shows the marginal effect of electoral democracy on the share of wind and solar

[78] Oil richness is log-transformed after 1 is added to all raw values of oil richness. A log-transformed value of 0.69 corresponds to raw oil richness score of 1.

[79] After thorough review of the dataset, these thresholds were chosen to make sure that well-established cases of a rentier economy—such as Russia—were included in the rentier subset. A less strict rentier threshold of 0.03 was included in the tests for robustness purposes.

in electricity consumption, moderated by corruption, rule of law, and quality of institutions when the variables are lagged by 4 and 10 years (regression results are not reported).[80]

Figure 7.6: Marginal Effect of Electoral Democracy on RE Development



[80] For corruption and rule of law, V-Dem indices are used in estimations as they are superior to their WGI peers (see Chapter 6 for further details). The result of estimating the moderating effect of WGI indices of corruption and rule of law are inconclusive.

The left-hand side of Figure 7.6 shows the marginal effects of electoral democracy when the independent variables are lagged by 4 years, which is the default number of lags in the baseline LMM estimation. These slopes are not consistent with the hypotheses. Improvement in quality of government counterintuitively diminishes the positive effect of electoral democracy on RE development, until this positive association disappears (becomes statistically insignificant) around the quality of government value of 3. As for corruption and rule of law, their moderating effects are positive but not statistically significant at any level. Overall, the results are either counterintuitive or statistically insignificant, and overall inconclusive.

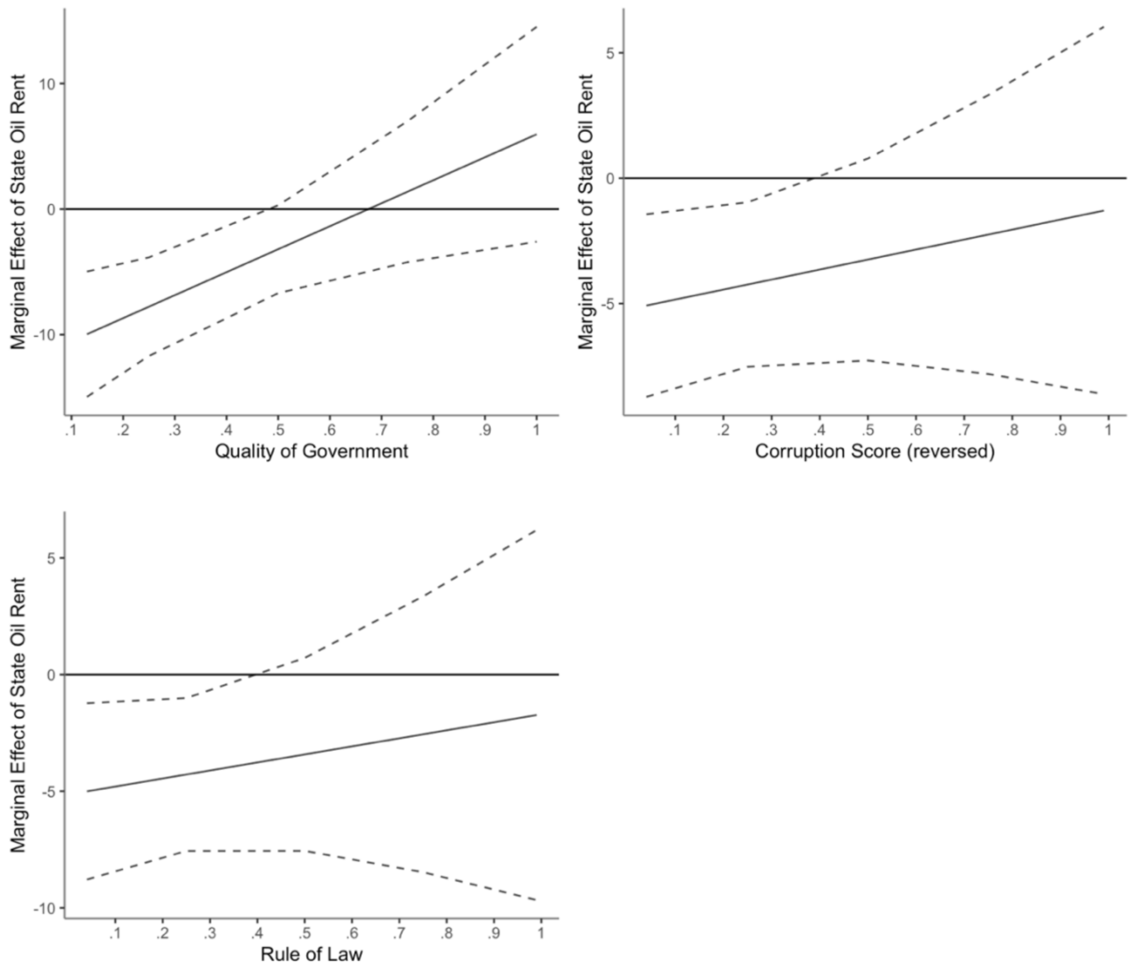
Examining the effect of electoral democracy on RE development in Section 7.1 revealed that a positive association emerged in the long term. The coefficients of all democracy variables are insignificant when the independent variables are lagged by 4 years. Using larger lags might reveal different patterns. The right-hand column of Figure 7.6 illustrates the marginal effect of electoral democracy moderated by quality of institution variables, when the independent variables are lagged by 10 years.[81] The positive slope of the diagrams, along with the confidence interval (dashed lines), reveals a moderating effect of institutional factors on the positive association between electoral democracy and RE development, which is also statistically significant. In the long term, improvements in terms of corruption, rule of law, and quality of government, amplify the positive association between level of electoral democracy and RE development. This moderating effect is always positive and significant for quality of government and corruption. For rule of law, however, it is only positive and significant for the rule of law values of 0.85 and above. Testing the moderating effects of institutional factors for other dimensions of democracy—liberal, deliberative, participatory, and egalitarian—reveals very similar patterns (result are not reported).

In the context of this study, another nuanced approach to investigating the effect of the quality of institutions and environmental and climate policy outcomes is the interaction of these factors with state oil rents. As discussed in the review of the resource curse literature (Chapter 3), bad governance, lack of fiscal discipline, and corruption are endemic to most

[81] All lags from 1 to 9 are also estimated. Lag 10 is the first lag that reveals patterns that are statistically significant and consistent with the hypotheses.

hydrocarbon rich and rentier countries. A negative link between institutional factors such as corruption, weak rule of law, and bad governance on the one hand and environmental and climate policy outcomes on the other is also well established in the literature (see Chapter 2). It is therefore compelling to investigate the moderating effect of quality of institution on the negative association between state oil rent and RE development. This is one of the hypotheses discussed in the theoretical framework chapter (Chapter 4). The moderating effects of the three institutional qualities are illustrated in Figure 7.7

Figure 7.7: Marginal Effect of State Oil Rent on RE Development



Improvement in quality of government, corruption (reversed score) and rule of law lessens the negative effect of state oil rent on RE development, cancelling out the negative effect altogether after a certain threshold. The threshold for all the variables is around 0.4. The moderating effect of quality of government is stronger and more robust, as the slope of its diagram is steeper, and the confidence interval is narrower.

In conclusion, the key findings of this examination of the direct and moderating effect of corruption, rule of law, and quality of government on RE development, using the LMM estimation, are:

i. A robust, strong statistical support for a positive link between the three quality of institution variables and RE development was not found. The results are inconsistent, counterintuitive, and/or statistically insignificant.
ii. A long-term (using data lagged by 10 years) moderating effect of the three quality of institution variables on the causal relationship between democracy and RE development emerged. Test results of a short-term moderating effect (using data lagged by 4 years) were counterintuitive and inconclusive.
iii. Improvement in quality of government, rule of law, and corruption can alleviate the negative effect of state oil rent on RE development. Sufficient improvement can potentially cancel out that negative effect altogether.
iv. The moderating effect of quality of government variable was particularly stronger and more robust and precise than that of corruption and rule of law.

7.8. Climate Change Vulnerability and RE Potentials

All the LMM estimations in this study control for three time-invariant variables: wind energy potential, solar energy potential, and climate vulnerability. The logic behind the inclusion of these time-invariant variables can be explained as follows. One might argue that at least some portion of RE development can be attributed to vulnerability to climate changes or natural endowments in terms of wind and solar potentials. All else being equal, countries more vulnerable to climate risks are expected to have stronger incentives to develop and implement policies that promote and facilitate green energy transitions and invest more in renewable energy. The same line of argument can be used for wind and solar energy potentials. Some part of the variation in RE development can be explained by a country's natural renewable resource endowments, such as sunshine duration and strength, average wind speed, length of coastline, etc. Including these variables in the estimations basically controls for all these effects, leaving the remaining variation in the dependent variable to be estimated by other independent variables. This is a robustness check for the key research hypotheses of this study.

In Table 7.4, the coefficients of all the models are positive but only significant for climate vulnerability and wind potential (at $\alpha < 0.05$). When different lags of data are estimated in Table 7.6, the results are not much different. The coefficient of climate vulnerability changes in magnitude but remains always positive and significant for lags of 3 years and beyond. The coefficient of wind energy potential varies for different lags but always stays positive and significant. However, the coefficient of solar energy potentials turns positive and negative for different lags and never becomes statistically significant.

There are a couple of explanations for the inconsistent and insignificant coefficient of solar potential and the positive, and significant coefficient of wind energy potential. First, as explained in Chapter 6, the variation of solar energy potential across countries is not large.[82] The key reason is that after the level of solar radiation, air temperature is the next most significant geographical factor in determining solar energy potential. Air temperature negatively affects photovoltaic conversion efficiency. Therefore, what a country may lose due to weaker solar radiation it can gain from having lower temperatures and vice versa. It is therefore not surprising that the coefficient estimates of solar potential are neither consistent nor significant. It is safe to assume that when it comes to solar energy development, policies matter more than solar irradiance and annual sunshine duration. Second, according to an estimate of global wind energy potential by the US National Renewable Energy Laboratory (Sullivan, 2014), offshore wind energy potential accounts for more than 36% of total wind energy potential. With recent advancements in offshore wind

[82] 90% of the world's population live in areas where the average daily PV potential is in the range between 3 and 5 kWh/kWp/day.

energy technologies, this share is likely to grow even further. It is apparent that landlocked countries have a natural disadvantage compared to those with sizeable coastlines when it comes to wind energy deployment.

Overall, the LMM estimations of this study indicate a positive and statistically significant effect of climate vulnerability and wind energy potential on RE development. They do not provide any statistical support for a positive link between solar energy potential and RE development.

7.9. Robustness Check and Further Analysis

The baseline LMM estimation in this study was based on a sample of data of 120 countries and 26 years (covering 1990–2020 but dropping 4 years due to the default 4-year lag). It included 1,695 observations.[83] In all the estimations made so far, the share of wind and solar in electricity consumption is the dependent variable. Only non-zero values of this share are included in the sample, though. One can argue that using this sample can potentially distort the results in several ways, since it does not properly represent developing and developing countries; nor does it cover democracies and non-democracies equally. In a raw dataset that does not filter out the zero country-year values of the dependent variable, almost half of the observations are of non-democracies, a quarter are of flawed democracies, and rest are of democracies.[84] In the dataset that includes only non-zero values of the dependent variable, less that 30% of country-year observations are of non-democracies, 20% are flawed of democracies, and more than half are of democracies. Democracy is apparently overrepresented in this sample.

The same can be said for developed economies. Developing and poorer economies are underrepresented in the sample. This study is not the first to deal with such sample biases.

[83] The number of observations decrease or increases depending on the number of lags applied to the independent variables.

[84] Threshold for non-democracy is arbitrary set at an electoral democracy score of below 0.5. Scores between .5 and 0.75 are classified as flawed democracy and those above 0.75 as democracy.

More data are available for wealthy countries that happen to be democratic too (correlation coefficient between the two is larger than 0.5). Furthermore, while in most developing countries, significant progress in RE adoption is a more recent phenomenon, many developed and democratic countries took their first steps in the 1980s and 1990s. It is therefore not surprising that more country-year renewable data are available for developed countries, from the 1990s to the early 2000s. To tackle this unwanted sample bias, this study estimated subsets of data that can be reasonably considered less biased than the default dataset. Table 7.9 reports estimations of these subsets of data along with that of the baseline model in column (4), and Figure 7.8 compares the coefficient estimates of these subsets. In column (1) of Table 7.9, almost 600 observations of highly democratic countries were excluded from the estimation. In column (2), more than 500 country-year observations of high-income developed countries were also excluded. And in column (3), all the country-year data of 1990–1999, more than 300 observations—most of them belonging to developed and democratic countries—were dropped from the sample. These changes tilt the balance towards less or non-democratic and developing countries. It appears safe to say that these subsets of the data are more representative of the real world than the original dataset. As can be seen in Table 7.9 and Figure 7.8, most of the coefficient estimates are consistent, meaning changes in the sample size and composition do not substantially impact the sign and statistical significance of the estimates.

Table 7.9: Baseline LMM Estimation for Data Subsets vs. Full Dataset

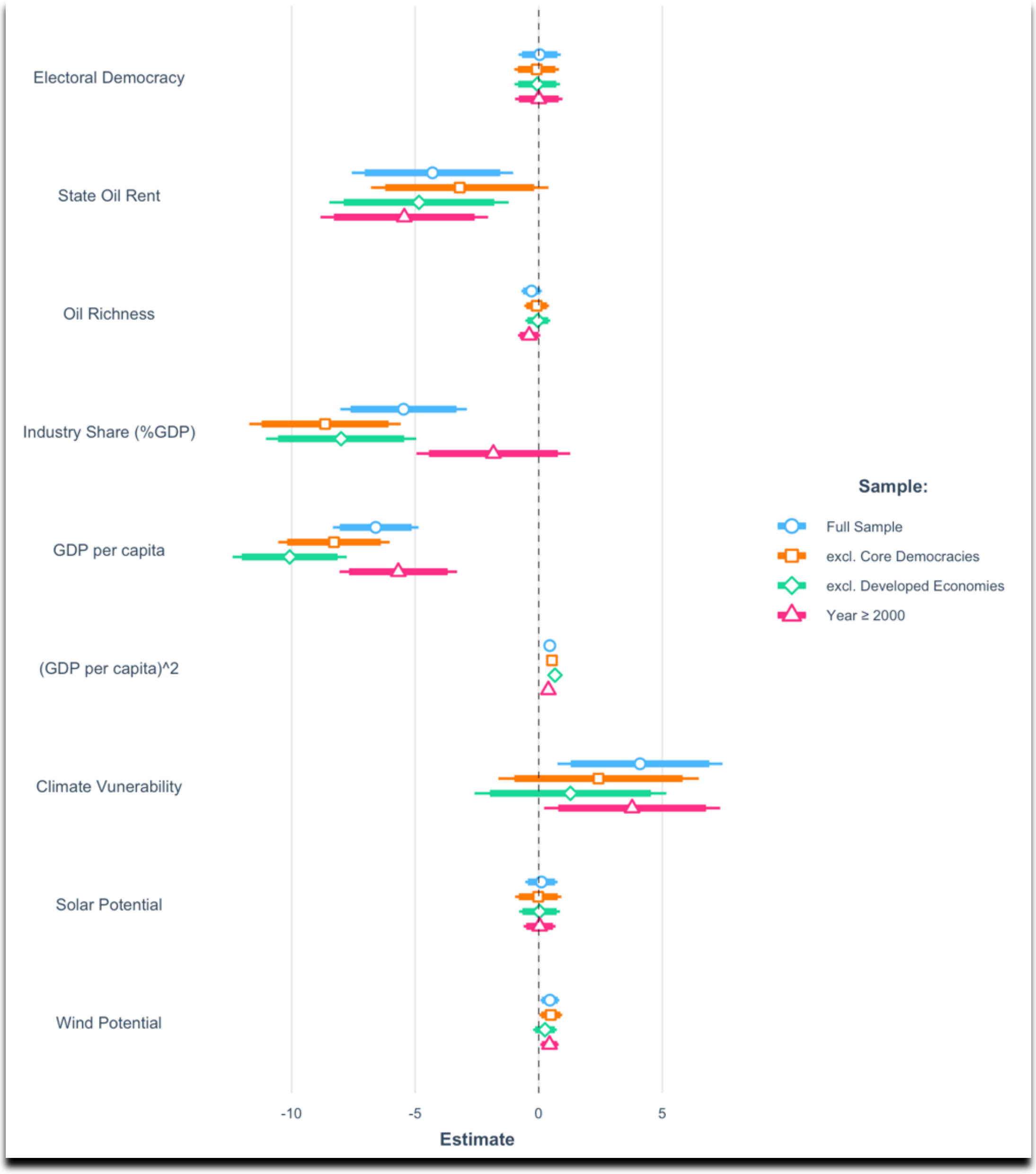
	Dependent Variable: Share of Wind & Solar in Electricity Consumption			
	Data Subsets:			
	excl. Core Democracies (*Elec. Dem.* < 0.85)	excl. Developed Economies † (*Ave. GDP percap* < 20,000)	Year ≥ 2000	Full Dataset
	(1)	(2)	(3)	(4)
Electoral Democracy	−0.083	−0.060	0.002	0.037
	(0.461)	(0.470)	(0.490)	(0.435)
State Oil Rent	−3.199*	−4.845***	−5.442***	−4.299***
	(1.832)	(1.853)	(1.731)	(1.667)
Oil Richness	−0.085	−0.037	−0.386*	−0.291
	(0.255)	(0.257)	(0.231)	(0.210)
Industry Share (*%GDP*)	−8.648***	−7.999***	−1.836	−5.471***
	(1.563)	(1.553)	(1.587)	(1.306)
GDP per capita	−8.288***	−10.080***	−5.683***	−6.598***
	(1.151)	(1.179)	(1.213)	(0.884)
(GDP per capita)^2	0.535***	0.658***	0.389***	0.447***
	(0.068)	(0.071)	(0.069)	(0.052)
Climate Vulnerability	2.419	1.283	3.779**	4.099**
	(2.069)	(1.981)	(1.817)	(1.705)
Solar Potential	−0.019	0.031	0.036	0.109
	(0.478)	(0.423)	(0.330)	(0.334)
Wind Potential	0.487**	0.253	0.435**	0.451**
	(0.235)	(0.243)	(0.189)	(0.195)
No. of Regions/Countries	9/93	9/95	9/120	9/120
No. of Years	25	26	16	26
Observations	1,111	1,167	1,356	1,695
Log Likelihood	−1,738.514	−1,850.582	−2,023.403	−2,570.337
Akaike Inf. Crit.	3,507.027	3,731.165	4,076.806	5,170.673
Bayesian Inf. Crit.	3,582.222	3,807.097	4,154.991	5,252.205
Intra-Class Correlation (ICC)	0.82	0.80	0.81	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.444/0.897	0.429/0.884	0.482/0.899	0.534/0.906

*p<0.1; **p<0.05; ***p<0.01

† Qatar, United Arab Emirates, Kuwait & Bahrain with a 1990–2020 average GDP per capita above constant 2010 US$20,000 are not considered developed economies, hence are included in estimation.

In Table 7.9, the coefficients of electoral democracy remain insignificant for all the estimations. Similar patterns can be observed in the estimations for state oil rent, oil richness, industry share of GDP, GD per capita and its squared term. The only important exceptions are in column (3), the coefficient of oil richness, which is statistically significant, and the coefficient of industry share of GDP, which is not significant. As for the time-invariant variables, the coefficient of climate vulnerability is positive and significant only in one of the estimated subsets, but the coefficient of wind potential is positive and significant in two of the three subset estimates. Overall, the baseline estimation shows considerable robustness to changes in composition and size of the sample.

Figure 7.8: Coefficient Estimates for Data Subsets vs. Full Dataset



As stated earlier, the dependent variable used in all the estimations so far is the share of wind and solar in electricity consumption. Testing the share of wind and solar in renewable electricity capacity appeared an interesting alternative.[85] Table 7.10 reports the baseline LMM estimations with the independent variables lagged by 1-8 years, using the share of wind and solar in electricity production capacity. Comparing the coefficient estimates of Table 7.10 and those of Table 7.6 reveals very similar patterns. The coefficient of electoral democracy becomes positive and significant when the data is lagged more beyond 4-5 years. The coefficients of state oil rent and hydrocarbon richness also behave very similarly in both tables. The only important difference is perhaps the coefficients of industry share in GDP, which remain negative but not statistically significant for lags larger than 2 years. Finally, the coefficients of wind energy are positive but not statistically significant, unlike those in Table 7.6. The similarities between the two sets of estimations results are not surprising. The share of wind and solar in electricity consumption and the same share in electricity production capacity are highly correlated (0.95); therefore, one would expect to see similar results when using the two variables as the dependent variable.[86]

[85] Testing the share of wind electricity and solar electricity separately is another option. However, separating the two leads to a substantial drop in number of non-zero observations for each of them, and does not yield robust and significant results.

[86] The share of wind and solar in electricity consumption and the same share in electricity production capacity are from two different datasets. The datasets vary in terms of country and year coverage. The electricity production capacity data covers a larger number of countries and contain more country-year data. Since the country-year observations of the two datasets are not the same, one needs extreme caution when trying to compare the coefficient estimates of models using them.

Table 7.10: Wind & Solar Electricity Capacity as Dependent Variable

	Dependent Variable: Share of Wind & Solar in Electricity Production Capacity							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Electoral Democracy	−1.030***	−0.886**	−0.519	−0.071	0.419	1.066***	1.799***	2.177***
State Oil Rent	−0.262	−0.999	−2.926**	−5.131***	−5.411***	−5.621***	−4.250***	−2.868**
Oil Richness	−0.469***	−0.534***	−0.414**	−0.230	−0.168	−0.154	−0.189	−0.154
Industry Share (*%GDP*)	−3.441***	−2.477**	−1.927	−1.437	−1.069	−0.293	−0.487	−0.970
GDP per capita	−3.878***	−3.875***	−3.709***	−3.246***	−2.396***	−1.581*	−0.742	−0.222
(GDP per capita)^2	0.271***	0.276***	0.271***	0.247***	0.193***	0.139***	0.085*	0.052
Climate Vulnerability	1.473	2.064	2.645*	3.010**	3.065**	3.001**	3.148**	3.141**
Solar Potential	−0.271	−0.275	−0.260	−0.224	−0.226	−0.230	−0.246	−0.251
Wind Potential	0.300*	0.292	0.282	0.277	0.267	0.246	0.232	0.254
No. of Regions/Countries	9/128	9/128	9/128	9/128	9/128	9/128	9/127	9/126
No. of Years	20	20	20	20	20	20	20	20
Observations	1,816	1,818	1,817	1,813	1,807	1,791	1,771	1,746
Log Likelihood	−2,693.490	−2,693.847	−2,691.098	−2,686.853	−2,683.684	−2,661.908	−2,633.337	−2,587.397
Akaike Inf. Crit.	5,416.981	5,417.695	5,412.196	5,403.706	5,397.368	5,353.817	5,296.673	5,204.793
Bayesian Inf. Crit.	5,499.547	5,500.277	5,494.770	5,486.247	5,479.859	5,436.175	5,378.863	5,286.770
Intra-Class Correlation (ICC)	0.79	0.79	0.78	0.78	0.77	0.76	0.75	0.75
Pseudo R^2 (*Marginal/Conditional*)	0.436/0.882	0.449/0.884	0.467/0.885	0.482/0.884	0.474/0.877	0.463/0.871	0.458/0.867	0.452/0.865

*p<0.1; **p<0.05; ***p<0.01

Using share of wind and solar in electricity production capacity as the dependent variable, this study also tested (i) the marginal effect of state oil rent, moderated by V-Dem dimensions of democracy, (ii) the marginal effect of democracy, moderated by corruption, rule of law and quality of government, and (iii) the marginal effect of state oil rent[87], moderated by corruption, rule of law and quality of government (results are not reported). Overall, the test results are identical to the estimations using the share of wind and solar in electricity consumption.

This study went one step further and tested the baseline model using total non-hydro renewable electricity consumption and electricity production capacity as dependent variables. The results are reported in Tables B.15 and B.16 in Appendix B. These results reveal patterns that in some cases are fundamentally different from those presented in

[87] For this estimation, the variance of year-random effect drops to zero resulting in boundary singular fit (overfitting). Dropping time trend variable or year-random effect resolves the issue. Removing time trend gives worse AIC, BIC, log-likelihood, and R-squared estimates than the other alternative. Year-random effect therefore is not specified in the estimation.

Tables 7.6 through 7.10.[88] These disparities are not surprising. As elaborated in Chapter 6, among all the non-hydro renewable resources, wind and solar appear to be more responsive to state policy. In this regard, they are substantially different from other non-hydro renewable sources such as tidal, geothermal, and biomass.[89] Therefore, one would not expect to see similar results if these renewable sources were added to the data. Indeed, the dissimilarity between wind and solar estimates and total non-hydro estimates can be considered yet another justification for excluding non-hydro renewable sources other than wind and solar energy in this empirical study. The baseline LMM of this study performs very well in terms of producing robust estimates that are also consistent with the research hypotheses, when focusing exclusively on wind and solar energy.

The state oil rent variable in this study is the value of oil production minus the total costs of production all as a percentage of GDP. A better measure of state oil rent, as discussed in the literature review (Chapter 3) and the data and modelling chapter (Chapter 6), is the share of oil revenue in total government revenues or expenditures. However, such data are only available for a limited number of countries for a limited number of years. The ICTD Government Revenue Dataset is a large, updated dataset that reports the share of natural resource revenues in total state revenue and expenditures. This dataset has two key limitations that affected the scope of this study. First, it does not distinguish between hydrocarbon and non-hydrocarbon resources[90]. Second, the number of observations (country-years) is substantially smaller than that of the World Banks's WD, where the data on state oil rent data are drawn from. Estimating the effect of total natural resource rents

[88] Using the share total non-hydro renewables in electricity consumption and in electricity production capacity, as dependent variables, numerous tests are done that are not reported here. The tests include estimating 1-8 lags of V-Dem dimensions of democracy, various aggregate measures of democracy—such as Polity2, CMLDI, Freedom House Index, etc.—and forms of democracy. The test results are either inconsistent or counterintuitive, and overall inconclusive.

[89] It is worth noting that biomass can also be considered highly policy responsive. The use of modern bioenergy indeed is the most extensive form of renewable energy around the world, constituting 55% of all RE sources and providing over 6% of the world's total energy supply. As per the Net Zero Emissions by 2050 plan, there would be a swift surge in bioenergy usage to replace fossil fuels by the year 2030 (IEA, 2021a).

[90] Though the dataset does not distinguish between hydrocarbon and non-hydrocarbon resource rents, it is still a useful tool. Historically, oil, natural gas, and coal have accounted for the lion's share of total natural resource revenues, though their share can vary substantially from one country or year to another. In 1970-2020 period, the average shares of oil alone and the three hydrocarbon resources combined in total natural resource rents are %63 and 81%, respectively (World Bank's WDI data are used for the calculations).

still can be useful as a robustness check for the baseline model. Table 7.11 reports the results of this estimation. State oil rent and oil richness are replaced by natural resource rents in the estimations. Data of only 77 countries were available for the estimations.[91] The coefficient estimates of natural resource rent are not as robust as those of the state oil rent, but they remain negative in all the estimations, and statistically significant when the independent variables are lagged by 3-6 years. The EKC effect is less robust and pronounced in these estimations than the baseline estimation in Table 7.6. Overall, the estimations in Table 7.11 are very similar to the baseline estimations in Table 7.6.

Table 7.11: Natural Resource Rents (% of State Revenue) and RE Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Electoral Democracy	0.305	0.004	−0.141	−0.071	0.075	0.786	1.640**	1.603**
Natural Resource Rents	−1.062	−1.106	−2.193	−3.464**	−4.377***	−3.028*	−1.496	−2.163
Industry Share (*%GDP*)	−7.302***	−7.613***	−8.002***	−7.364***	−6.000***	−4.818***	−4.098**	−1.520
GDP per capita	−3.204***	−3.084***	−2.564**	−2.504**	−1.934	−1.438	−0.734	0.109
(GDP per capita)^2	0.228***	0.230***	0.214***	0.219***	0.189***	0.153**	0.105	0.045
Climate Vulnerability	2.137	2.760	4.158**	5.163***	5.980***	6.189***	6.142***	5.831***
Solar Potential	0.197	0.187	0.220	0.284	0.272	0.198	0.139	0.084
Wind Potential	0.093	0.091	0.095	0.089	0.088	0.093	0.094	0.116
No. of Regions/Countries	9/77	9/77	9/78	9/78	9/78	9/77	9/77	9/77
Observations	1,111	1,100	1,081	1,055	1,028	999	969	935
Log Likelihood	−1,614.356	−1,599.559	−1,568.987	−1,534.955	−1,502.358	−1,467.722	−1,430.253	−1,378.137
Akaike Inf. Crit.	3,254.713	3,225.119	3,163.974	3,095.910	3,030.716	2,961.445	2,886.506	2,782.274
Bayesian Inf. Crit.	3,319.882	3,290.158	3,228.787	3,160.407	3,094.875	3,025.233	2,949.897	2,845.201
Intra-Class Correlation (ICC)	0.78	0.78	0.78	0.78	0.79	0.79	0.79	0.81
Pseudo R^2 (*Marginal/Conditional*)	0.515/0.891	0.510/0.891	0.512/0.892	0.511/0.893	0.485/0.890	0.457/0.883	0.431/0.879	0.354/0.877

*p<0.1; **p<0.05; ***p<0.01

Note: Year-random effect is not included due to over-fitting (zero variance of year random effect estimate)

Several popular control variables appear in numerous empirical papers that studied environmental and climate policy outputs and outcomes. They include share of trade in GDP,

[91] Year-random effect is not included in the estimations, for reasons explained above (see footnote 18).

population density, area size, share of urban population in total population, energy intensity (energy consumption per unit of GDP), and international energy—most crude oil—prices. All these variables are separately estimated. Among them, the share of trade in GDP, and oil price have negative coefficients that are not statistically significant. The coefficients of population density, urban population, and energy intensity are negative and significant. The results are not reported here, mainly because of lack of space, but also because, while they might be able to explain variation in specific environmental and climate policy outcomes such as CO_2 emissions, or water sanitation, they lack the theoretical and conceptual underpinnings linking them to RE development. Moreover, some of the variables already included in the estimations make these control variables redundant (see Chapter 6 for further details).

In summary, there are four key findings from running several robustness tests of the simple LMM:

(i) Almost all the estimations so far show robustness to changes in size and composition of the sample.

(ii) These estimations are also robust to using the share of wind and solar in electricity capacity as the dependent variable.

(iii) The empirical investigations corroborate the theoretical elaborations regarding the exclusion of other non-hydro RE sources such as tidal, geothermal, and biomass from this study.

(iv) Replacing state oil rent with a more accurate resource rent index—but with more limited country-year observations—produces roughly identical results.

This chapter delved into the results of the simple LMM estimations. Looking ahead, the next chapter will shift its focus towards the within-between estimations. Furthermore, it offers an all-encompassing conclusion that reviews the key findings of the simple LMM and within-between estimations, effectively encapsulating the quantitative analysis of this study.

8. Results and Discussion—Part Two: Within-Between Estimations

In this chapter, the within-between estimations are discussed and analyzed. This chapter follows the same structure as Chapter 7. The key findings of the within-between estimations broadly corroborate those of the simple LMM estimations in that chapter.

After a brief review of the within-between estimation and its advantages, the within and between effects of eight specific factors—democracy, oil richness, state oil rent, share of industry in GDP, income, institutional qualities, climate change vulnerability, and RE potentials—on RE development are examined and elaborated in separate sections. Following these is a robustness check to ensure the reliability of the results. The concluding section brings together the key findings of the empirical analysis, including those of the LMM estimation from Chapter 7.

8.1. Within-Between Estimation: A Quick Overview

It is worth noting that the within-between estimation is still an LMM estimation. What distinguishes it from the simple LMM estimation, discussed so far, is its specification. In within-between models, the specification is comprised of two parts. Any within-between estimation has a 'within' part that includes mean-centered (using country means) independent variables, and a 'between' part consisting of country-mean independent variables, in addition to the three time-invariant variables, climate vulnerability, solar potential, and wind potential. The country-mean variables in the between part are time-invariant. Technically, there is no difference between the between part variables and the three time-invariant variables.

The key advantage of within-between specification over the simple specifications discussed so far, lies in the separation of the within-part and the between-part in the model specification. A pooled OLS model provides estimates based on the assumption that all country-year observations are similar (homogenous). The LMM estimation pools together all the country-year observations, but controls for region, country, and year random effect, which means the observations are not treated as being homogenous. The within-between estimation goes further. The within-part produces estimates of average effect of change in an independent variable within the unit of analysis (country) on the dependent variable; for example, the average effect on the share of wind and solar in electricity consumption of a 0.1-unit change in the level of electoral democracy within countries. The between part provides an estimate of the effect of change in the country-average value of an independent variable on the dependent variable; for example, the effect on the dependent variable of a 0.1-unit difference between the average level of electoral democracy in one country and another one. The between part simply produces extra material for causal inference; hence it can potentially generate additional information and insight.

8.2. Baseline Within-Between Estimation

The three-way random effect specification was chosen for the same reasons elaborated in Section 7.2. Unless otherwise stated, all within-between estimations in this study control for three-way nested country, region, and year random effect; they also include a time trend term and an intercept, the coefficient estimates of which are not reported in the regression tables. Also, unless otherwise stated, all the independent variables are lagged by 4 years. Both column (7) of Table 8.1 and Figure 8.1 report the baseline within-between estimation. The patterns emerging in the within part are nearly identical to those in the LMM estimation. Column (7) of Table 8.1 is the estimation of the fully specified model, which includes all the baseline specification variables.

The interpretation of results, however, is slightly different. The coefficients of electoral democracy and oil richness are not statistically significant. Moreover, the sign of the estimate for democracy is not consistent with the research hypothesis that predicts a positive link between democracy and RE development. State oil rent has a negative and significant estimate. This means, all else being equal, an increase in the level of state oil rent in a country is associated with the decline in the share of wind and solar in that country. The industry share in GDP has a negative and significant coefficient estimate, which indicates, on average, a negative link between an increase in that share in a country and RE development in that country. The within part of the estimation also reveals a strong and significant EKC effect. The coefficients of GDP and its squared term are significant, and their signs are consistent with the EKC prediction.

Table 8.1: Baseline Within-Between Estimation

	Dependent Variable: Share of Wind & Solar in Electricity Consumption						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within:							
Electoral Democracy	−0.545	−0.826*	−0.525	−0.274	−0.121	−0.075	−0.120
State Oil Rent		−5.250***	−5.535***	−4.067**	−3.570*	−3.914**	−4.153**
Oil Richness			0.202	−0.141	−0.151	−0.292	−0.288
Industry Share (*%GDP*)				−6.532***	−8.074***	−5.933***	−5.801***
GDP per capita					1.046***	−8.999***	−9.532***
$(\text{GDP per capita})^2$						0.633***	0.667***
Between:							
Electoral Democracy	4.280***	2.556***	2.556***	2.618***	2.612***	2.264***	2.068**
State Oil Rent		−7.780***	−2.770	0.300	0.185	0.877	−1.744
Oil Richness			−0.597	−0.554	−0.530	−0.548	−0.556
Industry Share (*%GDP*)				−3.169	−2.987	−4.299	−1.574
Climate Vulnerability							1.961
Solar Potential							−0.495
Wind Potential							0.318*
No. of Regions/Countries	9/126	9/124	9/124	9/124	9/124	9/124	9/120
No. of Years	26	26	26	26	26	26	26
Observations	1,841	1,803	1,799	1,731	1,731	1,731	1,695
Log Likelihood	−2,844.848	−2,775.391	−2,761.079	−2,650.633	−2,640.372	−2,589.016	−2,534.993
Akaike Inf. Crit.	5,705.697	5,570.783	5,546.158	5,329.267	5,310.744	5,210.033	5,107.985
Bayesian Inf. Crit.	5,749.841	5,625.755	5,612.098	5,405.657	5,392.590	5,297.336	5,211.259
Intra-Class Correlation (ICC)	0.76	0.77	0.76	0.76	0.77	0.77	0.78
Pseudo R^2 (*Marginal/Conditional*)	0.447/0.869	0.440/0.868	0.450/0.869	0.445/0.868	0.442/0.871	0.451/0.876	0.461/0.881

*p<0.1; **p<0.05; ***p<0.01

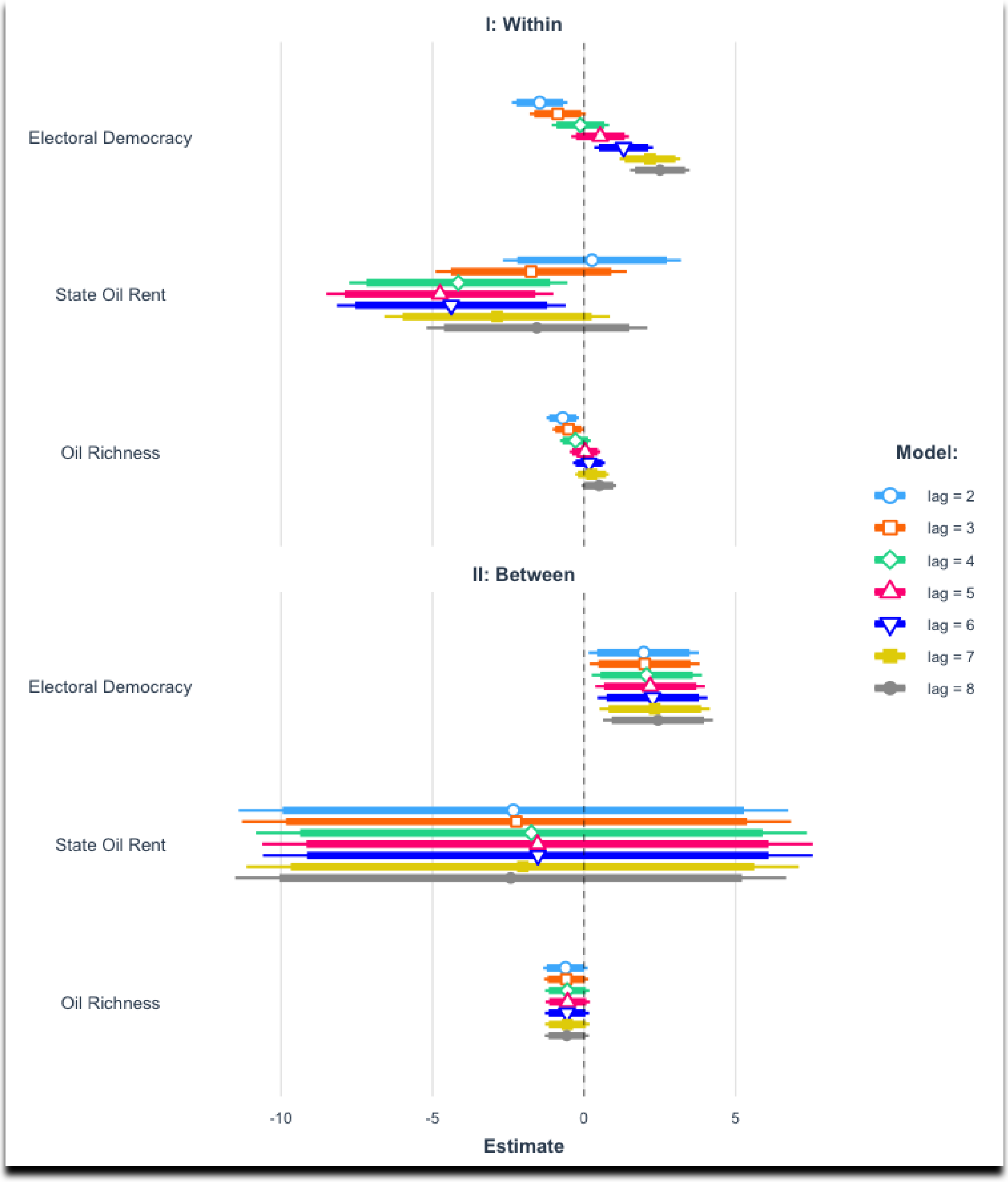
The coefficient estimates of GDP per capita, and its squared term were not statistically significant when they were experimentally included in the between part. They are therefore excluded from the estimations out of parsimony. The most striking pattern emerging from the between part is the robust and statistically significant effect of democracy. The way the coefficient is interpreted is different from that of the within part. The coefficient of electoral democracy here suggests, all else being equal, that a country that enjoys a higher average level of electoral democracy will have a higher share of wind and solar in electricity consumption than another country with a lower average level of electoral democracy. It is clear that the coefficient of a same variable—in name—in the between part of a within-between estimation is interpreted very differently than that of the within part. The signs of other between estimates are consistent with the research hypotheses, but none are significant. The within-between estimation fails to produce statistical support for a negative impact of state oil rent, oil richness, and the share of industry in GDP on RE development. One possible explanation for this is that the actual sample size virtually dropped from 1,695 country-year observations for the within part to 120 unique country-year observations for the between part. In a regression analysis, a drop in the sample size generally has a negative effect on precision, leading to larger standard errors of estimates. That the coefficient of electoral democracy in the between part still remains statistically significant is a substantial finding.

Figure 8.1: Within-Between Coefficient Estimates

Equally interesting are the estimates of the time-invariant variables. Except for that of the wind potential, the coefficients of the other two, climate vulnerability and solar potential, are not statistically significant. This a very interesting finding. These results indicate that natural endowments in the forms of solar energy potential and the level of vulnerability to climate risks cannot explain the variation in RE development across countries. Even in the case of wind energy potential, its explanatory power is not very robust as the coefficient is significant at α <0.1. These findings have some important policy implications, which are discussed in the conclusion chapter (Chapter 10).

The coefficient estimates of electoral democracy, state oil rent, and oil richness for different lags (2–8) of the independent variables are illustrated in Figure 8.2. The within part shows patterns for electoral democracy, state oil rent and oil richness that are roughly identical to those of the LMM estimations in Figure 8.2. The coefficient estimates in the between part, unsurprisingly, are more stable and do not change drastically in magnitude and sign. Electoral democracy coefficients for different lags are robustly positive and significant (at α <0.01). Those of state oil rent and oil richness are negative and consistent with the predictions but not statistically significant. Using several within-between estimations, Sections 8.3 to 8.7 examine the following: democracy and its dimensions; hydrocarbon richness and state hydrocarbon rent; industry share of GDP and income; institutional qualities; and climate change vulnerability and renewable energy potential. These are followed by a comprehensive robustness analysis and a conclusion that encompasses the key findings of both the LLM and within-between estimations.

Figure 8.2: Coefficient Estimate of Key Independent Variables (Various Lags)



8.3. Democracy and Its Dimensions

The within and between effects of the dimensions of democracy on RE development are reported in Table 8.2. The within part follows the same pattern as that of the simple LMM estimation. None of the coefficients is statistically significant. The between part, however, reveals a very interesting pattern. It appears that a change in the level of all the dimensions of democracy in a country does not have an immediate effect on that country's RE development. This conclusion is very similar to the one reached in the Chapter 7. All the between coefficients are positive and statistically significant. All else being equal, a country with a higher long-term average (1990–2020 average) level of the dimensions of democracy has a higher share of wind and solar in its total electricity generation in comparison with other counties with lower levels of those measures. Among the five dimensions of democracy, the participatory and egalitarian dimensions have larger coefficients.[92] [93]

[92] The liberal, deliberative, participatory, and egalitarian components of democracy are also separately examined. The results are reported in Table C.1 in Appendix C. The estimates of the within part are very similar to those of the baseline LMM estimation. Among the components, only the egalitarian component is statistically significant. This finding suggests that a country's progress in the egalitarian component—independent of change along the electoral dimension—has a positive effect on its RE performance. In the between part the results are rather inconclusive. The coefficients of liberal and deliberative components are positive and statistically significant but those of participatory and egalitarian ones are not statistically significant.

[93] Testing the continuous aggregate measures of democracy and dimensions of democracy does not produce any conclusive results. Tables C.2 to C.4 in Appendix C report the results of the continuous aggregate measures of democracy—Polity2, CMLDI, Freedom House Index, Vanhanen—and miscellaneous qualities of democracy—civil society, civil liberties, federalism, political constraint, and aggregate, vertical, diagonal, and horizontal accountability. For the aggregate measures of democracy, none of the coefficients in the within part is statistically significant. in the between part, only the coefficient of Freedom House democracy index is positive and statistically significant. As for the qualities of democracy, only the between coefficient of political constraint is positive and statistically significant. These results are simply inconclusive.

Table 8.2: Dimensions of Democracy and RE Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption				
	(1)	(2)	(3)	(4)	(5)
Within:					
Electoral Democracy	−0.120				
Liberal Democracy		0.184			
Deliberative Democracy			−0.004		
Participatory Democracy				−0.116	
Egalitarian Democracy					0.825
State Oil Rent	−4.153**	−4.113**	−4.167**	−4.143**	−4.104**
Oil Richness	−0.288	−0.284	−0.280	−0.278	−0.272
Industry Share (*%GDP*)	−5.801***	−5.894***	−5.821***	−5.823***	−5.916***
GDP per capita	−9.532***	−9.533***	−9.518***	−9.545***	−9.439***
$(\text{GDP per capita})^2$	0.667***	0.668***	0.667***	0.668***	0.662***
Between:					
Electoral Democracy	2.068**				
Liberal Democracy		2.551***			
Deliberative Democracy			2.799***		
Participatory Democracy				3.112***	
Egalitarian Democracy					2.959***
State Oil Rent	−1.744	−2.137	−1.790	−1.401	−2.470
Oil Richness	−0.556	−0.481	−0.496	−0.549	−0.483
Industry Share (*%GDP*)	−1.574	−1.446	−1.619	−2.053	−1.142
Climate Vulnerability	1.961	2.554*	2.571*	2.088	2.693*
Solar Potential	−0.495	−0.474	−0.465	−0.455	−0.404
Wind Potential	0.318*	0.310*	0.301*	0.306*	0.305*
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120
No. of Years	26	26	26	26	26
Observations	1,695	1,695	1,695	1,695	1,695
Log Likelihood	−2,534.993	−2,533.541	−2,533.312	−2,533.362	−2,532.585
Akaike Inf. Crit.	5,107.985	5,105.083	5,104.624	5,104.725	5,103.171
Bayesian Inf. Crit.	5,211.259	5,208.356	5,207.898	5,207.998	5,206.444
Intra-Class Correlation (ICC)	0.78	0.77	0.77	0.77	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.461/0.881	0.470/0.880	0.472/0.879	0.471/0.879	0.470/0.880

*p<0.1; **p<0.05; ***p<0.01

All the estimations made so far have the independent variables lagged by 4 years, as this is the default number of lags for all the baseline estimations. Applying other lags may yield additional information and insight, as was the case with the baseline LMM estimations. A very notable pattern indeed emerges when the data with other number of lags are used for the within-between estimation. The next table, table 8.3 reports these patterns. From columns (1) to (8), the coefficients of democracy in the between part remain positive and statistically significant in all the models. The interpretation of the between part is rather straightforward. All else being equal, a country with a higher long-term average electoral democracy score enjoys a higher level of RE development. As for the within part, the key finding is very similar to the one in the baseline LMM estimations (see Section 7.3). A delay is observed between improvement along the electoral democracy dimension in a country and ultimate progress in that country's RE transitions. The coefficient of electoral democracy in Table 8.3 turns positive and statistically significant after lag = 6 and beyond. This finding corroborates that of the between part, suggesting that the causal mechanism linking democracy with RE development is a long-term process. First, it takes time for electoral democracy to have a positive impact on RE development. Second, for a society, attaining and maintaining a higher level of electoral democracy is a long-term endeavor; once achieved, its positive effects become apparent in comparison with other societies enjoying lower levels of electoral democracy. The within-between model that estimated both variables simultaneously does not provide statistical support for both claims.

The above-mentioned findings are not limited to the electoral democracy dimensions. Estimating models with the independent variables lagged by 1-to-8 years for the liberal, deliberative, participatory, and egalitarian dimensions generate identical results. Tables C.5 – C.8 in Appendix C report the results of these estimations. The between coefficients of all these dimensions are positive and statistically significant for all lags. The within coefficients become positive and statistically significant for lag 5 or 6 and beyond. The key differences among the dimensions of democracy are the magnitude of their within and between coefficients. Figure 8.3 compares the within and between estimates of the dimensions of democracy for lags of 2-8 years. Again, the results are extremely close to those in the LMM estimations (see Figure 7.3). In both the within and between parts, the egalitarian and participatory dimensions have the largest coefficient estimates. In the long term, a country's progress along the egalitarian and participatory dimensions of democracy—in comparison with progress along other dimensions of democracy—has a larger positive effect on its RE development. Moreover, variations among countries in terms of egalitarian and participatory democracy dimensions are stronger predictors of their differences in terms of RE development than those of the other dimensions of democracy.[94]

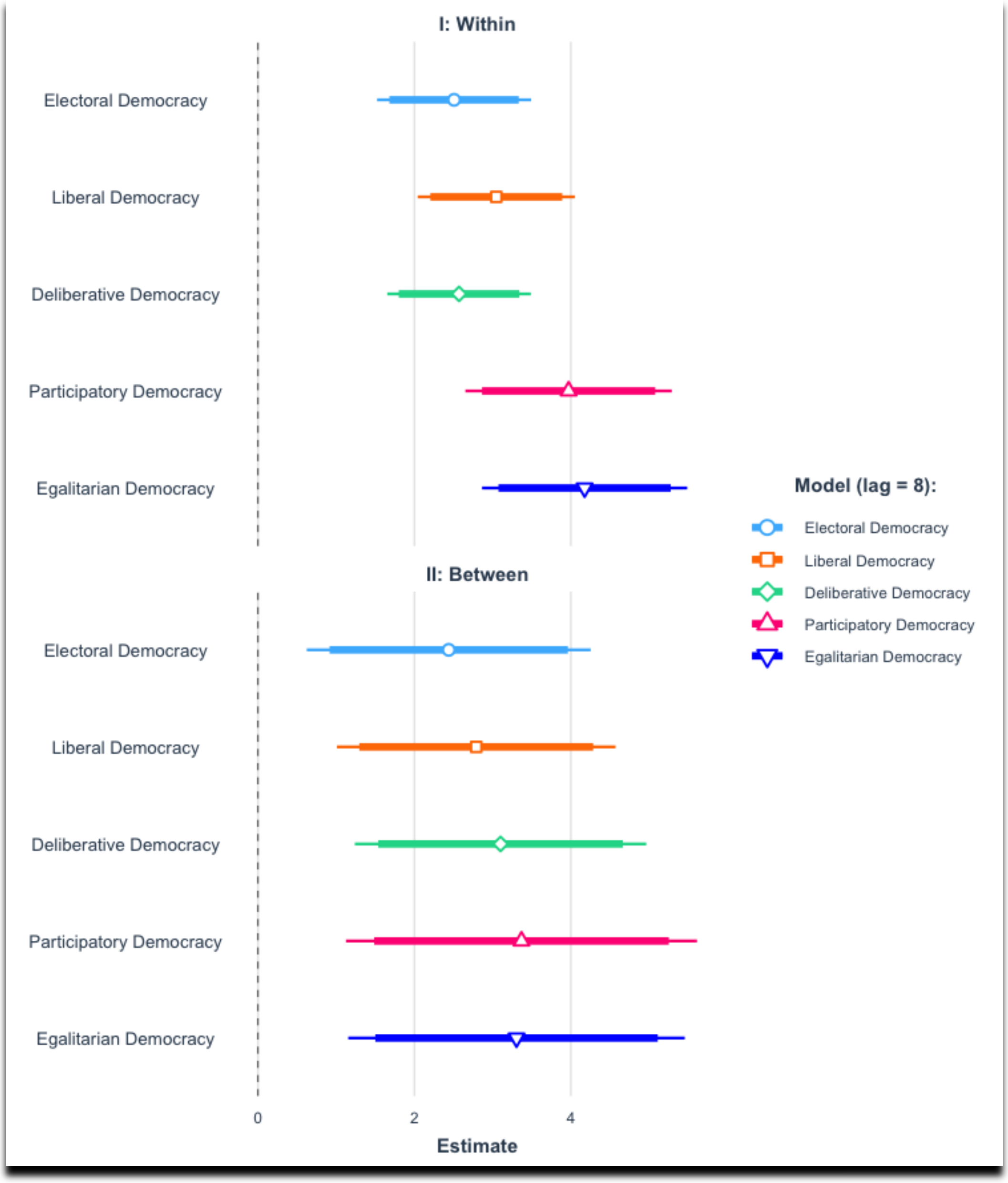
Table 8.3: Within-Between Estimation (1-to-8 Year Lags)

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Electoral Democracy	−1.610***	−1.465***	−0.870*	−0.120	0.533	1.305***	2.178***	2.507***
State Oil Rent	0.899	0.261	−1.747	−4.153**	−4.757**	−4.385**	−2.870	−1.560
Oil Richness	−0.716***	−0.707***	−0.513*	−0.288	0.034	0.162	0.260	0.497*
Industry Share (*%GDP*)	−6.980***	−6.527***	−6.367***	−5.801***	−5.111***	−4.212***	−3.582***	−2.057
GDP per capita	−8.526***	−8.946***	−9.311***	−9.532***	−8.840***	−7.552***	−5.830***	−4.099***
(GDP per capita)^2	0.561***	0.600***	0.640***	0.667***	0.628***	0.549***	0.444***	0.329***
Between:								
Electoral Democracy	1.923**	1.967**	1.999**	2.068**	2.183**	2.266**	2.332**	2.439***
State Oil Rent	−2.257	−2.336	−2.234	−1.744	−1.533	−1.522	−2.025	−2.421
Oil Richness	−0.626*	−0.613	−0.587	−0.556	−0.542	−0.564	−0.555	−0.571
Industry Share (*%GDP*)	−2.906	−2.515	−1.959	−1.574	−1.313	−1.087	−1.072	−1.108
Climate Vulnerability	2.271	2.211	2.139	1.961	1.736	1.447	1.180	1.061
Solar Potential	−0.453	−0.461	−0.482	−0.495	−0.492	−0.472	−0.453	−0.445
Wind Potential	0.292*	0.303*	0.311*	0.318*	0.323**	0.330**	0.336**	0.337**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,683.693	−2,645.412	−2,589.417	−2,534.993	−2,486.682	−2,436.417	−2,379.111	−2,315.526
Akaike Inf. Crit.	5,405.385	5,328.824	5,216.834	5,107.985	5,011.363	4,910.834	4,796.222	4,669.052
Bayesian Inf. Crit.	5,509.460	5,432.693	5,320.430	5,211.259	5,114.286	5,013.388	4,898.316	4,770.651
Intra-Class Correlation (ICC)	0.77	0.77	0.78	0.78	0.78	0.78	0.78	0.78
Pseudo R^2 (*Marginal/Conditional*)	0.492/0.882	0.485/0.881	0.473/0.882	0.461/0.881	0.452/0.878	0.444/0.876	0.435/0.873	0.430/0.872

*p<0.1; **p<0.05; ***p<0.01

94 Other continuous aggregate measures of democracy—Polity2, CMLDI, Freedom House, and Vanhanen Index—were separately tested for all the lags (results are not reported). The results were either inconsistent, counterintuitive, insignificant or a combination of all. Only the Freedom House democracy index has positive and statistically significant coefficients.

Figure 8.3: Coefficient Estimates of Dimensions of Democracy (Lag = 8 years)



In conclusion, the key findings of separating the within and between effects of democracy on RE development are:

i. Progress along all the dimensions of democracy in a country, in the long-term, has a positive and significant effect on the country's RE development. Among the dimensions, the egalitarian and participatory dimensions of democracy have a larger impact on RE development within a country.

ii. All else being equal, a country with a higher average level of each democracy dimension fares better in terms of RE development than a similar country with a lower average level of each democracy dimension. Once again, the egalitarian, and participatory dimensions of democracy explain better the variation in RE development across countries.

iii. Heterogeneity is observed among the impacts of the various dimensions of democracy and RE development. This is yet another justification for examining not just one aggregate measure of democracy but various dimensions and qualities of democracy in empirical studies.

8.4. Hydrocarbon Richness and State Hydrocarbon Rent

The coefficients of oil richness and state oil rent in the within part of the baseline within-between estimation are identical to those of the LMM estimation. Column (3) of Table 8.4 reports those estimates. The within coefficients of state oil rent and oil richness are negative, but only that of state oil rent is statistically significant. The results of column (3) of Table 8.4 statistically support the hypothesis that higher levels of state oil rent in a country are negatively associated with RE development in that country. In the between part, none of the coefficients is statistically significant, although both have a negative sign. A country that enjoys a higher average level of oil richness and/or on average has higher dependence on oil state rent is predicted to experience a lower level of RE development, in comparison with a peer with a lower average level of oil richness or state oil rent. The between estimations in column (3) do not produce statistical support for these predictions.

As discussed in Section 7.4, a relatively high correlation between state oil rent and oil richness can be one of the reasons some of the between and within estimates are not significant. The picture becomes relatively different when state oil rent and oil richness are estimated separately. Columns (1) and (2) of Table 8.4 contain the separate estimations. In column (1) oil richness is dropped from both within and between parts of the estimation. In column (2) state oil rent is dropped from both parts of the estimation. In column (1) the within coefficient of state oil rent remains negative and statistically significant this time at α < 0.01. The between coefficient, however, grows in magnitude but remains insignificant. Again, the estimation cannot find statistical support for a negative between effect of state oil rent on RE development. In column (2), both within and between coefficients of oil richness are negative and statistically significant at α < 0.05 and α < 0.1, respectively. These results support the negative within and between country effects of oil richness on RE development. An increase in the level of oil richness in a country has a negative effect on that country's RE development. Moreover, in terms of RE development, countries with higher average levels of oil richness fare worse than their less oil rich peers.

Table 8.4: Oil Richness vs. State Oil Rent

	Dependent Variable:		
	Share of Wind & Solar in Electricity Consumption		
	(1)	(2)	(3)
Within:			
Electoral Democracy	−0.288	−0.106	−0.120
State Oil Rent	−4.659***	-	−4.153**
Oil Richness	-	−0.454*	−0.288
Industry Share (*%GDP*)	−5.844***	−6.737***	−5.801***
GDP per capita	−9.591***	−9.434***	−9.532***
(GDP per capita)^2	0.675***	0.663***	0.667***
Between:			
Electoral Democracy	2.331**	2.111**	2.068**
State Oil Rent	−5.778	-	−1.744
Oil Richness	-	−0.652**	−0.556
Industry Share (*%GDP*)	−1.847	−3.009	−1.574
Climate Vulnerability	2.548*	1.670	1.961
Solar Potential	−0.441	−0.479	−0.495
Wind Potential	0.328**	0.320*	0.318*
No. of Regions/Countries	9/120	9/120	9/120
No. of Years	26	26	26
Observations	1,699	1,695	1,695
Log Likelihood	−2,545.253	−2,541.592	−2,534.993
Akaike Inf. Crit.	5,124.506	5,117.183	5,107.985
Bayesian Inf. Crit.	5,216.949	5,209.585	5,211.259
Intra-Class Correlation (ICC)	0.79	0.77	0.78
Pseudo R^2 (*Marginal/Conditional*)	0.452/0.882	0.469/0.879	0.461/0.881

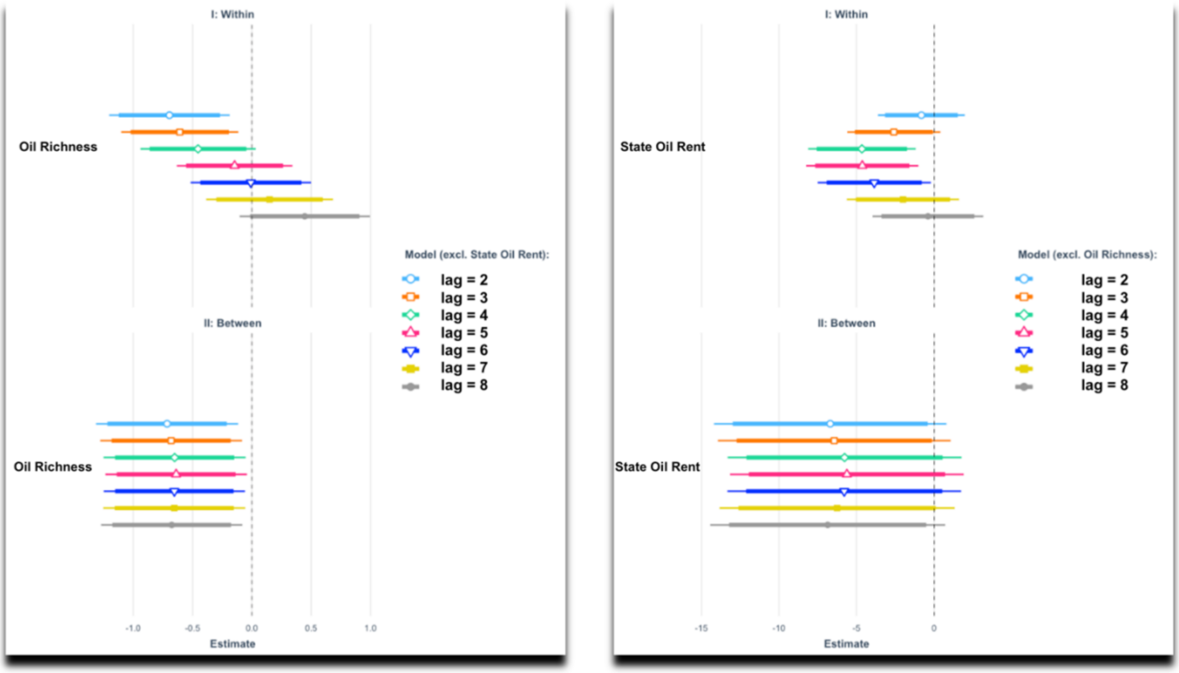
*p<0.1; **p<0.05; ***p<0.01

Replicating these estimations for the independent variables with other lags may reveal interesting patterns. Figure 8.4, along with Tables C.9 and C.10 in Appendix C, report the replication of the same estimations in columns (1) and (2) of Table 8.4 but for different lags of the data. The within estimates of oil richness in the absence of state oil rent are negative and statistically significant for lags 1-4.[95] These results are very similar to those of the baseline LMM estimation excluding state oil rent. The oil richness coefficients of the between part, however, remain negative and statistically significant for all the lags. This result appears to be very robust and in support of the hypothesis that, all else being equal, oil richer countries fare worse than their oil poorer peers, when it comes to RE development. As for state oil rent, the coefficients of some of the lags are negative and statistically significant. In the within part, all the coefficient estimates are negative but only statistically significant for lags of 3-6 years. In the between part, the results are less robust and precise. The coefficients of state oil rent for lags 1, 2, 3 and 8 years are negative and statistically significant at $\alpha < 0.1$. Overall, estimating state oil rent and oil richness separately reveals interesting patterns that are slightly different than the ones discussed in Section 7.4. Separating the effect of state oil rent and oil richness into within and between effects and estimating oil richness and state oil rent separately reveals a more nuanced picture of the dynamics and links between these factors and RE development.

This study also examined the effects of other hydrocarbon resources on RE development. Table C.11 in Appendix C compares the within-between estimations that include oil, natural gas, and coal separately; and oil and natural gas together; and all the three together. The test results appear to be inconsistent, counterintuitive, inconclusive or a combination of all (see Section 7.4).

[95] Note that Figure 8.4 only reports lags 2-to-8.

Figure 8.4: Separate Effect of State Oil Rent (right) vs. Oil Richness (left)



In summary, disentangling the average effect of state oil rent and oil richness into the within country and between country effects of oil richness and state oil rent, and estimating the effect of each variable separately in the absence of the other, provides statistical support for:

i. A negative within-country effect of state oil rent and oil richness on RE development. Higher levels of state oil rent and/or oil richness in a country are associated with lower levels of RE development in that country.

ii. A negative association between a country's level of state oil rent and its RE development.

iii. A very robust and negative between-country effect of oil richness on RE development. Countries with lower average levels of oil richness outperform their oil-richer peers with respect to RE development.

iv. Finally, the tests did not find a robust and statistically significant within-country and between-country effects of coal and natural gas on RE development.

8.5. Industry Share of GDP and Income

The overall effect of the share of industry in GDP on RE development is negative and significant, as discussed in Section 7.5. This is one of the most robust findings of this empirical study. This section separates that effect into within-country and between-country effects and investigates whether they are significant and consistent with the predictions. The estimations of the within and between effects of industry share of GDP can be found in Table 8.3 for different 1-to-8 year lags. The coefficients of the within part are negative and significant, which is consistent with the predictions. An increase in the share of industry in a country's GDP has a negative effect on that country's RE development, all else being equal. The estimates of the between part, however, are not statistically significant, although all are negative. The estimations simply do not find statistically support for the hypothesis that, all else being equal, a country with a higher average level of industry share of GDP, in comparison with another country with a lower level of the same measure, experiences a lower level of RE development.[96]

The detection of an EKC effect, along with the negative effect of industry on RE development, is another robust finding of this study. The signs of the coefficients of GDP per capita and its squared term are consistently negative and positive respectively, and the coefficients remain statistically significant for various model specifications and number of lags applied to the data. For the within-between analysis, only the within part is included in the estimations. As explained in Section 8.2, the between GDP per capita and its squared term are not included in the estimation.[97] The within part of the estimation in Table 8.3 indicates a very robust and strong within-country EKC effect. The test results provide robust statistical support for a non-linear relationship between economic development (growth in

[96] The within and between effects of manufacturing value added are also tested as a robustness check (results are not reported). Similar to those of the share of industry in GDP, the within coefficients of manufacturing value added are negative and statistically significant. The between coefficients, however, are counterintuitively positive but not significant for all the lags (1-to-8). Again, the share of industry in GDP appears to be a more suitable and wholistic measure of the influence of industry on RE outcomes.

[97] A model containing GDP per capita and its squared term in both the within part and between part was tested (results not reported). The coefficients of the between part were not either consistent with the predictions and/or not statistically significant.

income) and RE development in a country. There is a negative effect of economic development on RE development for a poor country in the early stages of its economic development. Beyond a certain level of economic development, the association becomes positive, meaning that further economic development yields more RE gains.

8.6. Institutional Qualities

The LMM estimations in Section 7.6 did not find a direct link between the quality of institutions—corruption, rule of law, and quality of government—and RE development. The coefficient estimates were inconsistent, counterintuitive, and/or statistically insignificant. A robust and long-term moderating effect of the quality of institutions on the causal relationship between state oil rent and RE development and also dimensions of democracy and RE development were identified. The baseline within-between estimation already has four more variables than the baseline LMM estimation. The addition of more variables in the form of interactive terms to a model whose main purpose is to separately investigate the within and between effects of independent variables would be hardly justifiable, technically, and conceptually. Therefore, in the within-between tests of the quality of institutions, the moderating effects were not examined out of parsimony and, more importantly, to avoid needless complexities.

Table 8.5 reports the within-between estimations of the quality of institutions. Similar to what was done in the LMM estimations, two indices of corruption and rule of law from two datasets were estimated. The results of the within estimation appear to be counterintuitive and inconclusive. They are very similar to those of the LMM estimations. The signs of two of the variables, V-Dem corruption and quality of government, are negative and the coefficient of the latter is even statistically significant. Among the coefficient estimates, only that of WGI rule of law is positive—which is consistent with the predictions—and statistically significant. It appears safe to say that the within part of these estimations does not provide any additional information or insight. The results fail to provide statistically support for the hypothesis that, all else being equal, a country's progress along institutional dimensions—

e.g., becoming less corrupt, enjoying stronger rule of law, and/or having good governance—has a positive effect on RE development in that country.

The between part creates a slightly different picture. The coefficients of all the variables are positive, which is consistent with the research hypothesis. But only that of the quality of government is statistically significant. Overall, the estimations failed to produce strong and robust evidence in support of a direct and positive between-country effect of institutional factors on RE development. It may well be the case that a country with a higher average level of quality of institutions, relative to another one with lower levels of them, enjoys a higher level of RE development. This claim is not, however, backed up by the findings of the between estimations.

The within-between estimations with for 1-to-8 year lags were also separately tested (results not reported). The coefficient estimates of different lags were either inconsistent, counterintuitive, statistically insignificant or a combination of all. The outcome of these tests does not alter the previous conclusion. This study does not find robust statistical support for direct and positive within-country and between-country effects of the quality of institutions on RE outcomes.

Table 8.5: Institutional Qualities and RE Development (Within-Between Estimation)

	Dependent Variable: Share of Wind & Solar in Electricity Consumption				
	(1)	(2)	(3)	(4)	(5)
Within:					
Electoral Democracy	−0.173	0.113	−0.398	−0.347	0.130
State Oil Rent	−4.991***	−4.168**	−5.239***	−4.156**	−4.540**
Oil Richness	−0.084	−0.267	−0.134	−0.285	−0.200
WGI Corruption (*reversed*)	0.127				
V-Dem Corruption (*reversed*)		−0.395			
WGI Rule of Law			2.726***		
V-Dem Rule of Law				0.318	
ICRG Quality of Government					−1.855***
Industry Share (*%GDP*)	−2.892*	−5.889***	−2.409	−5.897***	−5.424***
GDP per capita	−11.437***	−9.553***	−11.015***	−9.582***	−7.430***
$(\text{GDP per capita})^2$	0.780***	0.670***	0.743***	0.670***	0.544***
Between:					
Electoral Democracy	1.896**	1.512	1.615	0.668	1.891*
State Oil Rent	−1.637	−2.129	−1.809	−2.167	−0.772
Oil Richness	−0.535	−0.455	−0.518	−0.461	−0.528
WGI Corruption (*reversed*)	1.156				
V-Dem Corruption (*reversed*)		1.224			
WGI Rule of Law			1.878		
V-Dem Rule of Law				1.642	
ICRG Quality of Government					3.574**
Industry Share (*%GDP*)	−1.452	−1.693	−1.474	−1.535	−1.522
Climate Vulnerability	2.473	2.805*	2.713*	2.888*	3.975**
Solar Potential	−0.393	−0.498	−0.408	−0.542*	−0.506*
Wind Potential	0.287*	0.305*	0.263	0.313*	0.334*
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/111
No. of Years	17	26	17	26	26
Observations	1,389	1,695	1,389	1,695	1,614
Log Likelihood	−2,069.063	−2,532.600	−2,064.739	−2,532.169	−2,401.613
Akaike Inf. Crit.	4,180.125	5,107.201	4,171.478	5,106.338	4,845.227
Bayesian Inf. Crit.	4,290.088	5,221.345	4,281.441	5,220.482	4,958.343
Intra-Class Correlation (ICC)	0.78	0.78	0.78	0.78	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.420/0.872	0.465/0.880	0.424/0.872	0.459/0.881	0.496/0.883

*p<0.1; **p<0.05; ***p<0.01

8.7. Climate Change Vulnerability and Renewable Energy Potentials

The LMM estimation of this study identified a positive and statistically significant effect of climate vulnerability and wind energy potential on RE development. It did not provide statistical evidence in support of a robust positive link between solar energy potential and RE development. In the within-between estimations, the link between climate vulnerability and RE development disappears altogether. The coefficient is still positive but more than 50% smaller in magnitude and not statistically significant. The value of the coefficient of wind energy potential also drops by a third and the estimate itself become less precise (a drop in the level of significant from $\boldsymbol{\alpha} < 0.05$ to $\boldsymbol{\alpha} < 0.1$). It basically loses most of its explanatory power.

A simpler explanation for these observations is that the within-between estimation includes four more time-invariant variables than the LMM estimation. The between part of the within-between estimation controls for the country-average variables of electoral democracy, state oil rent, oil richness, and industry share of GDP, in addition to climate vulnerability and wind and solar energy potentials. The drop in the levels of significance and magnitude of the coefficients of climate vulnerability and wind energy potential can be attributed to the new additions. One straightforward conclusion of these outcomes is that natural renewable resource endowments—in the form of wind energy and solar energy potentials—and vulnerability to climate risks can barely explain variations in RE development across countries. It is safe to claim that the factors that affect and shape environmental and climate policies, such as hydrocarbon resource endowments, and political, institutional, and micro and macro-economic factors, possess stronger and more robust explanatory powers to explain these variations.

State policy is believed to have the most critical role in promotion and expansion of RE deployment and consumption. This is the underlying assumption of all the research hypotheses tested in this empirical study. The results of testing the three time-invariant factors provide a plausible justification for this underlying assumption.

8.8. Robustness Check and Further Analysis

The robustness analysis of the within-between estimation follows the same steps taken in Section 7.8. Table 8.6 and Figure 8.5 compare the estimations of the three subsets of data with that of the full dataset. Looking at the between parts of the four estimations, one can recognize rather identical patterns. Although the magnitude and precision of coefficients change as the sample size and composition change, they remain consistent with the predictions of the research hypotheses. The coefficient of state oil rent remains negative and statistically significant for all the estimations. The same is true for the coefficients of GDP per capita and its squared term. A robust and significant EKC effect emerges in all the estimations. Perhaps the only important exception in the within part is the coefficient of industry share of GDP in column (3), which is negative but not statistically significant. In the between part, the coefficient of electoral democracy is positive in all the models and significant in all of them except in the first estimation in column (1). All other coefficients have identical signs across all the models, apart from the coefficient of industry share of GDP in column (3). Among them, the coefficient of wind energy potential is robustly significant across all the estimations. Changes in the sample size and composition appear to have no considerable impact on the sign and precision of the coefficient estimates. The baseline within-between estimation indeed shows robustness to changes in composition and size of the sample.

Table 8.6: Within-Between Estimation of Data Subsets vs. Full Dataset

	Dependent Variable: Share of Wind & Solar in Electricity Consumption			
	Data Subset:			
	excl. Core Democracies (*Elec. Dem.* < 0.85)	excl. Developed Economies † (*Ave. GDP percap* < 20,000)	Year ≥ 2000	Full Dataset
	(1)	(2)	(3)	(4)
Within:				
Electoral Democracy	−0.223	−0.418	−0.344	−0.120
State Oil Rent	−3.505*	−4.874**	−4.526**	−4.153**
Oil Richness	−0.231	0.073	−0.249	−0.288
Industry Share (*%GDP*)	−9.019***	−7.307***	−2.830	−5.801***
GDP per capita	−11.440***	−12.759***	−11.307***	−9.532***
(GDP per capita)^2	0.760***	0.845***	0.787***	0.667***
Between:				
Electoral Democracy	1.116	1.689*	2.114**	2.068**
State Oil Rent	−3.030	−0.525	−3.929	−1.744
Oil Richness	−0.500	−0.657	−0.615	−0.556
Industry Share (*%GDP*)	−0.317	−1.737	0.838	−1.574
Climate Vulnerability	2.692*	1.959	1.096	1.961
Solar Potential	−0.138	−0.263	−0.515*	−0.495
Wind Potential	0.419**	0.348*	0.342**	0.318*
No. of Regions/Countries	9/93	9/95	9/120	9/120
No. of Years	25	26	16	26
Observations	1,111	1,167	1,356	1,695
Log Likelihood	−1,708.260	−1,823.669	−1,986.210	−2,534.993
Akaike Inf. Crit.	3,454.521	3,685.338	4,010.419	5,107.985
Bayesian Inf. Crit.	3,549.768	3,781.519	4,109.453	5,211.259
Intra-Class Correlation (ICC)	0.75	0.74	0.80	0.78
Pseudo R^2 (*Marginal/Conditional*)	0.444/0.863	0.460/0.862	0.386/0.876	0.461/0.881

*p<0.1; **p<0.05; ***p<0.01

† Qatar, United Arab Emirates, Kuwait & Bahrain with a 1990-2020 average GDP per capita above constant 2010 US$ 20,000 are included in subset.

Figure 8.5: Coefficient Estimates for Data Subsets vs. Full Dataset

In Table 8.7, the share of wind and solar in electricity consumption is replaced by the share of wind and solar in electricity production capacity. The table contains estimations for lags of 1-to-8 years. One pattern emerging from these estimations is slightly different than those from Table 8.3. In the within part, the coefficient of the industry share of GDP is not consistent—i.e., turning positive and negative—and not statistically significant. The coefficient of the share of industry in GDP in the baseline within-between estimation is negative and significant for all the lags. The rest of the within part of Table 8.7 is identical to that of the baseline within-between estimations. The coefficient of electoral democracy is first negative but turns positive and significant beyond a certain lag—here after lag of 6 years. State oil rent remains negative for all lags and statistically significant for most of them. Again, a very robust EKC effect emerges from the within part estimations. In the between part of the estimations, the estimate of electoral democracy is very robust. It remains positive and significant for all the lags. There are two notable disparities between the estimations in Table 8.7 and the baseline within-between estimations in Table 8.3. The between coefficients of industry share of GDP in Table 8.7 are negative and statistically significant. This means a country that has a higher on average share of industry in GDP enjoys a lower level of RE development relative to a country with a lower share of industry in GDP. The baseline within-between estimation failed to produce statistical support for this hypothesis. Another notable difference is the sign of the between coefficients of state oil rent that is counterintuitively positive although not statistically significant. The baseline within-between estimation looks rather robust to change of the dependent variable.

Table 8.7: Within-Between Estimation for Wind & Solar Electricity Capacity

	Dependent Variable: Share of Wind & Solar in Electricity Production Capacity							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Electoral Democracy	−1.843***	−1.695***	−1.295***	−0.777*	−0.218	0.627	1.604***	2.134***
State Oil Rent	−0.355	−1.077	−2.782**	−4.523***	−4.901***	−5.453***	−3.718**	−2.276
Oil Richness	0.012	−0.141	−0.099	0.026	0.114	0.138	0.122	0.246
Industry Share (*%GDP*)	−2.512*	−1.303	−0.603	−0.022	0.208	0.839	0.441	−0.241
GDP per capita	−6.552***	−6.634***	−6.313***	−5.455***	−4.137***	−2.873***	−1.531	−0.319
(GDP per capita)^2	0.469***	0.482***	0.467***	0.416***	0.333***	0.250***	0.168***	0.089
Between:								
Electoral Democracy	2.941***	2.972***	3.006***	3.060***	3.104***	3.118***	3.069***	3.041***
State Oil Rent	2.986	3.172	3.420	3.782	3.903	4.170	3.606	2.827
Oil Richness	−0.385	−0.421	−0.436	−0.442	−0.442	−0.456	−0.443	−0.406
Industry Share (*%GDP*)	−7.164**	−6.955**	−6.712**	−6.434*	−6.315*	−6.329*	−6.370*	−6.112*
Climate Vulnerability	0.271	0.146	0.034	−0.071	−0.184	−0.317	−0.438	−0.480
Solar Potential	−0.268	−0.277	−0.289	−0.304	−0.310	−0.307	−0.300	−0.299
Wind Potential	0.212	0.224	0.232	0.237	0.239	0.239	0.240	0.251*
No. of Regions/Countries	9/128	9/128	9/128	9/128	9/128	9/1128	9/127	9/126
No. of Years	20	20	20	20	20	20	20	20
Observations	1,816	1,818	1,817	1,813	1,807	1,791	1,771	1,746
Log Likelihood	−2,654.210	−2,654.065	−2,652.786	−2,651.968	−2,653.098	−2,636.489	−2,611.602	−2,568.781
Akaike Inf. Crit.	5,346.419	5,346.130	5,343.573	5,341.937	5,344.196	5,310.979	5,261.204	5,175.561
Bayesian Inf. Crit.	5,451.003	5,450.734	5,448.167	5,446.489	5,448.685	5,415.299	5,365.310	5,279.398
Intra-Class Correlation (ICC)	0.76	0.76	0.75	0.75	0.75	0.74	0.74	0.74
Pseudo R^2 (*Marginal/Conditional*)	0.463/0.869	0.464/0.869	0.466/0.868	0.467/0.867	0.468/0.864	0.469/0.863	0.468/0.862	0.464/0.863

*p<0.1; **p<0.05; ***p<0.01

This study also tested total non-hydro renewable electricity consumption and electricity production capacity as dependent variables. The results are reported in Tables C.12 and C.13 in Appendix C. Unsurprisingly, these results reveal patterns that in some cases are fundamentally different from those presented in Tables 8.3 and 8.7. As elaborated in Section 7.8, wind and solar are different from other non-hydro renewable sources such as tidal, geothermal, and biomass when it comes to policy response. Therefore, one should not expect to see similar results if these renewable sources are added to the data. The baseline within-between estimation performs very well in terms of producing robust estimates that are also consistent with the research hypotheses, when focusing exclusively on wind and solar energy. The only notable finding of total non-hydro estimations is a robustly positive and significant between-effect of electoral democracy. Indeed, the between effect of electoral democracy has been the most robust estimate of all the within-between estimations. No matter what data subsets or dependent variables are selected, the coefficient estimate of electoral democracy in the between part is always positive and, except for one data subset, statistically significant. The same is true for all the V-Dem dimensions of democracy (results not reported).

Next, this study examined the within and between effects of total natural resource rents. Using natural resource rents data has its own limitations, which are discussed in Section 7.8. Nevertheless, estimating its effect provided a proper robustness test for the estimates of the baseline within-between model. Table 8.8 includes within-between estimations that replace oil richness and state oil rent with total natural resource rents. The within coefficients of natural resource rents are all negative but not statistically significant. The between coefficients, however, are all negative and statically significant at $\alpha < 0.05$ and 0.1. These results suggest that a country with a lower average level of dependence on natural resource revenues, compared to a similar country with a higher average level of natural resource dependence, enjoys a higher level of RE development. The natural resource rents data combine all the natural resource revenues in into one statistic. Hence, this finding cannot be readily generalized to hydrocarbon resources or oil, although hydrocarbon resource rents and specifically oil rents account for the lion's share of global natural resource rents (see footnote 23).

Last, the share of trade in GDP, population density, area size, share of urban population in total population, energy intensity, and oil prices are separately estimated but are not reported in this study. None of the within and between coefficients of these popular control variables are statistically significant.

Table 8.8: Natural Resource Rents (% of State Revenue) and RE Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Electoral Democracy	−0.623	−1.029*	−1.201**	−1.143*	−1.195*	−0.621	0.153	−0.080
Natural Resource Rents	1.114	1.000	−0.091	−1.741	−2.906	−1.445	0.348	−0.208
Industry Share (*%GDP*)	−7.070***	−7.353***	−7.623***	−6.737***	−5.189***	−3.594**	−2.821	0.232
GDP per capita	−2.802**	−3.003**	−2.796**	−3.114**	−2.616*	−1.731	−0.639	0.549
(GDP per capita)^2	0.223***	0.246***	0.252***	0.282***	0.257***	0.199**	0.131	0.043
Between:								
Electoral Democracy	4.130***	4.161***	4.110***	4.125***	4.252***	4.390***	4.408***	4.506***
Natural Resource Rents	−8.840**	−8.876**	−8.500**	−8.270**	−8.390**	−8.310*	−8.573*	−8.704*
Industry Share (*%GDP*)	−1.657	−1.197	−1.302	−1.041	−0.499	−0.728	−0.976	−1.089
Climate Vulnerability	3.152**	3.218**	3.273**	3.291**	3.395**	3.479**	3.323**	3.219**
Solar Potential	0.004	−0.010	−0.018	−0.009	−0.003	0.010	0.030	0.066
Wind Potential	−0.082	−0.079	−0.055	−0.038	−0.021	−0.008	0.006	0.016
No. of Regions/Countries	9/77	9/77	9/78	9/78	9/78	9/77	9/77	9/77
Observations	1,111	1,100	1,081	1,055	1,028	999	969	935
Log Likelihood	−1,594.439	−1,577.564	−1,546.366	−1,511.990	−1,478.789	−1,444.439	−1,406.817	−1,352.545
Akaike Inf. Crit.	3,220.878	3,187.129	3,124.731	3,055.981	2,989.578	2,920.879	2,845.635	2,737.090
Bayesian Inf. Crit.	3,301.086	3,267.178	3,204.502	3,135.361	3,068.544	2,999.387	2,923.655	2,814.538
Intra-Class Correlation (ICC)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.507/0.902	0.500/0.899	0.494/0.897	0.479/0.895	0.466/0.893	0.456/0.889	0.449/0.886	0.443/0.885

*p<0.1; **p<0.05; ***p<0.01

Note: Year-random effect is not included due to over-fitting (zero variance of year random effect estimate)

In summary, the key findings of running several robustness tests of the within-between estimations are as follows:

i. Almost all the baseline within-between estimations are fairly robust to changes in size and composition of the sample data.

ii. They are also fairly robust to change of the dependent variable to the share of wind and solar in electricity capacity.

iii. The between-country effect of the V-Dem dimensions of democracy is very robust to change of the dependent variable. The coefficient remains positive and statistically significant for share of wind and solar in electricity capacity, share of total non-hydro renewable electricity consumption, and total non-hydro renewable electricity production capacity.

iv. When replacing state oil rent and oil richness with total natural resource rents, a negative and significant between-country effect emerges. This finding, however, cannot be readily generalizable to hydrocarbon resources and specifically oil.

8.9. Key Findings of the Quantitative Analysis

This study of RE development is the first to control for a country's vulnerability to climate change and natural renewable resource endowments such as wind and solar energy potentials. In this chapter and Chapter 7, panel data modeling was employed to investigate the effects of the dimensions of democracy, state oil rent, and oil richness on RE development. The causal links between the share of industry in GDP, economic development, and institutional factors such as corruption, rule of law, and quality of government on one hand and RE development on the other were also empirically examined. In Chapter 7, LMM estimation was used to empirically test all the hypothesized causal relationships elaborated in the theoretical framework chapter (Chapter 4). The current chapter does the same using within-between estimations. Running the within-between models, in and of itself, is a robustness test for the estimates and findings of the LMM estimations. More importantly, it can potentially provide additional information and insight regarding the mechanisms through which the independent variables of this study affect RE development. What follows are the key findings of this extensive empirical analysis.

Progress along the dimensions of democracy does not have an immediate effect on RE development. The positive effect of the progress appears around a decade later. Attaining and maintaining higher levels of democracy is a long-term undertaking for a society. Once achieved, that society can enjoy higher levels of RE development compared to its less democratic peers. These findings show considerable robustness to changing the composition and size of the sample and using other RE measures. A long-term positive association between democracy and RE development is unambiguous. Among the five dimensions of democracy, the egalitarian and participatory dimensions have consistently shown more explanatory power than the others. This observed heterogeneity evinces the conceptual and methodological inadequacies of using aggregate measures of democracy in similar empirical studies. This study did not find robust statistical support for a positive association between forms of democracy (presidential vs. parliamentary), other democratic qualities (civil society, civil liberties, political constraints, federalism, and various forms of accountability) and aggregate measures of democracy (Polity2, Freedom House Index, etc.) on one hand, and RE development on the other.

State oil rent and oil richness have a negative effect on RE development, especially when estimated separately. The negative effect is more robust for state oil rent than for oil richness. Higher dependence on hydrocarbon revenues has a more detrimental impact on renewable outcomes than being merely more hydrocarbon rich. Based on the findings of the within-between estimations, the negative effect of state oil rent is mainly attributable to the within-country effect. The growing dependence of a country on oil rent slows down RE development in that country. The within-country and between-country variation in oil richness can explain the observed negative association between oil richness and RE development. Positive changes in the oil richness of a country negatively impact RE development in that country. Moreover, countries with higher average levels of oil richness, relative to their oil poorer peers, experience lower levels of RE development.

The tests failed to produce statistical support for a robust negative between-effect of state oil rent on RE development. Replacing state oil rent and oil richness with total natural resource rents resulted in a negative and significant between-country effect of total natural resource rents. This finding, however, cannot be readily generalizable to oil or other hydrocarbon resources. A moderating effect of all the dimensions of democracy on the negative association between state oil rent and RE development was also identified. The results of testing the effect of coal and natural gas are inconclusive. Last, the estimates of the effects of state oil rent and oil richness are rather robust to changing the composition and sample size of the data and using share of wind and solar in electricity production capacity as the dependent variable.

This empirical study found statistical support for a robust and negative association between the size of industry—including manufacturing, mining, construction, and utilities sectors—in a country and RE development in that country. An increase in the share of industry in a country's GDP has a negative effect on that country's RE development, all else being equal. Given the results of the simple LMM and within-between estimations, this is mostly attributable to within-country dynamics. This study also revealed a robust EKC effect, linking economic development to RE development. There is a negative effect of economic development on RE development for a poor country in its early stages of economic development. Beyond a certain level of economic development, the association becomes positive, meaning that further economic development yields more RE gains.

This study has not produced statistical support for the robust effects of three institutional factors—corruption, rule of law, and quality of institutions—on RE outcomes. However, a long-term moderating effect of these three institutional quality variables on the causal relationship between democracy and RE development emerged from the LMM estimations. This study also identified another moderating effect of the institutional factors: improvements in corruption, rule of law, and especially quality of government, alleviate the negative effect of state oil rent on RE development to an extent that it can potentially cancel out that negative effect altogether.

The estimates of climate vulnerability and wind energy potential are positive and statistically significant in the LMM estimation. However, when the number of time-invariant variables increases in the within-between estimations (the addition of between electoral democracy, state oil rent, oil richness, and industry share of GDP variables) only the coefficient of wind energy potential remains statistically significant. It appears safe to claim that natural renewable resource endowments and vulnerability to climate change can barely explain variations in RE development across countries. Rather, it can be argued that state policy has the most critical role in the promotion and expansion of RE deployment and consumption. This has been the underlying assumption of all the research hypotheses tested in this empirical study. The testing of the three time-invariant factors provides a plausible justification for this underlying assumption.

Finally, this empirical study focused on two specific sources of RE: wind and solar. In the empirical literature, it is argued that among all renewable sources of energy, wind and solar are more responsive to state policy and thus behave differently from other renewable sources such as tidal, geothermal, wave or biomass. The observed disparities between the wind and solar estimates and the total non-hydro estimates several estimations can be regarded as another justification for excluding other non-hydro renewable sources from this empirical study. The baseline LMM model of this study performs very well in terms of producing robust estimates that are also consistent with the research hypotheses, when focusing exclusively on wind and solar energy. In summary, the findings of this empirical study, as examined and elaborated in this and previous chapters, provide statistical support for most of the research hypotheses discussed in Chapter 5.

The next chapter delves into a case study analysis of RE development in Algeria, Morocco, and Tunisia. This is followed by a concluding chapter that examines the study's various technical, methodological, and data availability limitations, along with its important policy implications. Additionally, the conclusion provides suggestions for further empirical studies to advance research in this field.

9. Case Studies: Drivers of Renewable Energy Development in Algeria Morocco and Tunisia

So far, the effects of the key independent variables of this study, namely democracy, hydrocarbon richness, and state hydrocarbon rents, on RE development are examined through quantitative analysis. This chapter centers on qualitative analysis, accomplished through an illustrative case study analysis of Algeria, Morocco, and Tunisia. The aim is to deepen the understanding of the causal mechanisms through which the key independent variables affect RE development.

By examining these case studies, this thesis aims to identify and analyze the specific pathways and interactions between democracy, hydrocarbon richness, state hydrocarbon rents, and the development of RE sources in these countries. Through a qualitative approach, valuable insights are gained into how political, economic, social, and environmental factors intersect to either promote or hinder the growth of RE initiatives.

The case study analysis serves as a complementary tool to the quantitative findings, providing a more nuanced understanding of the complex relationships at play. The unique political landscape, resource endowment, and energy policies of each country are carefully examined to draw meaningful conclusions about the interplay of these factors on the advancement of RE sources.

Ultimately, this combined quantitative and qualitative approach contributes to a more comprehensive and robust examination of the factors influencing RE development, particularly in the context of these North African nations. Moreover, it allows for drawing broader implications for other countries facing similar challenges and opportunities in their pursuit of sustainable and environmentally friendly energy solutions.

9.1. Introduction

Algeria, Morocco, and Tunisia are part of the Maghreb, the western part of North Africa that stretches from Western borders of Egypt to the Atlantic coast of Western Sahara (Figure 9.1). The three countries have a coastline in the Mediterranean Sea. Algeria, the largest country in Africa, is sandwiched between Morocco, Libya, and Tunisia. Morocco, officially the Kingdom of Morocco, also has relatively a relatively vast North Atlantic coastline. It shares its eastern border with Algeria, and eastern border is with Algeria and to the north, it is separated from Spain by a very slim body of water, the Strait of Gibraltar. Tunisia is the smallest and least populated country among the three.

Figure 9.1: The Maghreb Region (green area)

The three countries are located in a region that is very vulnerable to climate change, according to almost all UN Intergovernmental Panel on Climate Change reports, including the latest one (Pörtner et al., 2022). They are all Muslim and considered to be part of the Arab world. They were all part of the Islamic Caliphate and its successor the Ottoman Empire at some point. They share similar colonial history as they were all ruled by the French colonial empire and France. Furthermore, they are all developing economies with comparable GDP per capita figures[98]. The three countries appear to be befitting candidates for this case study analysis, as they broadly have similar geography and climate and face similar environmental and climate risks, in addition to sharing a distinct ethnic, linguistic, cultural, institutional, and historical background.

They, however, differ drastically in terms of the key independent variables of this empirical study, namely political system, hydrocarbon richness, and state hydrocarbon rents,

[98] Though Algeria has the highest GDP per capita in constant US Dollar (see Figure D.1 in Appendix D) and PPP terms, the gap between the three countries is not considerable.

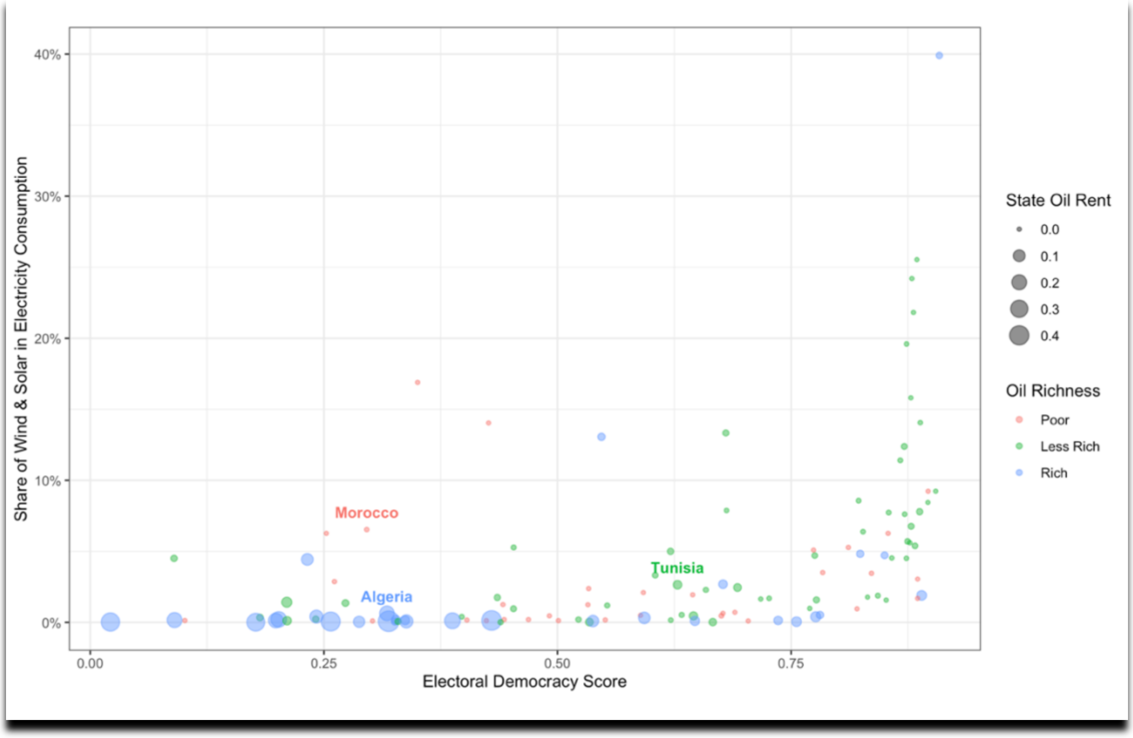
and also the dependent variable, share of wind and solar in the electricity mix (see Figure 9.2). First, Algeria has a presidential system that is not democratic according to all well-established indices of democracy. Morocco is a semi-constitutional monarchy with parliamentary system and a non-democracy. Tunisia has a presidential system and among the three countries, is the only country that is considered a democracy, though a nascent one[99]. Second, while Algeria is one of the major producers and exporters of hydrocarbon resources in Africa[100], Tunisia transitioned from energy self-sufficiency to import-dependency in a matter of few decades. Tunisia had a relatively large oil and gas industry from the 1970s to 90s, but a combination of factors such as depletion of its oil and gas reserves, population growth and increase in energy demand has led to Tunisia becoming a net importer of oil and natural gas since the early 2000s. Morocco, on the other hand, is a very resource poor nation. It has negligible extractable natural resources of any kind, let alone oil and gas.[101] Lastly, as will be discussed in detail in this chapter, the gap among the three countries regarding RE development and penetration is striking.

[99] Tunisia became a democracy after the 2011 revolution that ended the 25-year rule of former president and autocrat, Zine El Abidine Ben Ali.

[100] Algeria is the second largest natural gas producer (largest natural gas exporter) and fourth largest oil producer in Africa according to IEA statistics.

[101] The country's only natural resource worthy of note is phosphates.

Figure 9.2: Scatterplot of Share of Wind & Solar in Total Electricity Consumption



Note: 2010-2020 country averages are calculated. Oil Poor means Oil Richness value < 0.01. A Less Rich country has an Oil Richness value of 1 or below. Oil Rich denotes oil self-sufficiency (Oil Richness value > 1).

In summary:

1. Morocco has been consistently among top global performers and Africa's leading nation in RE transition according to numerous studies and reports, such as Germanwatch's Climate Change Performance Index Report (Burck et al., 2022), the Climate Action Tracker Report (Boehm et al., 2021) and African Climate Change Policy Performance Index (Epule et al., 2021).
2. Tunisia is regarded as laggard in North Africa with regards to RE development, and according to the abovementioned sources, despite having to import oil.
3. Algeria is the worst performer in terms of RE development in North Africa— apart from a civil war-torn Libya which is practically a failed state.

In this chapter, first RE potentials and outlook for the Maghreb Region and particularly the three countries are presented. Next, RE policy development (RE policy outputs) in the three countries in the past two decades are compared and contrasted. It is followed by a brief account of RE development (RE policy outcomes). Then, the extent to which democracy, abundance of hydrocarbons, and state hydrocarbon rents, as well as institutional qualities such as corruption rule of law and quality of government, can account for the differences in the RE trajectories among the three countries, are examined. The analysis includes both identification of factors hindering and/or facilitating RE transitions in the three countries, and elaboration on possible mechanism(s) though which these factors affect RE outcomes. The chapter ends with a brief conclusion.

9.2. Renewable Energy Potentials & Outlook: A Brief Review

The Maghreb generally is a semi-arid to arid region. All the countries in the region are, and will be, facing a wide range of climate change risks and threats in decades to come (Pörtner et al., 2022). For example, Algeria has seen a 30% decline in yearly average rain fall between 2010 and 2020 (Bouznit et al., 2020) and will most likely experience a rise in temperature higher than the global average (Sahnoune et al., 2013). The region on the other hand has immense wind and solar energy potentials for obvious reasons. Its arid and sunny weather, for more than 80% of its days (Bellakhal et al., 2019), creates ideal conditions for both solar photovoltaic (PV), and concentrated solar power (CSP) generation[102]. The region's extensive Mediterranean and Atlantic coastlines combined with its windy deserts make it perfect for

[102] Solar PV and CSP are totally different technologies. The PV cells directly transform light from solar irradiation into electricity. The concentrated solar power first concentrates solar irradiation through a solar collector field. The generated heat will be stored in storage units, usually filled with molten salt or synthetic oil. The heat can then drive a turbine or power a generator to produce electricity. The key advantage of CSP over other renewable sources is its embedded storability feature making it easier to manage and control power generation. Its main drawback is that, unlike solar PV, it require direct radiation to produce heat, which means no power generation capacity in cloudy days (Schmitt, 2018). The two key criteria for solar PV power generation are temperature and global horizontal (GHI), a measure of the amount of solar radiation received on a horizontal surface on earth, typically expressed in units of energy per unit area. For CSP, only direct normal irradiation (DNI) matters, which is basically a measure of the amount of solar radiation received on a surface perpendicular to the sun's rays, often expressed in units of energy per unit area (Moore, 2021; Tazi et al., 2018). It is worth noting that the electricity generation costs of CSP are higher than those of solar PV and wind (Schmitt, 2018).

generating wind power. In theory, the region's closeness to Europe positions it as one of the most desirable locations for RE investment globally (Stambouli et al., 2012). In reality, most of the countries in the region with the exception of Morocco lag behind their rather modest RE targets. Their overall RE performance is disappointing. When it comes to regional RE development cooperation—for example the DESERTEC Industrial Initiative—the picture is hardly any different[103]. There is barely any coherent regional RE project or development plan in North Africa.

Algeria has the highest GDP per capita among countries in the region and is also the largest country in terms of land area on the continent. Algeria’s potential for solar energy is immense, due to its geographical location. Its average direct solar irradiation exceeds 3,000 hours of sunshine per year (Sahnoune et al., 2013). Furthermore, Algeria has a dry climate, low precipitation, and abundant flat unused land adjacent to transport networks and power transmission grids (Stambouli et al., 2012). As for wind energy, a relatively high average wind velocity in most parts of Algeria makes it a desirable place for wind energy utilization (Bouraiou et al., 2020).

Morocco has more or less similar wind and solar potential profile. It has a 3,500 kilometer coastline with high average wind speed (Haidi et al., 2021; Kousksou et al., 2015). The average direct solar irradiation is 2,700 hours per year in the north and 3,500 hours per year in the south (Kousksou et al., 2015). As for Tunisia, the wind and energy potentials are similarly substantial. It has on average more than 2,980 hours of exposure to sunshine per year according to the National Meteorological Institute (République Tunisienne, 2019), and high wind speed especially in the northern part along its 1,300 kilometer coastline (Attig-Bahar et al., 2021).

[103] The overambitious DESERTEC Industrial Initiative, founded in 2009 mostly by German entities, aimed to invest almost half a trillion euro in solar CSP electricity generation in North Africa and the Arabian Peninsula for exports to Europe and local consumption (Griffiths, 2017; Komendantova et al., 2014; Schmitt, 2018). The target was to meet 15-20% of Europe’s electricity demand by 2050s (Griffiths, 2017). It was probably the most highly publicized international RE development and power integration schemes at the time of its inception. Multiple disputes regarding interpretation and implementation of the initiative led to its eventual collapse by 2015—for further details and in-depth analysis refer to Schmitt (2018).

Table 9.1: RE Potentials & CCPI Scores

Index	Algeria	Morocco	Tunisia	Global Average
Wind Energy Potential	2.25	2.73	2.78	2.16
Solar Energy Potential	4.90	5.00	4.70	4.20
Climate Change Vulnerability	0.33	0.34	0.32	-
2022 Climate Change Performance Index (CCPI)	39.91	71.60	-	-

Table 9.1 reports wind and solar energy potentials, and climate vulnerability scores for each country with the same measures and estimates used in the data and modelling part of this study. Not surprisingly, the wind energy potentials of the three countries and their climate vulnerability score are very similar, and above the global average. Furthermore, Figure D.2 in Appendix D compares the distribution of wind and solar potentials of the three countries with the global distribution. The bar charts are from International Renewable Energy Agency's country profiles (IRENA, 2021a, 2021b, 2021d). They clearly indicate wind and solar energy capacities in the country substantially higher than the global averages. Figure D.3 and D.4 in Appendix D also illustrate wind and solar PV potential maps[104], produced by Global Wind Atlas (Global Wind Atlas 3.0, 2022) and Global Solar Atlas (Global Solar Atlas 2.0, 2020) respectively for the three countries. In Algeria, almost all areas in the country have average winds speeds close to, or above, 10 meters per second at 100 meters above the ground level, which is a standard wind energy potential metric. For Morocco the southern and eastern regions have the same level of wind energy potentials. In Tunisia, large parts of the north and almost all the south experience wind speeds close to, or above, 10 meters per second. As for offshore wind energy, the potential for the countries, especially Algeria with its vast Mediterranean coat and Morocco with its long coastline along the Atlantic Ocean, is considerable. Even Tunisia with a shorter Mediterranean coastline still possesses considerable offshore wind potential according to a U.S. National Renewable Energy Laboratory report (Sullivan, 2014). Finally, the solar PV potential statistics of the three countries is very promising (see Figure D.4 of Appendix D). In Algeria, large parts of the southeast and the east have a very high photovoltaic potential. The same can be said about

[104] Global Solar Atlas 2.0 (2020) also produces direct normal irradiation (DNI) and global horizontal irradiation (GHI) maps for the three countries. They are not reported here because they are almost identical to the maps presented in Figure D.4 of Appendix D.

the eastern part of Morocco and the southern part of Tunisia. All the three countries are endowed with vast, open, and mostly flat lands (deserts), well-suited for solar and wind energy development. Overall, the fact that the three countries have immense solar and wind energy potentials is indisputable.

But RE progress in all the North African nations except Morocco is dismal or barely sufficient. Despite its proximity to Europe, one of the largest energy markets in the world, the whole region is one the least attractive destinations for foreign direct investment (FDI) broadly and FDI in renewable energy in particular (Komendantova et al., 2014). According to CCPI annual global rankings, Algeria is one the worst performers globally. The CCPI ranking is based on a country's GHG emission, RE development, energy use and climate policy (Burck et al., 2022). Tunisia is not included in CCPI rankings but with a very tiny share of renewables in its power mix, can be regarded as an underperformer. While RE potentials of all the three countries are huge and comparable, the large gaps between their RE achievements tell a totally different story. It is indeed a testament to the fact that a country's RE potentials do not necessarily lead to RE transitions. There are factors other than mere potentials—such as technical, political, economic, and institutional drivers—that appear to be critical for a country's RE development. This case study analysis intends to identify and examine these factors.

9.3. Renewable Energy Policies

Earliest policies to promote RE development in the Middle East and North Africa (MENA) region were introduced in 1980s. Tunisia was surprisingly one of the first developing countries that adopted RE policy measures in mid 1980s (Bellakhal et al., 2019; Omri et al., 2015). But RE policies and measures adopted earlier in the 80s and 90s were not particularly taken seriously for a number of reasons. First, in the 1980s and 1990s, RE technologies were in their early stages of development and were generally more expensive than traditional energy sources such as coal, oil, and gas. This made it difficult for renewable energy to compete in the market, and they were often seen as a niche or barely an alternative option for energy generation (Isoard & Soria, 2001). Additionally, the cost of fossil fuels was relatively low during this time, making it even more challenging for RE sources to be cost-competitive. Governments and businesses were primarily focused on delivering affordable energy to meet growing demand, and RE sources were not seen as viable solutions for this (Huenteler et al., 2016). Second, public awareness and understanding of the environmental and economic benefits of renewable energy was limited in in the 1980s and 1990s (Dincer, 2000; Rai & Beck, 2015). During this time, climate change was not yet widely recognized as a significant global issue, and there was little understanding of the long-term environmental impacts of burning fossil fuels. Additionally, the economic benefits of renewable energy were not well understood or widely promoted, and there was a general perception that RE sources were expensive and unreliable (Ntanos et al., 2018). Third, there was a lack of technological development and infrastructure for renewable energy at the time, which limited their practical applications and scalability. RE technologies were not as advanced as they are today, and there were limited practical applications for them. The infrastructure, such as grid connections and energy storage systems, needed to support renewable energy was also lacking (Popp et al., 2011; Reddy & Painuly, 2004). This made it difficult for renewable energy to compete with traditional energy sources, which were more established and had existing infrastructure and supply chains.

Renewable energy however has undergone a significant transformation since the early 2000s. In the past two decades the cost of RE technologies has dropped substantially, mainly due to technological advancements, economies of scale, and increased investment (Elia et al., 2021). As a result, renewable energy is becoming increasingly cost-competitive with traditional energy sources and is often the cheapest option for new energy projects in many parts of the world (Ajadi et al., 2020). As for public awareness, today, renewable energy is widely recognized as a viable and important solution for addressing climate change, and there is growing public support for RE policies that promote the deployment of RE technologies (Qazi et al., 2019). Lastly, RE technologies have advanced significantly due to investment in research and development, resulting in greater efficiency and reliability. Investment in the development of necessary infrastructure such as smart grids and energy storage systems has enabled the integration of RE sources into the electricity grid (Bamati & Raoofi, 2020). Therefore, the focus of this study is on RE policies and measures developed and implemented since the early 2000s, the period in which RE policies have had realistic chances to make a difference.

Table 9.2 through 9.4 contains RE related policies and measures of development which were adopted in Algeria, Morocco, and Tunisia since 2000s. The policy data are drawn from IEA/IRENA Global RE Policies and Measures Database (IEA/IRENA, 2022). The three countries differ considerably in terms of the number of developed and adopted policies and their national RE targets. Algeria has set a number of ambitious RE policies in the past two decades. Its current RE target is 27% of electricity generation capacity by 2030 (IRENA, 2021a). The same national target for Morocco and Tunisia are 52% and 30% respectively (IRENA, 2021b, 2021d). As for the number of policies, Tunisia has adopted 13 RE related policies and measures since early 2000s. This number for Algeria and Morocco is 6 and 11 respectively.

9.3.1. Algeria

Algeria's energy sector is comprised of various key players, including Sonatrash, a state-owned company responsible for research, production, transportation, transformation, and marketing of hydrocarbons. Another significant state-owned company is Sonelgaz, which oversees the production and distribution of electricity and gas in the country (Stambouli, 2011). The country also has the Algerian Renewable Energy Institute (IAER) and New Energy Algeria (NEAL) as instrumental actors in the energy sector. All these entities are regulated by the Ministry of Energy and Mines (MEM), which oversees their operations and functions (Stambouli et al., 2012). Algeria has the lowest number of RE policies with only 6 policies. Algeria’s set of policies includes, financial supports such as tax incentive and subsidies for RE projects, support for renewable energy R&D, and Feed-in Tariff and Power Purchase Agreement (PPA) schemes to meet the targets set in its national energy strategy with a special focus on renewables (Haddoum et al., 2018). The Feed-in Tariff scheme started in 2014. The PPA is basically a "reverse tender" program through which Sonelgaz grants long-term power purchase agreements (PPAs) to firms that propose the most affordable power prices (Hochberg, 2020). Additionally, a national fund called the National Fund for

Renewable Energy Cogeneration (NFREC) is established to encourage the production of electricity using RE sources and cogeneration methods, as well as to enhance energy management practices. The NFREC fund offers increased financial resources, primarily through a 1% tax on oil revenues and energy consumption taxes paid by users (Bouznit et al., 2020). The national energy strategy is called Renewable Energy and Energy Efficiency Development Plan that was initially adopted in 2011 and then revised and updated in 2015.

Table 9.2: RE Policies in Algeria

Policy (Date)	Content
Renewable Energy and Energy Efficiency Development Plan 2015-2030 (2015)	▪ Solar PV, wind, solar-thermal, biomass, cogeneration & geothermal targets to achieve 27% share of renewables in total power generation by 2030 ▪ Special focus on large-scale solar PV & onshore wind ▪ Realization of the plan open to state-owned private local and foreign investors. Implementation supported by National Fund for Renewable Energies and Cogeneration (NFREC)
Feed-in tariff for solar PV installations (2014)	▪ Adoption of feed-in tariff scheme for solar PV installations. Tariff differentiated based on plant size (> 1MW)
Renewable Energy and Energy Efficiency Development Plan 2011-2030 (2011)	▪ RE targets to meet 20% of electricity generation by 2030 ▪ Special focus on solar PV and solar thermal technologies
Renewable Energy National Fund (2009)	▪ Funds to be sourced through a 0.5% levy on oil tax revenues
Law 04-90 on Renewable Energy Promotion in the Framework of Sustainable Development (2004)	▪ A certification of origin system to attest to the renewable source of targeted energy technologies ▪ A national observatory for the promotion of Renewable Energies ▪ a financial incentive framework to support R&D and deployment of renewable energy
Law 04-92 on the Diversification of Power Generation Costs (REFIT) (2004)	▪ adoption of a feed-in tariff scheme to support hydropower, wind, solar PV & thermal, cogeneration waste to energy, and hybrid plants ▪ the state-owned utility company, Sonelgaz as the purchaser of RE power. Tariff differentiated based on plant size (> 50 MW)

9.3.2. Morocco

In Morocco, the government has implemented several policies to support the development of renewable energy in the past 20 years. They include a national RE plan that outlines its strategies for promoting renewable energy and achieving its RE targets. Another very important measure was the creation of a renewable energy agency, called National Agency for the Development of Renewable Energy and Energy Efficiency and the Moroccan Agency for Solar Energy (MASEN) in 2010 to coordinate the development and promotion of RE projects (Luomi, 2021). Additionally, the government has extensively provided financial support in the form of tax incentives, grants, investment premiums, and subsidies for RE projects, and actively supported investment in grid infrastructure for integration of renewable energy into the energy mix—including the development of a smart grid system. Both small and large scale wind and solar projects have received support from the government over the past two decades (Moore, 2021).

It is worth noting that Morocco's King Mohammed VI played a pivotal role in the country's renewable energy development by providing strong leadership and political support (Nicolai, 2022). His vision and commitment were instrumental in launching ambitious initiatives which set clear targets for renewable energy generation and attracted domestic and international investments (Sandberg & Binder, 2019). The king's endorsement of green energy projects sent a strong signal of commitment, facilitating collaboration with global partners and the development of large-scale renewable energy projects.

Table 9.3: RE Policies in Morocco

Policy (Date)	Content
Tatwir Green Growth Program (2021)	▪ financial support in the forms of investment premium, grants and subsidies for micro small and medium size enterprises involved in RE and green projects
Morocco Net-Metering legislation (2016)	▪ A net-metering scheme for solar PV and onshore wind plants
MorSEEF (2015)	▪ A 110-million-euro fund in collaboration with the European Bank for Reconstruction and Development, the European Investment Bank, the French Development Agency (AFD) and the Kreditanstalt für Wiederaufbau (KfW) to support small scale RE projects
Morocco Renewable Energy Target 2030 (2015)	▪ A set of RE targets (20% solar, 20% wind, 12% hydro) to reach 52% share of renewables in total electricity capacity by 2030
Morocco Renewable Power Tenders (2010)	▪ Auctioning solar PV and wind capacities by Moroccan Agency for Solar Energy (MASEN) & National Office of Electricity & Drinking Water (ONEE)
National Agency for the Development of Renewable Energy and Energy Efficiency (2010)	▪ Contributing to implementation of RE policies & providing deployment roadmaps ▪ Promoting international cooperation to support deployment policies
National Integrated Project for Solar Electricity Production (2010)	▪ Deployment of solar power plants reaching a total installed capacity of 2,000 MW procured through competitive tenders
Moroccan National Agency for Solar Energy (2010)	▪ Coordinating National Integrate Project for Solar Electricity Production ▪ Supporting training technical expertise and R&D in the field of solar energy ▪ Promoting public private partnerships (PPP) and international investment in solar projects

National Energy Strategy (2009)	▪ A set of RE targets to be revised and updated periodically ▪ Energy saving and energy consumption reduction targets
Renewable Energy Development Law (2009)	▪ Establishing core regulations for production & commercialization of renewable energies ▪ Setting up a RE roadmap ▪ 20% share of renewable electricity production by 2012
Law of Self-generation (2008)	▪ Supporting self-generation from 10-50 MW by industrial sites mainly to promote wind power

9.3.3. Tunisia

As mentioned above, Tunisia was one of the pioneers of RE policies in the developing world. In the past two decades it has adopted a relatively large number of renewable policies. Like the other two countries, it has created its own national renewable energy agency and national RE policy. Its policy pool includes financial support very similar to those of Morocco and Algeria, for RE projects. Lastly, similar to Morocco, the government has adopted policies to support investment in grid infrastructure for integration of renewable energy into its energy mix.

Table 9.4: RE Policies in Tunisia

Policy (Date)	Content
Renewable Energy Law for Electricity Production (2015)	▪ Boosting investment to achieve 30% share of renewables in electricity production capacity by 2030
The Decree on connection and access of renewable electricity to the national grid (2011)	▪ Setting conditions for connection & access of RE producers to national grid superseding previous conditions set in 2007
Decree 2009/362 on Renewable Energy and Energy Efficiency Premiums (2009)	▪ Allocating premiums in the form of refunds to RE projects (thermal water heaters, biogas, solar PV & cogeneration)
Decree on rules of selling renewable electricity to the Tunisian Company of Electricity and Gas (2009)	▪ Setting rules governing the sale of renewable power to Tunisian Company of Electricity and Gas (STEG). Feed-in tariffs set by Ministry of Energy.
Law 2009-7 on Energy Efficiency: Renewable Energy Provisions (2009)	▪ Authorizing sales of cogeneration electricity to STEG
Tunisian Solar Plan (PST) 2010-2016 (2009)	▪ A public-private partnership (PPP) promoting RE production through 40 projects ▪ Focusing on wind & solar technologies ▪ Raising share of renewables in energy mix to 4.3% by 2014
National Energy Efficiency Program 2008-2011: Renewable Energy Provisions (2008)	▪ allocating funds and premiums to RE projects ▪ Raising share of renewables in primary energy supply and installed electricity capacity to 4% and 10% respectively by 2011 ▪ Focusing on wind water pumping solar PV and biogas

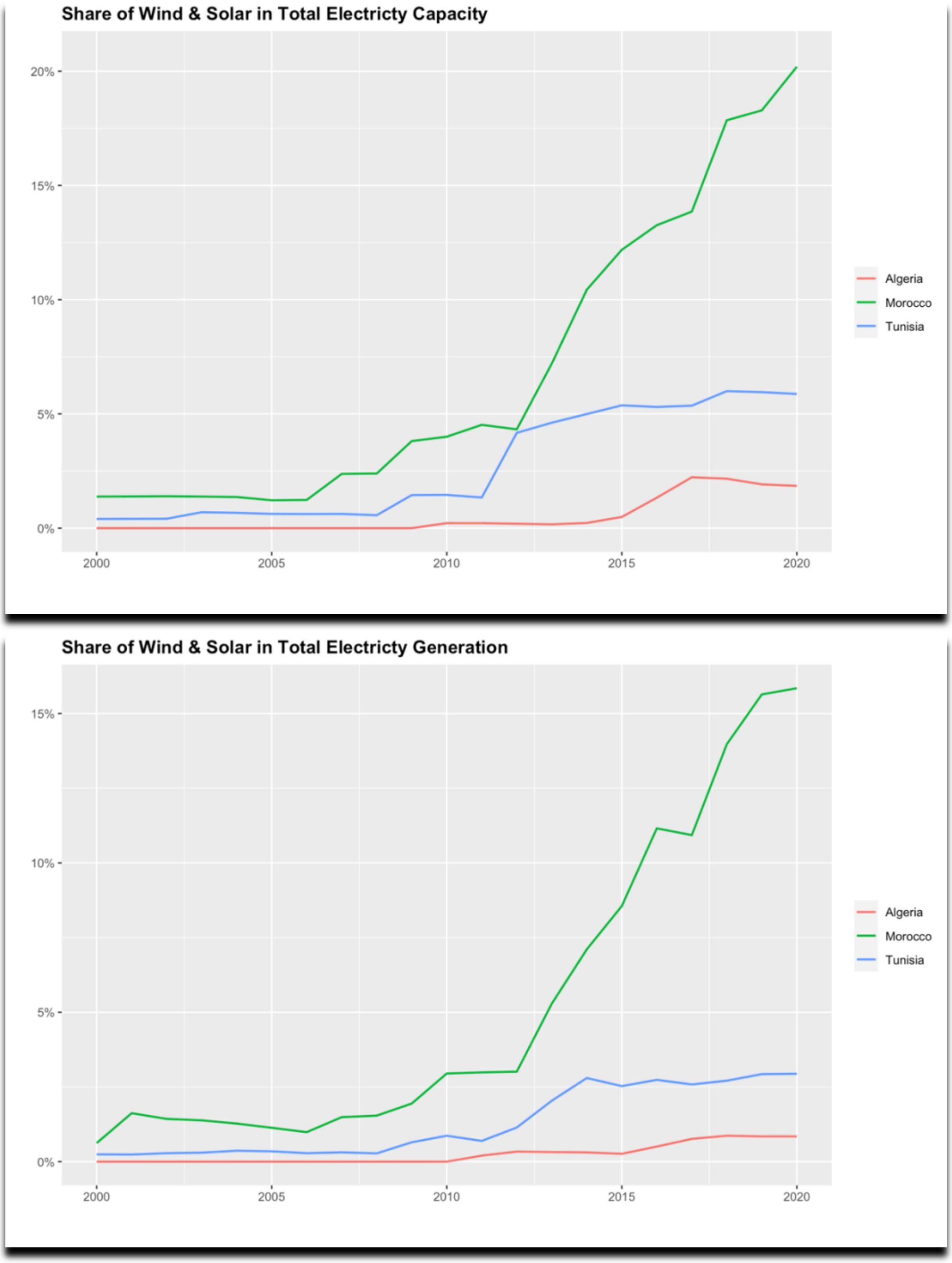
National Energy Efficiency and Renewable Energy Programme 2008-2011 (2007)	▪ allocating funds and premiums to RE projects ▪ Focusing on deployment of RE in agricultural sector and rural areas ▪ Promoting the development of water pumping and desalination from solar PV and wind energy
PROSOL Tertiary: Incentives for commercial solar water heaters (2007)	▪ Incentivizing purchase of solar water heaters for commercial buildings & tertiary sector through subsidies and credits
Law 2005-82 on Energy Efficiency Fund (FNME) (2006)	▪ Providing broad support for RE activities
Law and Decree on Energy Conservation and Renewable Energy (2005)	▪ Mandatory use of solar water heaters in new public buildings, promoting the use of photovoltaic energy, enhancing the use of wind energy & encouraging energy capitalization of waste and geothermal waters ▪ Offering subsidies for RE projects
PROSOL Residential: Incentives for solar water heaters (2005)	▪ Incentivizing purchase of solar water heaters for residential buildings through subsidies and credits
Law 2004-72 on Energy Efficiency: Renewable Energy Provisions (2004)	▪ Promoting cogeneration and establishing a Power Purchase Agreement ▪ Promoting wind solar thermal water pumping and geothermal energy sources

Overall, the three countries differ considerably in terms of the number of adopted policies, and the level of their national RE targets. However, all the three countries have developed a national RE plan. All of them have set national RE targets and established national agencies and entities responsible for RE development. Furthermore, they have introduced an array of incentives to promote RE deployment and penetration. It appears safe to say that their policy pools at least on paper incorporate similar key elements and aspects of policy support for renewables.

9.4. Renewable Energy Policy Outcomes: Deployment and Transition

Algeria, Morocco, and Tunisia have had drastically different RE trajectories in the past 20 years. Figure 9.2 shows the aggregate share of wind and solar in electricity capacity and consumption in the three countries since early 2000s, using IRENA data (IRENA, 2022).

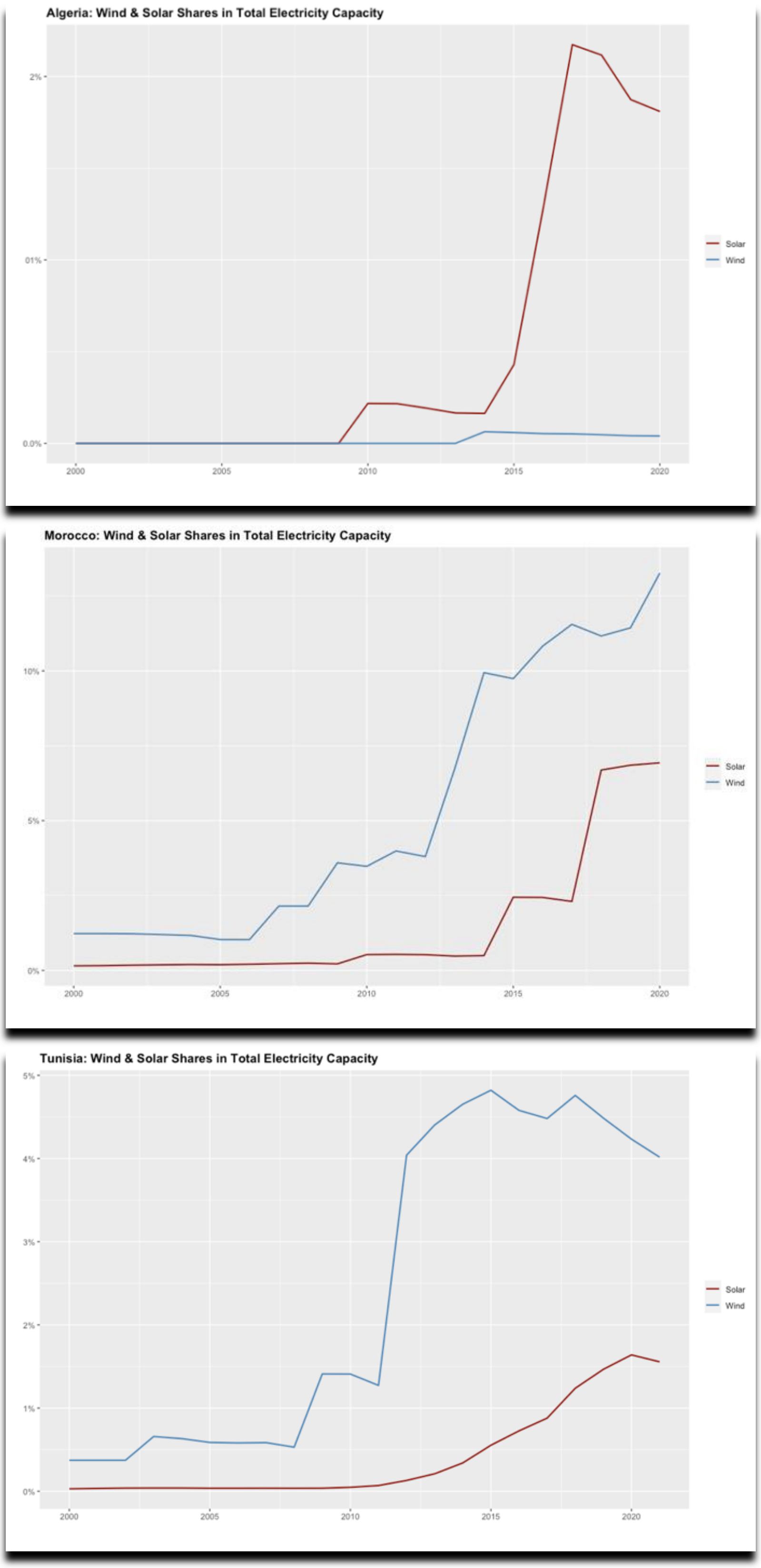
Figure 9.3: Share of RE in Electricity Capacity (top) and Consumption (bottom)



The share of wind and solar was negligible in the three countries in early 2000s. By 2010 Morocco and Tunisia showed some progress in RE deployment. In 2020, the share of wind and solar in electricity capacity surpassed the 20% mark in Morocco which is a significant achievement for a developing economy. Tunisia's share of wind and solar has stagnated since 2014. As for Algeria, except for a small gradual gain since 2015, the share of renewable barely moved throughout the period of analysis. As for public investment in renewables, a hydrocarbon rich Algeria, where the state is the main beneficiary of resource windfalls, lags far behind its poorer neighbors (see Figure D.5 in Appendix D that uses data from IRENASTAT (IRENA, 2022); note the y-axis is log-scaled). While Morocco has on the right path to wean itself from fossil fuels at least in the power sector, this sector in Algeria and to a certain extent Tunisia has been dominated by natural gas (IRENA, 2021a, 2021b, 2021d) and there is no evidence suggesting this dominance will be waning soon.

The countries also differ considerably with respect to their preferences of RE technologies. Figure 9.3, using data from IRENASTAT (IRENA, 2022), shows the share of wind and solar in electricity capacity separately. It seems Algeria has focused on solar energy development, especially since 2015. As for Tunisia, it seems wind energy has been the preferred technology for most of the period of analysis. Morocco on the other hand has adopted a most balanced approach among the three. While wind energy had a higher share in 2000s, the share of solar in electricity capacity has gone up considerably in recent years. The three countries not only differ considerably in terms of their RE achievements, they also diverge in terms of their RE composition and RE technology preferences.

Figure 9.4: Wind Share & Solar Share in Electricity Capacity



9.4.1. Algeria: A Case of Struggle and Stagnation

Meeting the rising demands for electricity and domestic water has been significant challenge in the face of high population growth, swift urbanization, and rapid development (Stambouli et al., 2012). Among the three countries, Algeria has been very slow in implementing a host RE policies and measure it has adopted since early 2000s (Haddoum et al., 2018). Despite two decades of policymaking and national RE planning, its RE sector is still in the early stages of development. Study after study indicates that given its sizeable RE potentials and its ambiguous RE targets and policies, Algeria’s RE performance is very poor (Bouraiou et al., 2020; Bouznit et al., 2020).

A case in point is implementation of the first round of the PPA scheme in 2019 which turned out to be a failure. As Hochberg (2020) elaborates four factors contributed to the limited success of the process in Algeria: (i) the novelty of the process in the country; (ii) the tender rules that restricted participation to Algerian companies or joint-ventures with a mandatory 51 percent stake for the Algerian entity; (iii) local content requirements for solar modules and equipment, despite limited solar-related manufacturing capacity; (iv) and requirements for financing from Algerian institutions. In summary, the tiny share of wind and solar in electricity capacity and electricity consumption and the disproportionate emphasis on solar energy despite the country’s immense wind energy potentials are emblematic of Algeria’s broad policy failure regarding RE development.

9.4.2. Morocco: A Success Story

According to a climate change policy performance index of African countries (Epule et al., 2021) Morocco is the leading country in Africa in greenhouse gas emissions reduction, RE development, and environmental protection. Morocco achieved a significant milestone in 2019 by transitioning from being an importer of electricity to becoming an exporter of green electricity (Haidi et al., 2021). Renewable energy is indeed prioritized as a key component of Morocco's broader industrialization strategy, which aims to transform the country into an emerging economy (Moore, 2021).

Despite being generally more expensive than solar PV technology, concentrating solar power (CSP) technology serves as a “charismatic, centralized technology” and a “nation-building technology” that helps Morocco meet its “social goals” while also generating more employment opportunities than solar PV (Moore, 2021). Solar PV technology has been gaining ground in Morocco recently as its costs have been declining fast (Ghazi, 2021). As for wind energy, this sector has been expanding quickly in Morocco. Compared to solar energy, wind is generally considered to be a more viable renewable source for large-scale projects with higher capacity (IRENA, 2016, 2021c)

Morocco also has made significant investments in wind and solar energy. Morocco has made a deliberate effort to obtain climate financing from the international community and has consistently been one of the leading recipients in the region. In the past two decades, Morocco has been the top recipient of international climate finance in MENA, and more recently through the Green Climate Fund (GCF) (Luomi, 2021). It has also taken steps to encourage private investment in the sector, including creation of a favorable investment climate (Rignall, 2016). MASEN, which is state-owned, is in charge of executing the plan for solar energy development with the aid of almost $1 billion in low interest loans from the World Bank, the European Bank for Reconstruction and Development, the European Investment Bank, the French Development Agency (AFD) and the Kreditanstalt für Wiederaufbau (KfW).

Despite its impressive achievements, Morocco has faced challenges and obstacles in its RE trajectory. The state’s energy policy involves managing various competing forces such as tackling social challenges that that may pose a risk to the stability of a state, and achieving sustainable development, industrial policy goals, securing international financing, and managing energy prices while balancing the trade-offs among these goals (Moore, 2021)[105]. Despite these challenges that are further elaborated in the following sections, Morocco's

[105] For example, as Moore (2021) points out, the state has been under pressure to achieve an energy transition that promotes inclusive development and avoids exacerbating existing disparities. One example of the challenges faced is the inadequate involvement of local communities in solar siting processes, as well as the use of water in the initial wet-cooled phase of the world’s largest CSP plant, Noor-Ouarzazate, loss of shared grazing land, and benefits primarily benefiting the central part of the community instead of the most affected populations (Moore, 2021).

impressive RE achievements include the construction of the world's largest concentrated solar power plant and the establishment of ambitious targets to generate 52% of its electricity from renewable sources by 2030, positioning the country as a global leader in the transition to clean energy.

9.4.3. Tunisia: Struggling in Transition

In terms of progress of national RE plans, Tunisia lies somewhere between Morocco and Algeria. It has apparently fared better than Algeria on RE metrics such as share of renewables and public investment in renewables but still trails behind Morocco by a wide margin. The country indeed can be considered to be in transition, socially, political and to a great extent economically. Politically and socially, among the three countries, Tunisia is unique in its recent experience with democracy. Tunisia's journey towards democracy has been marked by significant challenges and achievements since the popular uprising in 2011, which led to the overthrow of the long-standing authoritarian regime of President Zine El Abidine Ben Ali. Following the revolution, Tunisia embarked on a transition towards democratic governance, which included the drafting of a new constitution, holding of parliamentary and presidential elections, and the establishment of various democratic institutions.

Economically, the composition of national economy and the state fiscal structure has changed drastically in the past four decades. Up until the mid-1980s, Tunisia had enjoyed a highly advantageous energy position, with the oil and gas sector accounting for approximately 13% of GDP and 16% of national exports in 1980 (Omri et al., 2015). Nevertheless, in the late 1980s, that exceptional position deteriorated due to declining oil and gas production and a rapid increase in domestic energy demand, eventually culminating in a first-ever energy balance deficit in 1994 (Omri et al., 2015). Currently, domestic production of natural gas accounts for 47% of domestic consumption, the rest of which is covered by imports from Algeria (Attig-Bahar et al., 2021).

Tunisia will most likely be dependent on foreign direct investment (FDI) in years to come in order to reach its RE goals, which include a notable focus on wind energy. This strategy would require real improvement of legal and financial frameworks that currently support private RE players (Attig-Bahar et al., 2021). The Tunisian Minister for Industry, Energy, and Small and Medium Enterprises has initiated the PROSOL project, which has received technical and financial assistance from the United Nations Environment Program (UNEP), the Mediterranean Renewable Energy Center (MEDREC), and the Italian Ministry for Environment and Territory (Omri et al., 2015).

The production of electricity in Tunisia is heavily reliant on natural gas, with the state-owned utility company, Tunisian Company of Electricity and Gas (STEG) being the primary provider of electricity for domestic needs. This role has enabled STEG to function as a significant social, political, and economic instrument within Tunisian society (Schmidt et al., 2017). Rocher and Verdeil (2019) identifies the unwillingness of STEG to permit private interests access to the grid as the central impediment to the adoption of centralized RE technologies in Tunisia. The underlying reasons for this reluctance are explained in subsequent sections. Overall, While Tunisia has made notable strides in RE development, particularly with the implementation of its National Renewable Energy Action Plan, it still falls behind the regional leader, Morocco, while outpacing a stagnant Algeria.

9.5. Democracy Political Stability and Renewable Energy Development

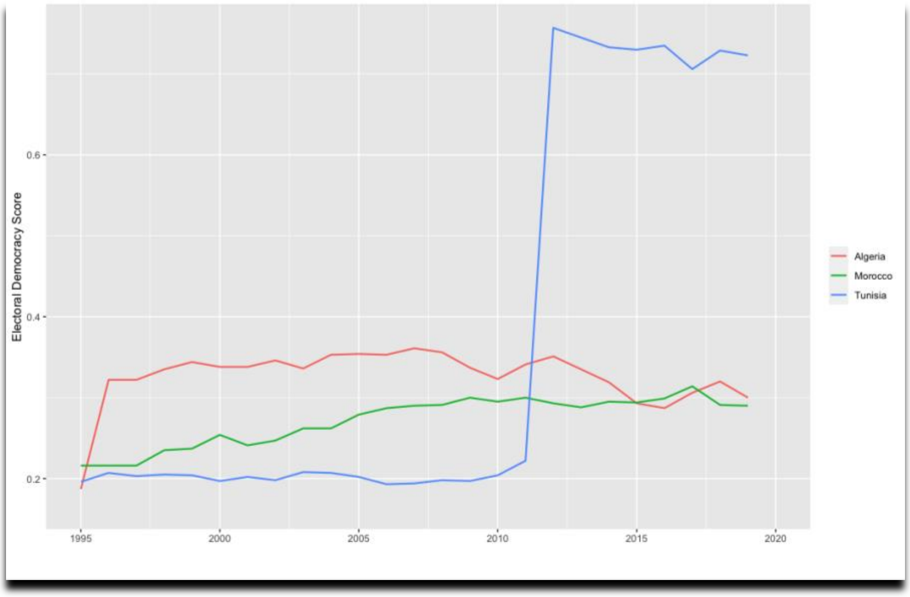
Democracy is one if the key independent variables of this empirical study. The link between democracy and RE development is well elaborated in the literature review and theoretical frame chapters (Chapter 2 and 4). The objective of this section is to investigate to what extent the level of democracy can explain variation in RE progress across Algeria, Morocco, and Tunisia in the past three decades. The three countries are suitable for this purpose, as Algeria, Morocco, and Tunisia are countries with varying degrees of democracy. While all three have experienced political upheaval in recent years—such as the Algerian Civil war between the state and Islamism rebel groups from 1991 to 2002, the 2011 Tunisian

Revolution, and the ongoing Western Sahara conflict between the Moroccan government and the Sahrawi Arab Democratic Republic (Polisario Front)–their political systems and levels of democracy still differ significantly.

Algeria is nominally a republic with a multi-party presidential system. The parliament has two chambers: the National People's Assembly and the Council of the Nation. However, the political system is heavily dominated by the military, which has been a powerful force in Algerian politics since independence in 1962. The government has been criticized for its lack of transparency, corruption, and restrictions on freedom of expression and assembly (Hadjadj, 2007). Morocco is a constitutional monarchy with a multi-party system where the prime minister is the head of government. The prime minster is the head of the party that wins general parliamentary election and is officially appointed by the king. While Morocco has made some progress towards democratization in recent years, the government has been criticized for its restrictions on freedom of expression and assembly, as well as its treatment of political dissidents and journalists (Arieff, 2011). Tunisia is a parliamentary republic with the president and prime minister are the head of state and the head of government respectively. Tunisia is widely considered to be the only country to have successfully transitioned to democracy following the Arab Spring protests in 2011. The government has made significant progress in expanding political freedoms and promoting human rights, although there are still some concerns about the influence of the military and security forces, and broadly democratic backsliding (Grewal, 2019; Ridge, 2022). In summary, the political systems in Morocco and Algeria are dominated by a powerful executive branch, while Tunisia has a more balanced system with a strong parliament.

The differences elaborated above are reflected in the three countries' democracy scores. Figure 9.4 indicates the level of electoral democracy in the three countries since 1995. Though other dimensions of democracy—liberal, deliberative, participatory, and egalitarian dimensions—are not reported here, the trajectories of the three countries along these dimensions are almost identical to that of electoral democracy. up until 2011, the three countries were very similar in terms of the level of democracy. They all had an electoral democracy score below 0.5 which safely put them in the category of non-democracies. After the 2011 revolution however, the level of democracy rose suddenly and significantly in Tunisia, separating it from all North African countries including Algeria and Morocco. Morocco and Algeria have followed very similar trajectories especially since 2010—though the latter experienced progress during 1995-early 2000s period which coincides with the end of the Algerian Civil War. Right now, Tunisia is the only North African country that can be considered a democracy.

Figure 9.5: Electoral Democracy in Algeria Morocco and Tunisia



Closely observing and examining the level of democracy and RE development in the three countries does not reveal causal pattern linking the former to the latter[106]. While Algeria and Morocco both have the very low levels of democracy, they differ dramatically in terms of RE development. While Morocco has achieved impressive RE targets in the past 20 years,

[106] It is worth noting that a possible causal relationship between democracy and renewable energy development is not necessarily a unidirectional one. For example, Mahdavi and Uddin (2021) argues that in the context of MENA, while conventional energy systems like oil and gas tend to lead to economic concentration, decarbonized energy systems are believed to promote diverse economies that promote inclusive governance and democratic institutions. This is attributed to four key features of renewable energy in contrast to non-renewable energy systems: low rents, diffuse systems—referring to diffuse structure of renewable energy systems in contrast to geographical and vertical concentration of oil and gas extraction–enhanced energy security, and increased employment prospects (Mahdavi & Uddin, 2021).

Algeria has faltered on implementing almost all its RE policies and plans. Furthermore, Tunisia with a substantially higher level of democracy lags far behind Morocco which is an autocratic monarchy. This case study simply observes the three countries during 1995-2020 period. It appears that in the context of this case study, the level of democracy in and of itself cannot explain variation in RE development at least in short to mid-term[107]. This finding is in line with the findings of the quantitative analysis of this study which broadly does not identify a direct and immediate effect of democracy on RE development. It is important to highlight that this analysis does not claim in any way that a link between democracy and RE outcomes in the three countries doesn't exist. It merely cannot find evidence in support of a positive association between democracy and renewable energy.

Indeed, in the case of Morocco, the king's pivotal role in Morocco's renewable energy development highlights an interesting intersection between autocracy and environmentalism literature. The success of Morocco's green energy initiatives under his leadership illustrates that autocratic leaders can champion sustainability and leverage their authority to drive eco-friendly policies, ultimately challenging the conventional notion that autocracies are inherently detrimental to environmental concerns. Indeed, this case exemplifies how autocratic regimes can adopt forward-thinking environmental agendas and achieve significant progress when leaders prioritize and support sustainable development efforts.

One can argue that it is political stability and not political system itself that matters when it comes to RE development, especially in the context of less or non-democratic countries, and young democracies. Political instability can cause regulatory uncertainties, security risks, and domestic energy market risks, which generally have a detrimental impact on RE policy development and implementation, and subsequently RE outcomes. Expropriation, currency convertibility, war, riot and civil war risks are strongly associated with political instability (Bellakhal et al., 2019). It can also force the state to reduce support for RE projects. During times of political turmoil, governments may shift their focus away

[107] Some studies try to link democracy and renewable energy development from different perspectives. For example, one study of African nations argues that, all else being equal, more democratic countries in Africa tend to have higher numbers of environmental distributed renewable generation NGOs (MacLean et al., 2015). The study however counterintuitively finds that a non-democratic Morocco with 9 distributed renewable generation NGOs hosts a higher number of such NGOs than Algeria and a more democratic Tunisia with 3 and 4, respectively.

from promoting renewable energy and instead focus on more immediate concerns. This will have a detrimental effect on financial incentives, subsidies, and other forms of support that are crucial for the growth of the RE sector. These risks and uncertainties will ultimately hamper public and private investments in RE projects.

Among North African countries only Morocco can be considered politically stable (Griffiths, 2017). According to a political stability index developed by TheGlobalEconomy.com, Morocco is ranked higher than Tunisia and Algeria, which is the least politically stable of the three. The index takes into account the probability of disorderly transfer of political authority, armed combat, aggressive protests, societal instability, global tensions, terrorism, and also conflicts based on ethnicity, religion, or region (TheGlobalEconomy.com, 2022).

A review of the literature on RE development in North Africa indeed reveals the critical role of political stability or lack thereof on RE outcomes. Pfeiffer and Mulder (2013) examine the advancement of RE technologies for producing electricity in developing nations and contend that the dissemination of such technologies is positively influenced by the presence of stable democratic governments. An empirical study by Belaïd et al. (2021) uses a political stability index that includes government stability, internal conflict, external conflict, religious tension, and ethnic tension, and finds a significant effect of political stability on investment in renewables in the MENA region. A survey study focusing on foreign investment in renewables in the North African region identifies political instability as the most important risk factor perceived by foreign investors (Komendantova et al., 2014).

Successive Algerian governments have prioritized managing oil revenues for social and political stability over addressing the root causes of its RE underdevelopment for political reasons (Haddoum et al., 2018). this has hampered public financing of RE projects in Algeria (Griffiths, 2017; Hawila et al., 2014). The present doubts regarding the enduring political stability of the Algerian governments have resulted in RE policies being considered as a matter of minimal political importance (Mahdavi & Uddin, 2021).

Even in the case of Morocco, the relationship between political stability and RE development is more nuanced than it appears. When it comes to matters of state security and stability, politics take precedence over economic forces. A case in point is Morocco’s pursuit of renewable energy from CSP, which is apparently more expensive than its solar PV alternative, in order to enhance energy independence and at the same time to fulfill socioeconomic and industrial policy objectives (Komendantova, 2021; Moore, 2021). CSP technology simply provides more employment and R&D opportunities for local businesses and wider communities (Moore, 2021).

As for Tunisia, attempts to reform energy subsidies in response to budgetary imbalances caused by the depletion of hydrocarbon resources have often been quickly reversed due to public protests and political unrest despite pressure from the IMF (Blatter & Buzzell, 2013). The fragile post-revolutionary context has heightened the government's concerns about instability, resulting in politicians being hesitant to undertake any reform efforts (Schmidt et al., 2017). Despite positive prospects for future stability in Tunisia, the political climate still presents a challenging situation for some investors (Attig-Bahar et al., 2021).

In summary, the link between political stability and RE development in Algeria, Morocco and Tunisia appears to be strong. Political stability affects RE outcomes through the risks associated with political instability—such as financial risks, political risks, etc.—and abandonment of necessary policies due to fear of political instability. Morocco's strong political stability has enabled the country to attract more foreign investment and secure long-term financing for its RE projects, giving it a competitive edge over Algeria and Tunisia. The political stability in Morocco has also facilitated the implementation of RE policies and the establishment of regulatory frameworks that promote clean energy development and innovation. In contrast, political instability in Algeria and Tunisia has hindered the growth of their RE sectors, causing delays and disruptions in project implementation, and limiting their potential for economic growth and sustainability.

9.6. Corruption Rule of Law and Renewable Energy Development

The hypothetical and theoretical links between corruption, rule of law and quality of government on one hand and RE development on the other are discussed and examined in the literature review and theoretical framework chapters (Chapter 2 and 4) and later empirically examined in subsequent chapters (Chapter 7 and 8). This section investigates if institutional qualities such as corruption, rule of law, and quality of government can explain variation in RE development in the context of this case study analysis. Though corruption is endemic to the whole MENA region, the three countries differ substantially in this regard. The same can be said about rule of law and to a good extent quality of government.

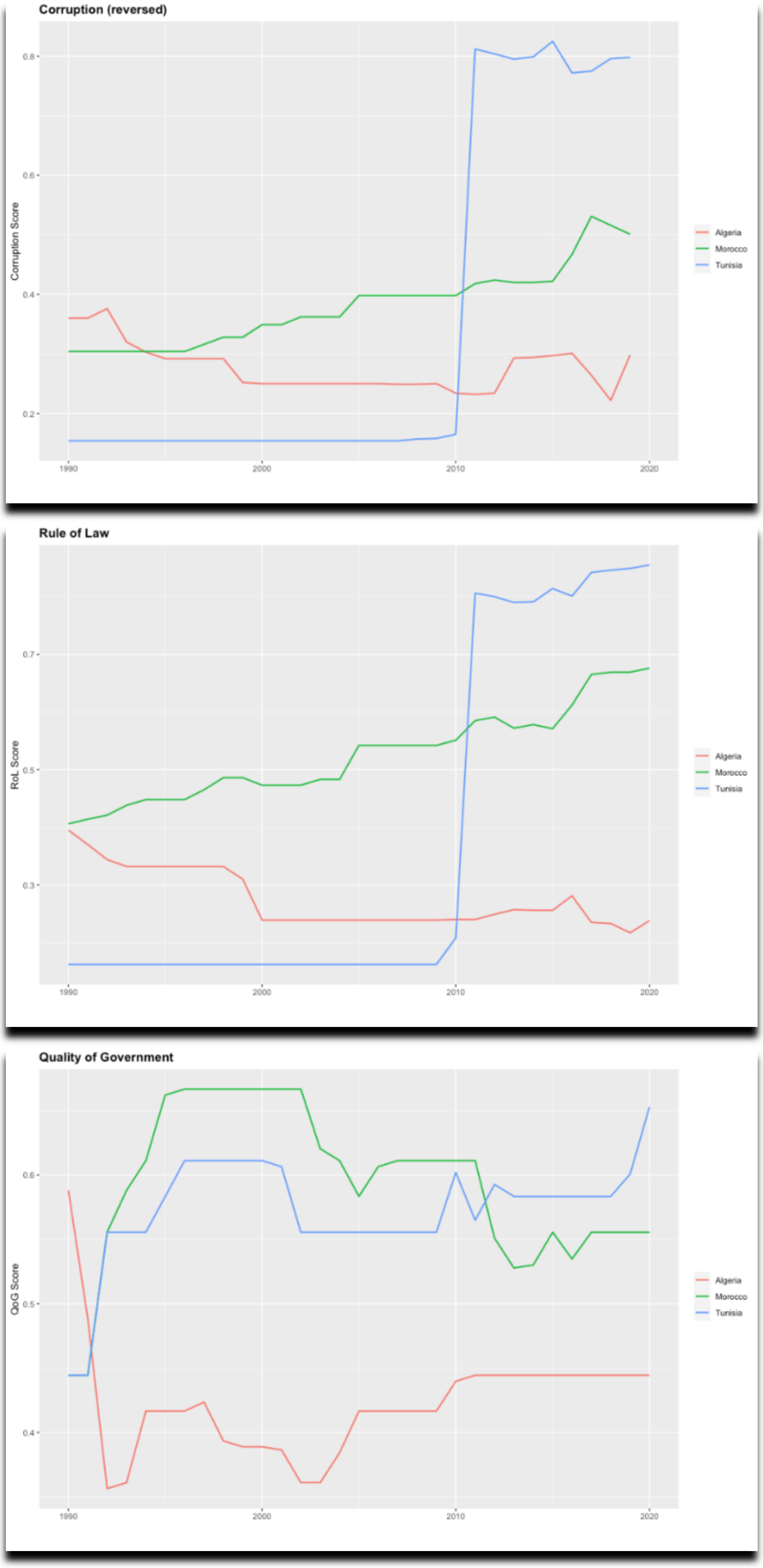
A number of studies specifically investigate the link between quality of institutions and RE outcomes in MENA. An empirical study investigates the effect of institutions including corruption, law and order, and bureaucratic quality and identify a positive link between them and RE transitions in MENA (Saadaoui, 2022). Bellakhal et al. (2019) reports a negative and significant effect of weak institutional qualities on RE development in MENA countries. Furthermore, a survey study reveals institutional factors such as corruption, lack of transparency and government accountability as major barriers for private investment in renewables in the MENA region (Komendantova et al., 2014). Among various forms of corruption, bureaucratic corruption is perceived to be the most impactful one (Komendantova et al., 2014). There appears to be a consensus broadly on the impact of institutional qualities on RE development in North Africa. This case study however exclusively focuses on Algeria, Morocco and Tunisia.

Figure 9.5 shows corruption, rule of law, and quality of government, in the three countries through 1990-2020 period. Up until 2010, the three countries were all considered corrupt with varying degrees. Morocco was generally the least corrupt, and Tunisia the most corrupt with Algeria somewhere in between. The Tunisian revolution in 2011 has had a transformational impact on the level of corruption in Tunisia. It has turned it from the most corrupt among the three into the least corrupt in North Africa—though it still faces daunting challenges regarding tackling corruption and establishing rule of law (Tamburini, 2022; Zouaoui et al., 2022). In Morocco, the National Commission for Integrity and Anti-Corruption was established in 2011 and a National Strategy for Anti-Corruption was adopted in 2016 all with mixed results (Berraou, 2019). Overall, Tunisia and Morocco have progressed throughout the period of analysis, while corruption in Algeria has worsened. Corruption can be seen as a more complex and severe problem in Algeria due to its intricate interaction with other factors, most noteworthy of them being the state hydrocarbon rents which provide an environment conducive to corruption within the incompetent and bloated state bureaucracy (Limam, 2012).

As for rule of law, the country trajectories are very similar to those of corruption. Morocco enjoyed the highest level of rule of law prior to 2011 and Tunisia has had the highest rule of law score after 2011. As for the quality of government the trajectories are different than those of corruption and rule of law, but the countries' relative performance against each other remains the same. Morocco had the highest quality of government score prior to 2011. It was replaced by Tunisia after the revolution though the gap between the two is not as wide as those of corruption and rule of law. Algeria again has the lowest score overall with a significant drop in early 1990s which corresponds with the onset of the Algerian Civil War after suspension of the parliamentary election in 1991. Though it made up some the losses in quality of government after the end of the civil war in early 2000s, it still lags far behind the other two countries.

In summary, after the 2011 revolution, the quality of institutions rose suddenly and significantly in Tunisia, separating it from all the North African countries. Morocco have slowly progressed in tackling corruption and establishing rule of law, while Algeria has deteriorated on all fronts during 1990-2020 period. Right now, Tunisia is the least corrupt north African nation with the best performance regarding rule of law and quality of government.

Figure 9.6: Corruption (top) Rule of Law (middle) and Quality of Government (bottom)



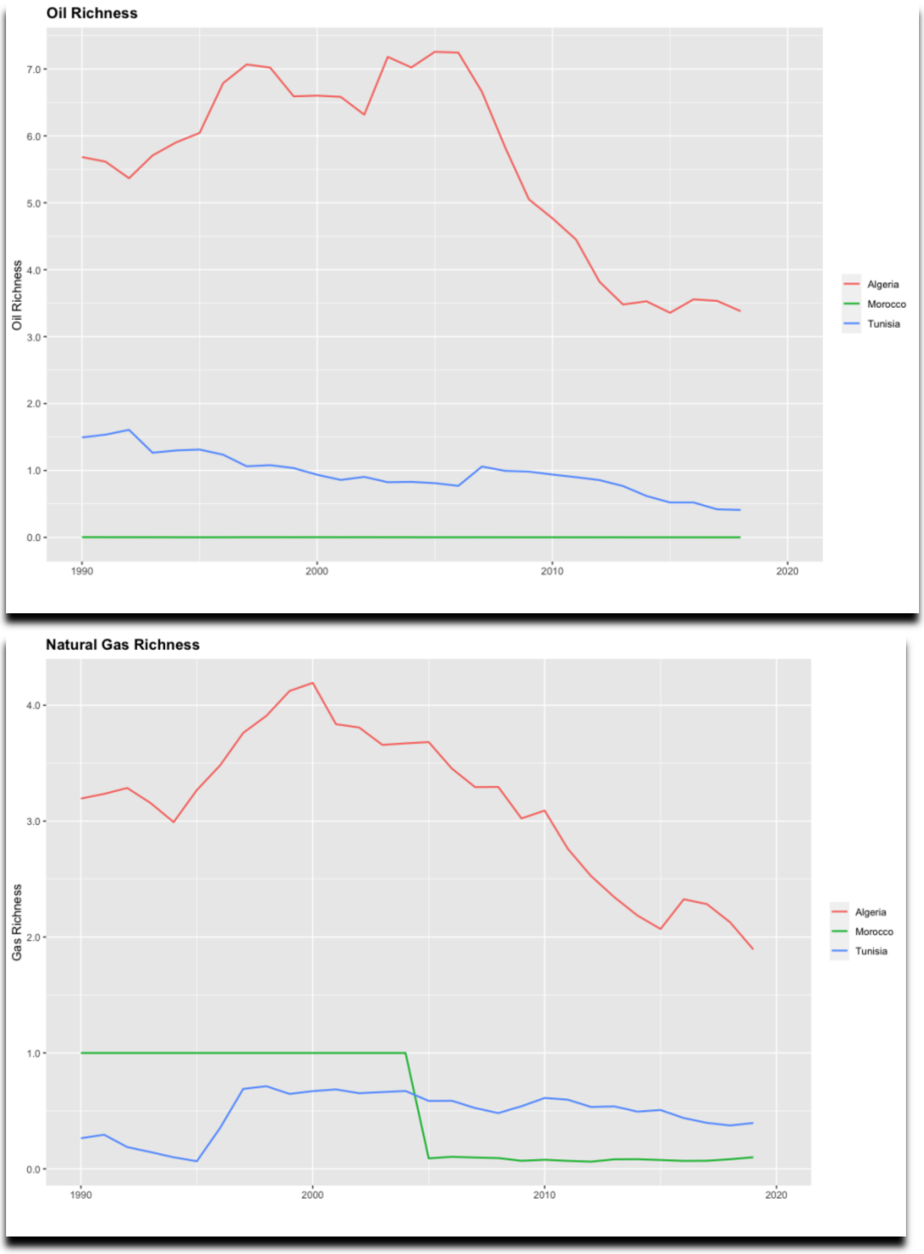
Examining the institutional qualities and their recent historical trajectories, along with RE development in the three countries, does not reveal a causal pattern linking the former to the latter. Despite Algeria and Morocco sharing relatively high levels of corruption and low rule of law scores, they differ significantly in terms of their RE development. Morocco has made significant strides in achieving RE targets over the past two decades, while Algeria has struggled to implement almost all of its RE policies and plans. Furthermore, Tunisia with a substantially lower level of corruption, higher level of rule of law and quality of government lags far behind Morocco which has a worse standing regarding institutional qualities. This case study only observes the three countries during 1990-2020 period which is a noteworthy limitation. Nevertheless, it appears that in the context of this case study, institutional qualities cannot explain variation in RE development at least in short to mid-term. This finding aligns with the results of the quantitative analysis conducted in this study, which does not generally identify a direct, immediate, and statistically significant impact of corruption, rule of law, and quality of government on the development of renewable energy. Again it is worth reemphasizing that this analysis does not assert the absence of a relationship between corruption, rule of law and quality of government on one hand and RE development on the other. It simply cannot discover any proof to back up the notion that these institutional factors and renewable energy have a positive connection.

9.7. Hydrocarbon Resource Dependence and Renewable Energy Development

Causal mechanisms through which hydrocarbon richness and state hydrocarbon rent affect RE development are conceptually elaborated and empirically examined in the previous chapters. In this case study analysis, the link between these factors and RE outcomes are revisited and re-examined in the context of Algeria and Morocco, and Tunisia. Figure 9.6 shows the level of oil and gas richness in the three countries over the past three decades. Coal is not included in this study as the three countries either have no or a very limited amount of coal production. As evident from the graphs, the gap between Algeria and two other countries is large. Algeria has been a member of OPEC since 1967 and is among the biggest producers of hydrocarbons in Africa. Oil and gas revenues have historically accounted for around 50% of the national budget and 90% of export earnings (Hochberg, 2020). Algeria is the largest African supplier of natural gas to Europe (Stambouli et al., 2012). Morocco has negligible oil production and a very small gas production relative to its domestic consumption[108]. Tunisia used to have a relatively large oil and gas industry in 1970s and 80s, but gradual increase in oil and gas demand coupled with depletion of its reserves gradually diminished its hydrocarbon wealth.

[108] Note that the substantial drop in Morocco's natural gas richness index in 2005 is indeed due to sudden increase in domestic gas demand. The increase is due to commissioning of two very large gas-fired power plants, Tahaddart and Tarfaya plants that made the country more dependent on gas imports (Enerdata, 2022).

Figure 9.7: Oil (top) and Gas (bottom) Richness in Algeria Morocco and Tunisia



As for state oil rent, the gap between Algeria and the two countries is huge again, not surprisingly. The differences between three countries are very evident in Figure 9.7. The share of oil revenue in GDP of Algeria is an order of magnitude higher than that of Tunisia, while the share of oil rent in the Moroccan economy is practically zero. The same differences are observed when including all natural resource rents (see Figure D.6 in Appendix D).

Figure 9.8: State Oil Rent (% GDP) in Algeria Morocco and Tunisia

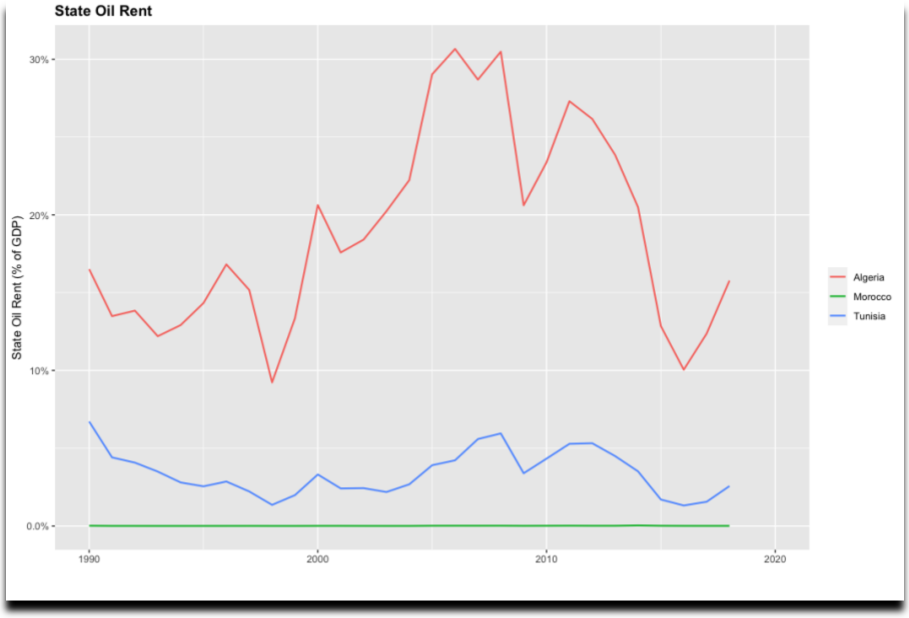


Table 9.5 reports the share oil and gas revenue in the government revenues in the three countries, using data from Global State Revenues and Expenditures Dataset (GSRED) (Richter & Lucas, 2016). Though the dataset has not been updated recently, it can still provide invaluable information regarding the composition of the state revenues in the three countries from 19960s until 2000s. In Algeria the share of oil and gas rent increased throughout that period, in Tunisia it peaked in 70s and 80s and declined drastically in 90s. For Morocco, according to the dataset, state oil and gas rents remained always zero. Overall, Morocco can be considered absolutely resource poor with zero hydrocarbon rents. Algeria is the most hydrocarbon rich country with a national economy heavily dependent on oil revenues. Tunisia, relative to Algeria, is poorer in terms of hydrocarbon resources and less dependent on hydrocarbon revenues. It is therefore not a coincidence that in Algeria and Tunisia state-owned entities with a long history of oil and gas production are tasked with RE development.

Sonelgaz in Algeria regulates and controls the electricity market as a state-owned entity. STEG in Tunisia is responsible for promoting RE production and consumption. Mahdavi and Uddin (2021) identifies pushback from such state-owned energy and utility companies as one of the biggest obstacles to energy market reforms and RE development in hydrocarbon rich countries of the MENA region. This is the case since, these energy entities historically have controlled the lion's share of the state revenues and have been the major sources of employment in the national economy. The emergence of RE alternative simply challenges these two forms of dominance (Moe, 2010) (refer to Chapter 4 for further theoretical and conceptual elaboration of the link between hydrocarbon richness state hydrocarbon rent and RE development).

Table 9.5: State Hydrocarbon Rents (% of State Revenue) and Electricity Subsidies

Index	Algeria	Morocco	Tunisia
Ave. Oil & Gas Rent (% of State Revenue)			
1960-70	19%	0%	9%
1970-80	47%	0%	19%
1980-90	40%	0%	23%
1990-00	62%	0%	7%
Ave. Electricity Subsidies (2010-2020)			
%GDP	1.32%	0.03%	1.21%
Per Capita (Constant 2010US$)	55.42	0.86	46.14

Table 9.5 also reports average electricity subsidies in the three countries in 2010-2020 period. The data are drawn from Fossil Fuel Subsidy Tracker dataset that compiles and aggregates subsidy data from IEA, IMF and OECD datasets (Fossil Fuel Subsidy Tracker, 2022). A very interesting pattern, consistent with the ones in hydrocarbon richness and rents, emerges here. The Algerian government pays the largest amount of electricity subsidies in per capita (constant 2010 USD) and share of GDP terms and Morocco pays the lowest. Tunisia lies somewhere in between though it does not lag far behind Algeria. It appears that a strong association between hydrocarbon richness and electricity subsidies exists. This case study analysis indeed identifies energy subsidies as a strong predictor of RE development across the three countries.

The literature on the link between energy policy energy subsidies and RE development broadly, and RE development in the MENA region in particular is extensive. Energy policy broadly involves how the government approaches the development of energy, covering production, distribution, and consumption. As Haddoum et al. (2018) elaborates, key aspects of energy policy may consist of legislation, international treaties, incentives, taxation, and energy conservation guidelines, with pricing being the most effective tool for managing energy demand in the medium and long term. Hawila et al. (2014) argue that RE alternatives lose their competitive edge in hydrocarbon rich countries mainly due to the energy markets being distorted by energy subsidies[109]. Less electricity tariffs simply discourage investment in and development of RE electricity. Other channels through which energy subsidies can hamper RE development include straining government finances, and deepening dependence on cheaper fossil fuels.

Subsidies can be theoretically and conceptually be linked to the topic of political survival through the fundamental assumption in political economy that the objective of leaders is to maintain their hold on power (Victor, 2009). To sustain their power, the leaders may use policies involving subsidies to allocate resources towards interest groups that have the capacity to impact the government's survival, including through their voting influence (Victor, 2009). Furthermore, Andresen (2008) observes negative association between energy subsidies and the level of political freedom. One explanation for this observation that Victor (2009) offers is that even governments that don't face elections still experience existential challenges such as political instability. Therefore, they simply would seek to reduce instability by providing some services at low cost[110] through subsidies, which are by nature hard to discontinue once started[111].

The cost of electricity in Algeria is notably cheap, particularly for households, primarily because of the country's low internal prices for natural gas (Stambouli et al., 2012). Energy prices in Algeria are significantly lower than international market prices (Mahdavi & Uddin,

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[109] It is important to highlight that not all forms of subsidies are necessarily detrimental. As Victor (2009) notes, subsidies can be used to help provide services to low-income communities as part of a worthy effort to redistribute income or help alleviate poverty. Subsidies also can be part of a program to nurture infant industries—e.g., subsidies to promote exports (Victor, 2009).

[110] It is important to understand that for major hydrocarbon resource exporters the fiscal burden of energy subsidies is small when global hydrocarbon resource prices are low and large when those prices are high, and the state enjoys high resource windfalls. Therefore, the state would barely feel any pressure for subsidy reforms unless resource production declines (Victor, 2009).

[111] Any energy subsidy can become a contentious issue. Even in the case of a resource poor Morocco, the state faces public pressure against energy subsidy reforms (Moore, 2021).

2021). Despite increasing costs and household incomes, energy prices in Algeria have remained unchanged since 2006, which does not encourage efforts to improve energy efficiency and transition to cleaner energy alternatives (Haddoum et al., 2018)[112]. Bouznit et al. (2020) elaborates that the growth in electricity consumption, driven by changes in industrial production methods and consumer behavior, as well as heavily subsidized, low electricity prices, leads to a need for increased generation and inefficient use of electricity. Energy subsidies are deeply intertwined with Algeria's economy, making any efforts to reform particularly complicated. The country faces a dual challenge of shifting its economy away from dependence on oil and gas, while also mitigating the social consequences of energy reform which are directly related to the topic of political stability (Haddoum et al., 2018).

As for Morocco, liquefied butane is the only fossil fuel that is subsidized and only partially (Moore, 2021). There is no systematic and direct electricity subsidy in Morocco, making the electric market very competitive (Avis, 2020). Moroccan consumers pay considerably more for gasoline compared to neighboring hydrocarbon-rich countries like Algeria or even Tunisia. Morocco is phasing out its remaining energy subsidies, a decision made out of necessity than choice. Due to the absence of significant fossil fuel resources in comparison to other nations in the MENA region, the Moroccan government is unable to maintain political stability through the provision of extensive subsidies on energy services to its citizens (Moore, 2021).

Tunisia's economic development strategy has relied on direct electricity subsidies through below cost of production pricing, and indirect subsidies through preferential pricing for natural gas used for electricity generation (World Bank Group, 2014). the horizontal integration gas and electricity services into one state-owned entity, STEG, which holds a monopoly on both gas and electricity distribution, has made it even easier for the state to administer and maintain these subsidy schemes (Schmidt et al., 2017). STEG used to be the largest employer and remains of the largest in Tunisia with the state controlling its employment and salary levels (World Bank Group, 2014). As Schmidt et al. (2017) observes,

[112] Even when it came to promoting renewable alternatives, instead of aiming to curb existing fossil fuel subsidy to promote renewable energy, offering subsidies for renewables had been the go-to policy in Algeria until 2016 (Haddoum et al., 2018).

the role of energy subsidies in Tunisia has evolved from just being a means of social protection and economic development, to a necessary expense for maintaining political stability, as they have become an integral part of the social contract between the state and the society. In this regard, the topic of energy subsidies and political stability, discussed earlier, are intricately interrelated. Energy subsidies are indeed used as a tool for the state to avoid political stability or maintain status quo in Algeria and Tunisia.

Energy subsidies are an ineffective use of fiscal resources, entrenched in an energy system heavily reliant on fossil fuel-based technologies, and more importantly buttressed by positive economic, institutional, technological and political feedback loops (Schmidt et al., 2017). For example, natural gas pipelines were expanded substantially during the oil and gas boom period in Tunisia in 1970-80s, or fast development of public railroads in South Africa was actually to a great extent in response to coal industry's demand (Schmidt et al., 2017). The outcome of these processes is an energy-intensive and energy-inefficient national economy that is very hard to transform. This effect is evident from the striking disparity between the oil and gas rich Algeria on one hand and Tunisia and Morocco on the other in terms of the share of industry in national economy, energy intensity and energy consumption per capita (see Figures D.8 through D.10 in Appendix D). Algeria has the highest share of industry sector in its national economy, a sector significantly more energy intensive than the other sectors of the national economy. Its energy consumption per capita and energy intensity (energy consumption per unit of economic output) are higher than the other two and in the case of energy intensity Algeria is the only country with an overall upward trajectory throughout the period of analysis. It is basically the only country that has become less energy-productive in the past three decades. Efforts to reform energy subsidies have been relatively successful in Morocco, have yielded mixed results in Tunisia and, and have not achieved any meaningful progress in Algeria (Griffiths, 2017). In summary, the level of energy subsidies and government's success in energy subsidy reforms appear to be strong predictors of RE development in the three countries.

9.8. Discussion and Conclusion

This chapter provides an overview of RE development in Algeria, Morocco, and Tunisia in the past three decades and examines the link between democracy and political stability, institutional qualities, hydrocarbon resources, and state hydrocarbon rent on one hand and RE development on the other.

While the three countries differ considerably in terms of their national RE targets and number of adopted policies, their policy pools on paper seem incorporate similar key elements and aspects of policy support for renewables. However, the share of wind and solar energy in the electricity capacity of these countries varies significantly. Examining the level of democracy and institutional qualities in the three countries did not reveal a causal pattern linking them to RE development. Nevertheless, the findings of this study suggest that the link between political stability and RE development in Algeria, Morocco, and Tunisia is strong. Government may abandon policies vital for RE development due to fear of political instability. Political instability itself can negatively affects RE development though its association with political, economic, and social risks. Morocco, the most politically stable country among the three, has had the highest level of progress in RE transitions. On the other hand, political instability in Algeria and Tunisia has hindered the growth of their RE sector, causing delays and disruptions in project implementation and limiting their potential for economic growth and sustainability.

This chapter examines the institutional qualities and their recent historical trajectories, along with RE development in Algeria, Morocco, and Tunisia. Despite these countries' different institutional qualities and their varied efforts in RE development, no causal pattern linking institutional qualities to RE development is identified. The findings of this study suggest that institutional factors such as corruption, rule of law, and quality of government cannot explain variation in RE development at least in the short to mid-term. This conclusion is supported by the results of the quantitative analysis conducted in this study.

This case study analysis also revisits and re-examines the link between hydrocarbon richness, state hydrocarbon rent, and RE development in Algeria, Morocco, and Tunisia. The emergence of RE alternatives challenges the dominance of state-owned entities in hydrocarbon rich Algeria and relatively hydrocarbon rich Tunisia. These entities have historically controlled the lion's share of state revenues and have been the major sources of employment in the national economy. More importantly, the analysis identifies energy subsidies as a strong predictor of RE development across the three countries. Energy subsidies can hamper RE development by straining government finances, intensifying dependence on cheaper fossil fuels, and distorting energy markets. This study also finds that political stability and energy subsidies are closely interwoven. Energy subsidies have been used as means to maintain political stability or avoid instability in Tunisia and Algeria that happen to be more hydrocarbon rich than Algeria. Overall, the findings indicate that addressing the political economy issues related to hydrocarbon richness, state hydrocarbon rent, and energy subsidies is critical for promoting RE development in these countries.

To compare and contrast the findings of this case study analysis with those of the panel data modeling, a useful tool, called Crisp Set Qualitative Comparative Analysis (csQCA) can be used. csQCA is a methodology that evaluates the combination of conditions needed for an outcome, using Boolean algebra. csQCA can be used to compare and contrast the key findings of this case study analysis with those of a quantitative analysis by converting quantitative data into qualitative (categorical) data. This tool allows for identifying the necessary and sufficient conditions for an outcome to occur. This method can identify the specific combinations of conditions that lead to a particular outcome, in this case RE development.

Table 9.6 contains dichotomous values (0 or 1) for simplicity. Among the three countries, only Tunisia stands as a democracy. Both Algeria and Tunisia enjoy varying levels of hydrocarbon richness and state hydrocarbon rents, with Algeria possessing substantially higher oil and gas reserves, and receiving more hydrocarbon revenues compared to Tunisia. Morocco is the only country among the three with negligible hydrocarbon wealth. The values in the outcome column are assigned based on the share of wind and solar in electricity consumption. At 21%, Morocco has a substantially higher share of wind and solar energy than Tunisia (6%) and Algeria (2%). In terms of RE development, Morocco stands out as a success story. The same cannot be told about Algeria and Morocco.

Table 9.6: Simple Crisp Set Qualitative Comparative Analysis (csQCA)

	Democracy	Hydrocarbon Richness	State Hydrocarbon Rents	Outcome: RE Development
Algeria	0	1	1	0
Morocco	0	0	0	1
Tunisia	1	1	1	0

Key takeaways from Table 9.6 are as follows: (i) democracy does not appear to be a necessary and/or sufficient condition for RE development. Democracy in Tunisia has not led to substantial RE gains while a non-democratic Morocco has become a global RE front-runner; and (ii) an abundance of hydrocarbon resources and the reliance on hydrocarbon rents can be viewed as potential hindrances to the advancement of renewable energy. Morocco has exceled in RE development in the absence of any hydrocarbon resources, while hydrocarbon-rich Algeria and Tunisia have shown disappointing progress in this area.

These findings largely confirm the results of the quantitative analysis conducted earlier. As observed from the panel data modeling in the preceding two chapters, democracy did not exhibit an immediate effect on RE development. Conversely, it was evident that oil abundance and state oil rent had a significant and adverse impact on RE development.

This case study analysis has some limitations that need to be acknowledged. First, the role of regulatory and financial institutions and their impact on RE investment and development was not included in the analysis. Second, the study did not consider geopolitical dynamics and regional rivalries between the three countries, which could have notable impacts on the implementation of RE policies and RE development. Third, the analysis did not include public opinion and perception of RE transitions and sustainability due to data availability constraints. Fourth, the study has a relatively short period of analysis, spanning only 25-30 years, which may not fully capture the long-term impacts of democracy or lack thereof, institutional qualities and hydrocarbon richness and the long-term effect of RE policies. Finally, the study acknowledges the intricate interconnectedness between factors such as corruption, state hydrocarbon rents, and democracy, which may have significant implications for RE development. For example, more rentier states tend to be less democratic and more corrupt or less democratic societies tend to be more corrupt. Future research should focus on addressing these limitations to gain a more comprehensive understanding of the challenges and opportunities for RE development. Specifically, future research should investigate the role of regulatory and financial institutions in RE development, the impact of regional dynamics on RE policies, public opinion and perception of RE transitions and sustainability. Future research is needed to investigate the relationship between democracy and institutional qualities and RE development in the long run. Additionally, future research should consider complex dynamics between of factors such as corruption, state hydrocarbon rents, and democracy to fully comprehend the challenges and opportunities for RE development.

10. Conclusion

This project is an empirical study that includes quantitative analysis in the form of regression modelling, and qualitative analysis in the form of illustrative case studies. Applying regression analysis, this study used simple linear mixed model estimation and ‘within between’ estimations. The quantitative part of the projects investigated the effect of democracy, hydrocarbon richness, state hydrocarbon rents and several other factors—such as income, institutional qualities, etc.—and their likely interactions— on the share of solar and wind electricity in a country’s electricity capacity and consumption. The qualitative part of the project consisted of illustrative case studies of Algeria, Morocco and Tunisia that included identification and examination of the causal mechanisms through which the independent variables of interest affect RE development.

10.1. Key Contributions

This study has made several substantial contributions to the existing empirical literature of environmental politics.

First, most of the empirical environmental politics literature focuses on environmental and climate policy outputs and outcomes such as GHG emissions, environmental degradation, environmental commitments, etc. There is indeed a gap in the literature in terms of RE policy outcomes. This thesis has tried to fill this gap by focusing on RE development as a RE policy outcome.

Second, following a recent trend in the literature that distinguishes between different dimensions and qualities of democracy, this study has gone beyond using a single aggregate measure of democracy and has compared and contrasted the effect of various dimensions and qualities of democracy on RE development.

Third, in almost all existing empirical literature, a single variable is included to measure hydrocarbon wealth. This study distinguished between hydrocarbon richness and state hydrocarbon rents and included both variables as they capture different aspects of hydrocarbon wealth in a country. This study constructed and used hydrocarbon richness as a measure of the relative size and importance of hydrocarbon sector in a country. State hydrocarbon rent on the other hand is introduced to capture the relative importance of the state hydrocarbon revenues in a country.

Fourth, this study was perhaps the first study that constructed and included country-level measures of RE potentials and vulnerability to climate risk, when investigating the effect of the key independent variables on RE development. The inclusion of these so-called control variables could in and of itself be considered a robustness test for the estimated effect of the key independent variables of this study on the dependent variable.

Fifth, this study was part of a growing body of the empirical environmental politics literature that employed the linear mixed model, and within-between estimations. The within-between estimations simply produced extra material for causal inference, and hence generated additional information and insight.

10.2. Key Findings

In the quantitative part of this study, linear mixed models were used to investigate the effects on RE development of democracy, state oil rent, and oil richness, along with several institutional factors such as corruption, rule of law, and quality of government. The quantitative analysis was also controlled for a country's vulnerability to climate change and natural renewable resource endowments such as wind and solar energy potentials. Simple linear mixed model estimations and within-between estimations were employed to test the hypothesised causal relationships between the independent variables of interest and RE development.

The key findings of the quantitative analysis are that progress along five dimensions of democracy has a long-term positive association with RE development, with egalitarian and participatory dimensions showing more explanatory power than the other dimensions. State oil rent and oil richness have strong and negative effects on RE development, although this negative effect is more robust for state oil rent than for oil richness. The research also found a negative effect of the size of the oil industry on RE development, and a strong environmental Kuznets curve (EKC) effect linking economic development to RE development.

The quantitative analysis did not find statistical support for the direct effects of institutional factors such as corruption, rule of law, and quality of institutions on RE outcomes. However, it identified the moderating effect of institutional factors—including a long-term moderating effect of the three institutional quality variables—on the causal relationship between democracy and RE development. It suggests that the effect of democracy on RE development depends on the level of corruption, rule of law and quality of government in a country. The research also identified that improvements in corruption, rule of law, and especially quality of government alleviated the negative effect of state oil rent on RE development to an extent that it can potentially cancel out that negative association between state oil rent and RE development altogether. In addition, the above-mentioned findings show considerable robustness to changing the composition and size of the sample and using other RE measures.

Among the climate vulnerability and wind and solar energy potential variables, only the coefficient of wind energy potential remained robustly significant across all estimations and specifications. Indeed, it can be argued that natural renewable resource endowments and vulnerability to climate change fail to explain variations in RE development across countries. State policy appears to have a critical role in promoting and expanding RE deployment and consumption, which is the underlying assumption of all the research hypotheses tested in this empirical study.

The case study analysis of this project provided an overview of RE development in Algeria, Morocco, and Tunisia over the past three decades, and it examined the link between the key independent variables of this study and RE development. These three countries have similar RE potential profiles, and all are exposed to similar climate risks. Although they have differing national RE targets and policies, their policy pools incorporate similar policy support for renewables. However, the share of wind and solar energy in each country's electricity capacity varies significantly. The study allowed us to make the hypothesis that political stability plays a crucial role in RE development, with Morocco, the most politically stable country, making the most progress, whereas political instability in both Algeria and Tunisia has hindered these countries' progress in the RE sector.

The case study analysis also investigated the relationship between democracy, hydrocarbon richness, and state hydrocarbon rent on the one hand, and RE development on the other. While no causal pathway linking democracy to RE development was observed, a strong negative association between hydrocarbon wealth and RE development was revealed; the identified link between the two in the context of the three cases is through energy subsidies, which have been historically high in hydrocarbon-rich countries that enjoy high levels of state hydrocarbon rents. Energy subsidies are identified as a strong predictor of RE development across the three countries. Algeria, with the highest level of hydrocarbon richness, hydrocarbon rents and energy subsidies, lags far behind the other two countries in terms of RE development. The study also found that energy subsidies and political stability are closely interwoven, with energy subsidies used to maintain political stability or avoid instability especially in the case of in Algeria and Tunisia.

These case study findings broadly confirm what has been learned from the quantitative analysis of this study, namely: (i) in terms of effect on RE development, democracy takes time to have a meaningful impact (ii) hydrocarbon richness and state hydrocarbon rents hamper RE development through several causal pathways; (iii) a robust and strong non-linear relationship (EKC effect) between income and RE development was observed; and (iv) factors such RE potential and vulnerability to climate change fail to explain the variations in RE development across countries.

10.3. Policy Implications

This empirical study has highlighted the importance of distinguishing between the dimensions of democracy when examining its effect on RE outcomes in particular and climate and environmental policy outcomes more broadly. Among the dimensions of democracy, the egalitarian and participatory dimensions appear to have stronger associations with RE development. This is an important finding, especially from the policy perspective. When it comes to promoting democracy in a society to achieve a wide range of environmental and non-environmental goals, national and international policy makers, along with the international community, should pay attention to the dimensions of democracy beyond the electoral dimensions. In terms of unhindered involvement in political processes that shape, decide, and implement policies, the participatory dimension that incorporates the concept of civil society participation in public decision making and the egalitarian dimension that emphasizes the concept of political equality across all social strata are as important or perhaps more important than a minimalistic electoral interpretation of democracy.

This study has also shed light on the detrimental effect of hydrocarbon wealth and state hydrocarbon revenues on RE development and on how institutional factors can alleviate or even nullify this detrimental effect. A country's hydrocarbon wealth can hinder its RE transition through several mechanisms. Among the two hydrocarbon factors, state hydrocarbon rent is shown to have a negative effect on RE outcomes larger in magnitude than that of hydrocarbon richness. A clear but hard to implement solution to a country's dependence on its hydrocarbon revenues would be to promote fiscal and financial discipline. This should be accompanied by strengthening institutional qualities such as rule of law, quality of government and fighting corruption. The moderating effect of these institutional qualities on the negative link between state hydrocarbon rent and a wide range of environmental and non-environmental outcomes has been thoroughly examined and validated in this empirical study.

Lastly, this empirical study has revealed a very robust and strong non-linear relationship between income and RE development, and also a robust and negative link between the share of resource intensive industries in the national economy and RE development. Therefore, decoupling these detrimental associations is critical especially for developing economies in their earlier stages of economic development. Promoting a wide range of off-the-shelf policy solutions such as carbon pricing, renewable portfolio standards, subsidies and tax breaks for RE projects is essential but might not be sufficient in many of these economies. This can be due to a lack of efficient and effective institutions and more importantly insufficient financial resources. The lack of sufficient public and private resources have historically been a major issue in many developing economies.

In the context of developing economies with limited available financial resources, it is still possible to set and achieve realistic national targets in terms of energy efficiency and intensity and RE development. Public education and awareness can obviously be an integral part of this policy solution. Increasing public awareness about the importance of energy efficiency and renewable energy as a means to achieve higher levels of energy efficiency can create demand for clean energy. Lastly, international cooperation is another way to address several imitations that developing economies are dealing with in their RE transitions. Working with other countries to share best practices, technologies, and funding can accelerate the adoption of renewables and can indeed create a global market for clean energy. The success story of Morocco, one the case studies of this study, is a case in point. These solutions are indeed not hypothetical. [113]

10.4. Limitations and Suggestions for Future Research

This project has shed light on the relationship between democracy and hydrocarbon resources and RE development. However, there are several limitations to this study that need to be acknowledged and can be considered in future studies. First, data for 120 countries were available for this empirical analysis and more than half of the observations were from developed economies. Second, the study primarily focused on oil mostly as a result of limited data availability. Moreover, natural gas and coal appeared to behave drastically different than oil when it comes to their effect on RE development. Third, the measure of state oil rent used in the analysis underestimates the true extent of dependence on oil revenues in many oil-rich countries with a state-own oil company. Last but not least, the inclusion of income, democracy, and institutional qualities in the regression model, while

[113] A recent report indicates that over the past two decades at least 33 developing economies, including Mexico, Uruguay, Egypt Argentina, Most of the Eastern Europe, have achieved economic growth while cutting their emissions (Economist, 2022). This achievement was not through exporting emissions but through energy efficiency and intensity improvements coupled with further RE penetration.

providing a more comprehensive understanding of the dynamics between them and RE development, can lead to oversimplification of a complex reality of political economy nature. It is, therefore, necessary to recognize these limitations and conduct further research to address them and gain a more nuanced understanding of the factors affecting RE development.

There are several exciting avenues for future research to explore. Firstly, future studies could exclusively focus on autocracies and attempt to distinguish between different forms of autocracies and their effect on RE outcomes. This study distinguished between the five dimensions of democracy when it came to examining the effect of democracy on RE development. Future studies could go one step further and investigate various subcomponents of these dimensions and identify the ones affecting RE development most. Third, future empirical studies could focus on natural resources other than oil. The effect of coal and natural gas on RE development could be examined separately. It would also be interesting to explore the impact of other non-hydrocarbon natural resources on RE development. Moreover, creating composite indicators of hydrocarbon richness and state hydrocarbon rents, including oil, natural gas, and coal, could be an ideal way to assess the overall impact of a country's hydrocarbon wealth on its RE progress. Fourth, studying the factors affecting RE sources other than wind and solar could provide additional insights. One step further could be constructing and using a composite indicator that properly captures a country's overall RE potential. These research areas offer significant potential for identifying and understanding factors affecting RE development in a country in particular, and a wide range of environmental and climate policy outcomes more broadly.

Appendix A: Measuring Dimensions and Qualities of Democracy

A.1. Introduction

Measurement of democracy is very important topic in political science and especially comparative politics. Quantified measures of democracy with sufficient year and country coverage—such as Polity2, and Freedom House's democracy index—have been available to empirical scholars since the 1970s. The data is, however, faced with a fair amount of criticism regarding their data collection and generation procedures, aggregation rules, and conceptual and theoretical underpinnings. Until recently most empirical studies that were interested in the effect of democracy on various variables of interest, would include a single measure of democracy. A growing number of studies especially in field of environmental politics, and provision of public goods, offer more nuanced theoretical frameworks that deliberately distinguish between different aspects of democracy such as political rights, civil liberties, and government accountability. Furthermore, recently a grand project called the Varieties of Democracy (V-Dem) has gone beyond electoral properties of democracy and expanded the concept of democracy into new dimensions. It has made it possible to empirically investigate the effect of democracy from different perspectives. In this Appendix, first a few important topics in the democracy measurement literature are presented and reviewed. Next, the recent shift in the literature from democracy as a whole to various dimensions, components, qualities, or attributes of democracy are discussed, which are then followed by a brief introduction to V-Dem's dimensions and other qualities of democracy.

A.2. Measurement of Democracy

Giebler et al. (2018) discusses three important aspects of democracy measurement: (i) *Conceptualization,* which refers to the differences between democracy indices due to their different theoretical grounding; (ii) *Measurement,* which mostly concerns about how democracy indices are quantified, aggregated, and scaled; and (iii) *Application,* which is about how the applicability of a democracy measure is influenced by the first two aspects. Before further discussing a couple of important topics of democracy measurement, one has to acknowledge the difference between democracy as a theoretical construct, and democracy as a concept with observable manifestations (Dahl, 1971). A majority of democracy measures borrow their conceptual framework from Dahl (1971) whose concept of democracy famously includes contestation and participation dimensions (Giebler et al., 2018)[114]. As Boese (2019) elaborates, from an empirical perspective, democracy indices

[114] Seymour Lipset is believed to be the first one that turns Robert Dahl's procedural conception of democracy into a quantifiable measure suitable for empirical analysis (Boese, 2019).

intend to measure "observed levels of authority patterns or systems of governance" with an emphasis on the word 'observed' which implies that democracy is treated as a latent but still observable and quantifiable concept. This study as an empirical investigation, deals with the concept of democracy from the empirical perspective. The theoretical aspect of democracy, for obvious reasons, is beyond the scope of this empirical study.

The literature on empirical measures of democracy discusses validity and reliability as the two key objectives of any democracy measurement endeavor. 'Validity' refers to the consistency and unbiasedness of an index in measuring what it is constructed to measure, and 'reliability' can be thought of as the precision and replicability of measurement outcomes (Boese, 2019; Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). The type of data used in constructing democracy indices varies considerably. Skaaning (2018) lists four key types of data used in democracy indices: (i) *observational data* which encompass any observable data such as election turnouts and exitance of certain political institutions; (ii) *in-house coding data* which rely on researchers' assessment of a country based on reports, newspapers, archival material, etc.; (iii) *expert survey data* that are based on country-specific knowledge of country experts; and (iv) *representative survey data* which aggregates ordinary citizens' view on specific topics.[115]

When it comes to quantifying a single measure of democracy for practical purposes (empirical investigation), there is no shortage of indices and measures—to name a few, the Freedom House's political rights and civil liberty indices (Freedom House, 2021), the Polity Project's Polity2 (Marshall et al., 2020), the democracy-dictatorship index (Bjørnskov & Rode, 2018), the Vanhanen index (Vanhanen, 2019), the continuous and dichotomous machine-learning (ML) democracy indices (Gründler & Krieger, 2020), and V-Dem's Polyarchy (Coppedge et al., 2021). These democracy indices, however, are not without limitations and deficiencies.[116]

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[115] Each type of data has its own advantages, according to Skaaning (2018). Observational data are usually based on fixed and comparable scales and steer clear of personal biases. In-house coding enjoys high level of consistency in capturing non-observable traits due to a set of fixed coding criteria. Expert survey data can provide country-specific and context specific knowledge not available through other methods of data collection and generation.

[116] For example, the democracy-dictatorship index has an unrealistic alternation of power condition that leads to misclassification of many young democracies (Boese, 2019). The Freedom House's index overlaps with concepts such as corruption which are beyond the scope of democracy, has arbitrary threshold values ,and is not sufficiently capable of distinguishing between countries at the two ends of the spectrum (Gründler & Krieger, 2021; Vaccaro, 2021). The Vanhanen index sets unrealistic democratic conditions such as parliaments being highly fractionalized and election turnouts being close to one hundred percent, in addition to failing to properly separate highly autocratic regimes (Gründler & Krieger, 2021). Finally, a few studies report serious methodological and conceptual deficiencies of Polity2—which was perhaps the most widely used democracy index until recently. It overlaps with concepts beyond democracy (Boese, 2019)—for example, independence of the courts—lacks an appropriate scoring system for political systems in transition, or countries under occupation (Gründler & Krieger, 2021), and applies questionable and or oversimplistic aggregation rules (Cheibub et al., 2010).

One of the latest additions to the long list of democracy indices is V-Dem's Polyarchy, which some theorists consider superior to other democracy indices in terms of reliability, validity, measurement scale, aggregation rules and theoretical grounding (Boese, 2019; Elff & Ziaja, 2018; Gründler & Krieger, 2021; Vaccaro, 2021). It is the only measure of democracy that incorporates observational data, in-house coding, and expert surveys (Skaaning, 2018). The Polyarchy index and other principles (dimensions) of democracy—deliberative, participatory, liberal, and egalitarian democracy principles—developed by the Varieties of Democracy project are used as the main indicators of democracy and its dimensions in this study. The V-Dem project and its dimensions of democracy are discussed in a following section. However, as Elff and Ziaja (2018) and Vaccaro (2021) recommend, using several democracy indices from different sources helps check the robustness of results in any empirical study. This study follows this recommendation.

A.3. Measuring Dimensions of Democracy: Varieties of Democracy (V-DEM) Project

V-Dem project, cohosted by University of Gothenburg, and the Kellogg Institute at the University of Notre Dame, is a result of collaboration of tens of academic scholars, project managers, regional managers, country coordinators, and thousands of country experts[117]. It is one of the grandest ever political science data collection undertakings (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). V-Dem project produces a rich set of democracy indices and its subcomponents mainly due to employing various data collection methods[118]. V-Dem project defines seven principles or dimensions of democracy: electoral, liberal, participatory, deliberative, egalitarian, consensual, and majoritarian democracy principles. The majoritarian and consensual dimensions are yet to be quantified and included in V-Dem's dataset which means they are not be empirically examined in this study.[119] Other understandings of democracy beyond electoral properties have led to the inclusion of

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[117] It is worth noting that a majority of country experts are nationals of their country of expertise and have lived in their country for at least 30 years—in contrast to the Freedom House's and Polity Project's experts who are predominately US citizens (Elff & Ziaja, 2018).

[118] Though praised as one of the best and most complete sources of democracy measures, the project still receives some criticism regarding its aggregation rules (see Gründler and Krieger (2021)).

[119] Majoritarian principle, as Coppedge, Gerring, Lindberg, Skaaning and Teorell (2017) elaborates, refers to the idea that the will of the majority should prevail. Unitary constitution, unicameralism, a two-party system, weak judicial oversight, and overall, a small number of veto players results in a high level of majoritarian democracy score. Consensual principle, is somehow the opposite of the majoritarian principle and reflects the idea of hearing as many voices as possible when it comes to political decision-making (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). As Lijphart (2012) correctly points out, higher levels of majoritarian and consensual dimensions, unlike the other five dimensions of democracy, do not indicate a country is more democratic or less democratic.

additional dimensions of democracy other than electoral democracy principle (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017).

The *electoral* democracy index, is constructed based on Dahl's conceptualization of polyarchy which argues that democracy is achieved through 'contestation' among various political groups/ideas and 'participation' of a broad electorate in periodic elections (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). The index, called Polyarchy, incorporates freedom of association, freedom of expression, share of population with suffrage, and most importantly clean election (free and fair election) indices. Among the five principles, the electoral democracy dimension plays a pivotal role in that no country would be considered democratic in other dimensions if it was not electorally democratic in the first place[120]. the *liberal* principle of democracy emphasizes on protection of individual rights which is achieved through protecting civil liberties, maintaining rule of law and presence of executive constraints (checks and balances) (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). The *participatory* dimension of democracy conceptually borrows from the idea of direct, non-representative democracy and measures direct rule and active participation of the citizenry in political decision making. It incorporates indices of civil society participation (non-electoral avenues of participation such as citizens' assemblies, townhall meetings, public hearings, etc.), direct popular vote and the power of local and regional governments (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017).

The central principle of the *deliberative* dimension is grounded in the notion that political decisions aimed at the common good should be guided by respectful and rational dialogue at all levels, instead of being influenced by emotional appeals, group affiliations, narrow interests, or force (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). According to Held (2006), the objective of deliberation is to transform individual preferences through a process of discourse into stances that can endure public examination and assessment. Polities in which public hearings, panels and assemblies are frequent, and their role in shaping public policies is substantial, are considered more deliberative (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). The deliberative principle, though measuring a specific aspect of democracy, is closely related to the participatory dimension. Finally, the *egalitarian* dimension intends to capture the level of political equality across all social strata—in terms of wealth, education, ethnicity, religion, language, region, gender, etc. (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). According to this principle, all social groups should be equally capable of participating in political processes that shape,

[120] For example, participatory democracy index is constructed by aggregating electoral democracy index and participatory component index. The latter itself is constructed by aggregating participation measures such as civil society participation, direct popular vote index, and local and regional government indices. If a country receives high scores in all participation measures and consequently a high participatory component score but a low score of electoral democracy, its overall participatory democracy index would be accordingly downgraded, relative to its participatory component index.

decide, and implement policies. Inequality of health, education and income, would simply undermine such capability (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017).

In addition to the five key dimensions of democracy, V-Dem project also produces indices that are regarded in the literature as qualities, subcomponents, or attributes of democracy. They include civil liberties, civil society, division of power, and various forms of government accountabilities—vertical accountability, diagonal accountability, and horizontal accountability (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). Civil liberty measures the absence of physical violence and constraints against private and political liberties by the state. Civil society intends to capture the citizenry's autonomy from the state to pursue its political and civic goals. Division of power or federal-unitary index, measures if elected local and regional governments exists and how much political decision-making power they hold. Finally, government accountability is perceived as constraints on the state power that force the state to justify its actions and decisions (Coppedge, Gerring, Lindberg, Skaaning, & Teorell, 2017). V-Dem project distinguishes between three types of government accountability and aggregate them into a single measure of accountability: (i) vertical accountability which captures the citizenry's ability to hold state accountable through elections; (ii) horizontal accountability which measures the oversight power of other state institutions such as the legislative and the judiciary over the government; and (iii) diagonal accountability which refers to actions and mechanisms through which citizens and civil society organizations (CSOs) along with independent media are able to hold the state accountable for its decisions and actions. All these qualities of democracy are empirically examined in this study.

Appendix B: Additional Simple LMM Estimations

Table B.1: Liberal Democracy and Renewable energy Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liberal Democracy	−1.267***	−0.702*	−0.289	0.221	0.915**	1.698***	2.429***	2.922***
State Oil Rent	1.084	−0.074	−1.951	−4.243**	−5.026***	−4.839***	−3.763**	−2.954*
Oil Richness	−0.814***	−0.775***	−0.547***	−0.282	−0.045	0.002	−0.024	−0.034
Industry Share (*%GDP*)	−8.009***	−6.367***	−6.114***	−5.473***	−4.931***	−4.039***	−3.544***	−2.457*
GDP per capita	−6.023***	−6.361***	−6.477***	−6.592***	−6.044***	−5.050***	−3.815***	−2.677***
(GDP per capita)^2	0.380***	0.413***	0.431***	0.446***	0.413***	0.349***	0.270***	0.192***
Climate Vulnerability	0.044	1.573	2.951*	4.187**	4.586***	4.576***	4.392***	3.843**
Solar Potential	−0.058	−0.002	0.059	0.115	0.126	0.106	0.054	−0.031
Wind Potential	0.461**	0.464**	0.455**	0.446**	0.437**	0.421**	0.403**	0.400**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,731.838	−2,674.940	−2,622.085	−2,570.222	−2,520.270	−2,465.094	−2,403.574	−2,334.286
Akaike Inf. Crit.	5,493.676	5,379.880	5,274.170	5,170.445	5,070.539	4,960.187	4,837.149	4,698.571
Bayesian Inf. Crit.	5,575.966	5,461.882	5,355.956	5,251.976	5,151.794	5,041.151	4,917.749	4,778.781
Intra-Class Correlation (ICC)	0.77	0.78	0.79	0.80	0.80	0.79	0.78	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.522/0.891	0.526/0.895	0.532/0.901	0.537/0.907	0.534/0.905	0.529/0.900	0.519/0.893	0.495/0.884

*p<0.1; **p<0.05; ***p<0.01

Table B.2: Deliberative Democracy and Renewable energy Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Deliberative Democracy	−1.236***	−0.943**	−0.487	0.098	0.828**	1.530***	2.230***	2.629***
State Oil Rent	0.576	−0.029	−1.975	−4.275**	−5.044***	−4.853***	−3.843**	−3.112*
Oil Richness	−0.832***	−0.786***	−0.556***	−0.289	−0.053	−0.012	−0.037	−0.050
Industry Share (*%GDP*)	−6.880***	−6.458***	−6.143***	−5.470***	−4.895***	−4.042***	−3.527***	−2.459*
GDP per capita	−6.347***	−6.408***	−6.502***	−6.594***	−6.041***	−5.054***	−3.792***	−2.652***
(GDP per capita)^2	0.404***	0.416***	0.433***	0.446***	0.413***	0.351***	0.270***	0.192***
Climate Vulnerability	0.573	1.496	2.876*	4.128**	4.543***	4.486***	4.287***	3.704**
Solar Potential	−0.042	−0.010	0.053	0.110	0.119	0.092	0.031	−0.063
Wind Potential	0.473**	0.469**	0.460**	0.449**	0.441**	0.426**	0.407**	0.405**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,706.536	−2,673.389	−2,621.624	−2,570.381	−2,520.493	−2,465.681	−2,404.046	−2,336.037
Akaike Inf. Crit.	5,443.072	5,376.778	5,273.248	5,170.762	5,070.986	4,961.362	4,838.093	4,702.075
Bayesian Inf. Crit.	5,525.236	5,458.780	5,355.034	5,252.293	5,152.241	5,042.326	4,918.694	4,782.284
Intra-Class Correlation (ICC)	0.78	0.78	0.79	0.80	0.80	0.79	0.78	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.519/0.893	0.523/0.895	0.530/0.901	0.535/0.906	0.532/0.905	0.525/0.899	0.512/0.892	0.483/0.882

*p<0.1; **p<0.05; ***p<0.01

Table B.3: Participatory Democracy and Renewable energy Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Participatory Democracy	−1.208**	−0.841	−0.315	0.263	1.144**	2.164***	3.146***	3.817***
State Oil Rent	0.533	−0.049	−1.939	−4.255**	−5.067***	−4.873***	−3.808**	−3.027*
Oil Richness	−0.810***	−0.765***	−0.542***	−0.285	−0.053	−0.007	−0.031	−0.043
Industry Share (*%GDP*)	−6.846***	−6.419***	−6.131***	−5.455***	−4.861***	−3.972***	−3.466***	−2.392*
GDP per capita	−6.276***	−6.357***	−6.476***	−6.595***	−6.071***	−5.110***	−3.886***	−2.803***
(GDP per capita)^2	0.400***	0.413***	0.431***	0.446***	0.414***	0.352***	0.274***	0.201***
Climate Vulnerability	0.855	1.736	3.029*	4.131**	4.380***	4.255**	3.991**	3.430**
Solar Potential	−0.046	−0.010	0.056	0.118	0.140	0.136	0.104	0.030
Wind Potential	0.466**	0.462**	0.454**	0.447**	0.439**	0.422**	0.402**	0.400**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,709.344	−2,674.936	−2,621.875	−2,569.959	−2,520.221	−2,465.123	−2,403.129	−2,333.732
Akaike Inf. Crit.	5,448.688	5,379.871	5,273.750	5,169.917	5,070.443	4,960.247	4,836.258	4,697.464
Bayesian Inf. Crit.	5,530.852	5,461.873	5,355.536	5,251.449	5,151.697	5,041.210	4,916.858	4,777.673
Intra-Class Correlation (ICC)	0.78	0.78	0.79	0.80	0.80	0.78	0.78	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.521/0.893	0.526/0.895	0.532/0.901	0.537/0.906	0.535/0.904	0.532/0.899	0.524/0.892	0.504/0.884

*p<0.1; **p<0.05; ***p<0.01

Table B.4: Egalitarian Democracy and Renewable energy Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Egalitarian Democracy	−0.428	−0.235	0.199	0.831	1.762***	2.631***	3.457***	3.880***
State Oil Rent	0.512	−0.039	−1.890	−4.159**	−5.027***	−4.912***	−3.941**	−3.222**
Oil Richness	−0.787***	−0.745***	−0.522**	−0.257	−0.009	0.043	0.024	0.001
Industry Share (*%GDP*)	−6.697***	−6.330***	−6.082***	−5.424***	−4.822***	−3.928***	−3.354***	−2.221*
GDP per capita	−6.314***	−6.374***	−6.442***	−6.482***	−5.828***	−4.736***	−3.409***	−2.262**
(GDP per capita)^2	0.400***	0.412***	0.427***	0.438***	0.399***	0.330***	0.246***	0.168***
Climate Vulnerability	0.817	1.731	3.155*	4.483***	5.027***	5.080***	4.986***	4.426***
Solar Potential	−0.013	0.016	0.082	0.151	0.186	0.184	0.149	0.063
Wind Potential	0.454**	0.452**	0.443**	0.432**	0.419**	0.401**	0.380**	0.379**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,711.425	−2,675.975	−2,621.968	−2,569.011	−2,517.500	−2,461.684	−2,400.210	−2,332.645
Akaike Inf. Crit.	5,452.850	5,381.950	5,273.937	5,168.023	5,065.000	4,953.369	4,830.420	4,695.289
Bayesian Inf. Crit.	5,535.014	5,463.952	5,355.723	5,249.554	5,146.255	5,034.332	4,911.021	4,775.499
Intra-Class Correlation (ICC)	0.77	0.77	0.79	0.80	0.80	0.79	0.78	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.530/0.891	0.533/0.894	0.538/0.901	0.542/0.907	0.541/0.906	0.535/0.901	0.524/0.895	0.498/0.885

*p<0.1; **p<0.05; ***p<0.01

Table B.5: V-Dem Democracy Components and Renewable energy Development

	Dependent Variable:			
	Share of Wind & Solar in Electricity Consumption			
	(1)	(2)	(3)	(4)
Liberal Component	0.432			
	(0.413)			
Deliberative Component		0.181		
		(0.360)		
Participatory Component			−0.231	
			(0.663)	
Egalitarian Component				1.516**
				(0.707)
State Oil Rent	−4.165**	−4.234**	−4.327***	−4.095**
	(1.670)	(1.671)	(1.665)	(1.668)
Oil Richness	−0.269	−0.286	−0.298	−0.252
	(0.210)	(0.209)	(0.209)	(0.210)
Industry Share (*%GDP*)	−5.503***	−5.477***	−5.495***	−5.471***
	(1.305)	(1.305)	(1.307)	(1.305)
GDP per capita	−6.643***	−6.620***	−6.566***	−6.420***
	(0.885)	(0.885)	(0.892)	(0.892)
(GDP per capita)^2	0.449***	0.448***	0.445***	0.436***
	(0.052)	(0.052)	(0.052)	(0.053)
Climate Vulnerability	4.281**	4.144**	4.091**	4.990***
	(1.707)	(1.699)	(1.698)	(1.753)
Solar Potential	0.116	0.110	0.094	0.180
	(0.334)	(0.334)	(0.336)	(0.339)
Wind Potential	0.444**	0.450**	0.452**	0.430**
	(0.195)	(0.194)	(0.195)	(0.197)
No. of Regions/Countries	9/120	9/120	9/120	9/120
No. of Years	26	26	26	26
Observations	1,695	1,695	1,695	1,695
Log Likelihood	−2,569.848	−2,570.405	−2,569.860	−2,567.578
Akaike Inf. Crit.	5,169.696	5,170.809	5,169.720	5,165.155
Bayesian Inf. Crit.	5,251.228	5,252.341	5,251.252	5,246.687
Intra-Class Correlation (ICC)	0.80	0.80	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.538/0.908	0.535/0.907	0.532/0.906	0.537/0.909

*p<0.1; **p<0.05; ***p<0.01

Table B.6: Misc. Democracy Indices and Renewable energy Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Measures of Democracy:							
V-Dem Polyarchy	0.037						
Machine Learning Democracy Index		0.145					
Polity2			−0.479				
Freedom House				0.423			
Vanhanen Index					−0.229		
Machine Learning Democracy (*Dichotomous*)						0.452***	
Democracy-Dictatorship Index (*Dichotomous*)							0.202
Other Variables:							
State Oil Rent	−4.299***	−4.211**	−4.595***	−4.188**	−4.278***	−3.989**	−4.183**
Oil Richness	−0.291	−0.252	−0.324	−0.236	−0.288	−0.205	−0.247
Industry Share (*%GDP*)	−5.471***	−5.621***	−5.370***	−5.478***	−5.452***	−5.715***	−5.630***
GDP per capita	−6.598***	−6.597***	−6.436***	−6.647***	−6.543***	−6.611***	−6.621***
(GDP per capita)^2	0.447***	0.447***	0.436***	0.448***	0.444***	0.449***	0.448***
Climate Vulnerability	4.099**	4.277**	3.867**	4.313**	4.088**	4.414***	4.261**
Solar Potential	0.109	0.114	0.149	0.119	0.074	0.138	0.128
Wind Potential	0.451**	0.458**	0.642***	0.445**	0.468**	0.451**	0.446**
No. of Regions/Countries	9/120	9/121	9/118	9/121	9/121	9/121	9/121
No. of Years	26	26	26	26	26	26	26
Observations	1,695	1,703	1,682	1,703	1,702	1,703	1,703
Log Likelihood	−2,570.337	−2,582.451	−2,549.557	−2,581.614	−2,580.081	−2,579.248	−2,582.365
Akaike Inf. Crit.	5,170.673	5,194.902	5,129.113	5,193.228	5,190.162	5,188.496	5,194.730
Bayesian Inf. Crit.	5,252.205	5,276.504	5,210.529	5,274.831	5,271.755	5,270.099	5,276.332
Intra-Class Correlation (ICC)	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.534/0.906	0.536/0.907	0.528/0.904	0.539/0.907	0.530/0.905	0.542/0.908	0.539/0.906

*p<0.1; **p<0.05; ***p<0.01

Table B.7: Democracy-Dictatorship Index and Renewable energy Development

	Dependent Variable: hare of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Democracy-Dictatorship Index (*Dichotomous*)	−0.080	−0.035	0.069	0.202	0.328*	0.436**	0.472***	0.462***
State Oil Rent	0.898	0.203	−1.665	−4.183**	−5.016***	−4.912***	−3.986**	−3.413**
Oil Richness	−0.785***	−0.732***	−0.510**	−0.247	−0.041	−0.038	−0.129	−0.183
Industry Share (*%GDP*)	−6.565***	−6.316***	−6.190***	−5.630***	−5.148***	−4.320***	−3.838***	−2.775**
GDP per capita	−6.333***	−6.385***	−6.488***	−6.621***	−6.135***	−5.231***	−4.050***	−2.938***
(GDP per capita)^2	0.401***	0.413***	0.431***	0.448***	0.421***	0.365***	0.292***	0.218***
Climate Vulnerability	1.001	1.877	3.152*	4.261**	4.420***	4.143**	3.766**	3.084*
Solar Potential	0.009	0.030	0.079	0.128	0.126	0.092	0.016	−0.092
Wind Potential	0.441**	0.444**	0.445**	0.446**	0.451**	0.444**	0.433**	0.434**
No. of Regions/Countries	9/121	9/121	9/121	9/121	9/121	9/121	9/120	9/120
No. of Years	29	28	27	26	25	24	23	22
Observations	1,776	1,757	1,732	1,703	1,672	1,640	1,601	1,560
Log Likelihood	−2,724.984	−2,689.128	−2,635.301	−2,582.365	−2,533.769	−2,482.687	−2,426.892	−2,363.654
Akaike Inf. Crit.	5,479.969	5,408.256	5,300.602	5,194.730	5,097.539	4,995.374	4,883.784	4,757.309
Bayesian Inf. Crit.	5,562.201	5,490.326	5,382.458	5,276.332	5,178.865	5,076.410	4,964.460	4,837.595
Intra-Class Correlation (ICC)	0.77	0.77	0.78	0.80	0.80	0.79	0.78	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.534/0.890	0.535/0.894	0.538/0.900	0.539/0.906	0.530/0.904	0.519/0.897	0.497/0.887	0.459/0.876

*p<0.1; **p<0.05; ***p<0.01

Table B.8: Machine-Learning Dichotomous Democracy Index and Renewable energy Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Machine Learning Democracy (*Dichotomous*)	0.074	0.219	0.365**	0.452***	0.474***	0.357**	0.248	0.100
State Oil Rent	0.925	0.242	−1.590	−3.989**	−4.859***	−4.877***	−4.050**	−3.574**
Oil Richness	−0.762***	−0.690***	−0.455**	−0.205	−0.003	−0.027	−0.137	−0.211
Industry Share (*%GDP*)	−6.576***	−6.358***	−6.310***	−5.715***	−5.239***	−4.346***	−3.791***	−2.675**
GDP per capita	−6.340***	−6.383***	−6.507***	−6.611***	−6.073***	−5.105***	−3.915***	−2.788***
(GDP per capita)^2	0.401***	0.413***	0.433***	0.449***	0.419***	0.359***	0.285***	0.209***
Climate Vulnerability	1.018	1.932	3.255**	4.414***	4.580***	4.242**	3.811**	3.064*
Solar Potential	0.029	0.057	0.104	0.138	0.120	0.055	−0.038	−0.154
Wind Potential	0.434**	0.437**	0.442**	0.451**	0.463**	0.466**	0.460**	0.462***
No. of Regions/Countries	9/121	9/121	9/121	9/121	9/121	9/121	9/120	9/120
No. of Years	29	28	27	26	25	24	23	22
Observations	1,776	1,757	1,732	1,703	1,672	1,640	1,601	1,560
Log Likelihood	−2,725.084	−2,688.344	−2,633.004	−2,579.248	−2,531.341	−2,483.135	−2,429.257	−2,367.016
Akaike Inf. Crit.	5,480.168	5,406.688	5,296.009	5,188.496	5,092.681	4,996.271	4,888.513	4,764.032
Bayesian Inf. Crit.	5,562.399	5,488.759	5,377.864	5,270.099	5,174.008	5,077.308	4,969.189	4,844.318
Intra-Class Correlation (ICC)	0.77	0.77	0.79	0.80	0.80	0.79	0.78	0.78
Pseudo R^2 (*Marginal/Conditional*)	0.537/0.890	0.540/0.894	0.543/0.902	0.542/0.908	0.530/0.906	0.511/0.898	0.484/0.887	0.440/0.875

*p<0.1; **p<0.05; ***p<0.01

Table B.9: Misc. Qualities of Democracy and Renewable energy Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Civil Liberties	−0.099							
Civil Society		−0.052						
Political Constraints			0.255					
Federalism				0.367				
Aggregate Accountability					−0.114			
Vertical Accountability						0.137		
Diagonal Accountability							−0.155	
Horizontal Accountability								−0.006
State Oil Rent	−4.341***	−4.328***	−1.502	−4.258**	−4.339***	−4.286**	−4.357***	−4.309***
Oil Richness	−0.297	−0.295	−0.352*	−0.296	−0.300	−0.287	−0.302	−0.294
Industry Share (*%GDP*)	−5.472***	−5.476***	−6.478***	−5.514***	−5.466***	−5.473***	−5.466***	−5.472***
GDP per capita	−6.588***	−6.596***	−6.326***	−6.685***	−6.595***	−6.603***	−6.589***	−6.599***
(GDP per capita)^2	0.446***	0.447***	0.434***	0.450***	0.447***	0.447***	0.446***	0.447***
Climate Vulnerability	4.056**	4.067**	4.480***	4.056**	4.047**	4.138**	4.044**	4.081**
Solar Potential	0.102	0.105	0.063	0.124	0.103	0.112	0.100	0.107
Wind Potential	0.453**	0.452**	0.442**	0.462**	0.453**	0.450**	0.453**	0.452**
No. of Regions/Countries	9/120	9/120	9/119	9/120	9/120	9/120	9/120	9/120
No. of Years	26	26	26	26	26	26	26	26
Observations	1,695	1,695	1,685	1,695	1,695	1,695	1,695	1,695
Log Likelihood	−2,570.166	−2,570.526	−2,549.243	−2,569.963	−2,570.321	−2,570.169	−2,570.352	−2,570.633
Akaike Inf. Crit.	5,170.332	5,171.052	5,128.486	5,169.927	5,170.642	5,170.338	5,170.703	5,171.266
Bayesian Inf. Crit.	5,251.864	5,252.584	5,209.928	5,251.459	5,252.174	5,251.870	5,252.235	5,252.797
Intra-Class Correlation (ICC)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.533/0.906	0.533/0.906	0.537/0.907	0.537/0.907	0.533/0.906	0.535/0.907	0.532/0.906	0.534/0.906

*p<0.1; **p<0.05; ***p<0.01

Table B.10: Forms of Democracy and Renewable energy Development

	Dependent Variable:	
	Share of Wind & Solar in Electricity Consumption	
	(1)	(2)
DD Index (*Presidential*)	0.531	
	(0.398)	
DPI Index (*Assembly-elected President*)		−0.025
		(0.332)
DPI Index (*Parliamentary*)		0.749**
		(0.306)
State Oil Rent	−4.230**	−4.288***
	(1.655)	(1.664)
Oil Richness	−0.280	−0.230
	(0.206)	(0.207)
Industry Share (*%GDP*)	−5.599***	−5.374***
	(1.298)	(1.312)
GDP per capita	−6.690***	−6.469***
	(0.886)	(0.892)
(GDP per capita)^2	0.454***	0.439***
	(0.052)	(0.053)
Climate Vulnerability	4.125**	4.791***
	(1.696)	(1.749)
Solar Potential	0.073	0.139
	(0.334)	(0.348)
wind Potential	0.498**	0.427**
	(0.194)	(0.196)
No. of Regions/Countries	9/121	9/120
No. of Years	26	26
Observations	1,703	1,697
Log Likelihood	−2,581.303	−2,569.784
Akaike Inf. Crit.	5,192.606	5,171.569
Bayesian Inf. Crit.	5,274.208	5,258.555
Intra-Class Correlation (ICC)	0.80	0.81
Pseudo R^2 (*Marginal/Conditional*)	0.532/0.906	0.543/0.914

*p<0.1; **p<0.05; ***p<0.01

Table B.11: Baseline LMM Estimation Excluding Oil Richness

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Electoral Democracy	−0.878**	−0.874**	−0.554	−0.093	0.385	1.115**	1.867***	2.165***
State Oil Rent	−1.620	−2.118	−3.715***	−5.448***	−5.516***	−5.031***	−3.890***	−3.272**
Industry Share (*%GDP*)	−7.281***	−6.816***	−6.485***	−5.677***	−5.026***	−4.266***	−4.040***	−2.889**
GDP per capita	−6.290***	−6.434***	−6.536***	−6.688***	−6.186***	−5.420***	−4.051***	−2.872***
(GDP per capita)^2	0.401***	0.420***	0.438***	0.456***	0.428***	0.380***	0.297***	0.220***
Climate Vulnerability	1.194	2.141	3.491**	4.642***	5.001***	5.022***	5.149***	4.688***
Solar Potential	0.016	0.035	0.083	0.130	0.125	0.119	0.079	−0.012
Wind Potential	0.501***	0.502***	0.483**	0.464**	0.453**	0.439**	0.416**	0.420**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,769	1,751	1,727	1,699	1,669	1,639	1,602	1,562
Log Likelihood	−2,717.301	−2,684.293	−2,631.648	−2,581.172	−2,535.300	−2,488.994	−2,436.355	−2,372.831
Akaike Inf. Crit.	5,462.602	5,396.586	5,291.296	5,190.344	5,098.600	5,005.989	4,900.709	4,773.662
Bayesian Inf. Crit.	5,539.297	5,473.138	5,367.654	5,266.473	5,174.479	5,081.615	4,976.016	4,848.614
Intra-Class Correlation (ICC)	0.78	0.79	0.80	0.80	0.80	0.79	0.78	0.78
Pseudo R^2 (*Marginal/Conditional*)	0.499/0.891	0.500/0.895	0.514/0.901	0.526/0.908	0.526/0.906	0.523/0.901	0.512/0.895	0.483/0.884

*p<0.1; **p<0.05; ***p<0.01

Table B.12: Baseline LMM Estimation Excluding State Oil Rent

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Electoral Democracy	−1.056**	−0.967**	−0.534	0.104	0.753*	1.461***	2.189***	2.490***
Oil Richness	−0.798***	−0.796***	−0.682***	−0.545***	−0.361**	−0.312*	−0.261	−0.224
Industry Share (*%GDP*)	−6.639***	−6.474***	−6.899***	−6.815***	−6.465***	−5.561***	−4.940***	−3.820***
GDP per capita	−6.289***	−6.370***	−6.420***	−6.437***	−5.874***	−4.908***	−3.694***	−2.625***
(GDP per capita)^2	0.400***	0.414***	0.427***	0.437***	0.404***	0.343***	0.268***	0.197***
Climate Vulnerability	0.782	1.587	2.780*	3.881**	4.172**	4.056**	3.925**	3.400**
Solar Potential	−0.042	−0.024	0.022	0.070	0.080	0.072	0.051	−0.027
Wind Potential	0.468**	0.468**	0.456**	0.444**	0.436**	0.421**	0.403**	0.408**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,594	1,554
Log Likelihood	−2,710.214	−2,675.046	−2,623.653	−2,575.063	−2,527.317	−2,473.284	−2,412.720	−2,346.960
Akaike Inf. Crit.	5,448.429	5,378.092	5,275.306	5,178.126	5,082.633	4,974.569	4,853.440	4,721.920
Bayesian Inf. Crit.	5,525.115	5,454.627	5,351.639	5,254.222	5,158.471	5,050.135	4,928.676	4,796.800
Intra-Class Correlation (ICC)	0.78	0.78	0.79	0.80	0.79	0.78	0.77	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.520/0.892	0.522/0.895	0.530/0.901	0.536/0.90	0.534/0.903	0.530/0.898	0.523/0.892	0.499/0.883

*p<0.1; **p<0.05; ***p<0.01

Table B.13: Linear Mixed Model Estimation Including Oil and Gas Variables

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Electoral Democracy	−1.092***	−1.077**	−0.685	−0.140	0.462	1.126**	1.766***	2.090***
State Oil Rent	1.030	1.028	−0.421	−2.566	−3.653**	−3.413*	−2.530	−2.422
State Gas Rent	−22.278***	−27.505***	−34.578***	−36.836***	−32.818***	−34.053***	−33.538***	−28.577***
Oil Richness	−0.838***	−0.930***	−0.797***	−0.558**	−0.286	−0.238	−0.227	−0.124
Gas Richness	0.421**	0.586***	0.650***	0.605***	0.448***	0.325*	0.081	−0.303*
Industry Share (*%GDP*)	−5.823***	−5.563***	−5.203***	−4.387***	−3.837***	−2.988**	−2.375*	−1.103
GDP per capita	−5.966***	−6.139***	−6.401***	−6.684***	−6.223***	−5.286***	−4.097***	−3.112***
(GDP per capita)^2	0.375***	0.396***	0.423***	0.449***	0.422***	0.362***	0.285***	0.216***
Climate Vulnerability	0.062	0.970	2.311	3.540**	3.834**	3.567**	2.801*	2.080
Solar Potential	−0.072	−0.053	0.019	0.092	0.114	0.104	0.078	0.009
Wind Potential	0.496***	0.499***	0.496***	0.489**	0.477**	0.459**	0.430**	0.430**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/118	9/118
No. of Years	29	28	27	26	25	24	23	22
Observations	1,755	1,736	1,711	1,682	1,651	1,619	1,580	1,540
Log Likelihood	−2,678.773	−2,641.497	−2,585.988	−2,533.707	−2,488.746	−2,435.263	−2,374.499	−2,309.043
Akaike Inf. Crit.	5,391.546	5,316.995	5,205.976	5,101.414	5,011.491	4,904.525	4,782.997	4,652.086
Bayesian Inf. Crit.	5,484.540	5,409.804	5,298.538	5,193.685	5,103.446	4,996.148	4,874.205	4,742.858
Intra-Class Correlation (ICC)	0.77	0.78	0.79	0.80	0.80	0.78	0.77	0.75
Pseudo R^2 (*Marginal/Conditional*)	0.515/0.890	0.518/0.895	0.530/0.903	0.538/0.909	0.535/0.906	0.534/0.899	0.530/0.890	0.510/0.878

*p<0.1; **p<0.05; ***p<0.01

Table B.14: Hydrocarbon Resources (Oil Gas & Coal) and Renewable energy Development

	Dependent Variable: Share of Wind & Solar in Electricity Consumption				
	(1)	(2)	(3)	(4)	(5)
Electoral Democracy	0.037	0.196	0.310	−0.140	−0.132
	(0.435)	(0.435)	(0.435)	(0.441)	(0.440)
State Oil Rent	−4.299***			−2.566	−2.549
	(1.667)			(1.737)	(1.736)
Oil Richness	−0.291			−0.558**	−0.551**
	(0.210)			(0.228)	(0.227)
State Gas Rent		−33.672***		−36.836***	−36.886***
		(6.465)		(6.674)	(6.674)
Gas Richness		0.601***		0.605***	0.640***
		(0.167)		(0.175)	(0.178)
State Coal Rent			3.915		4.481
			(4.240)		(4.193)
Coal Richness			−0.107		−0.133
			(0.121)		(0.123)
Industry Share (*%GDP*)	−5.471***	−6.354***	−7.024***	−4.387***	−4.189***
	(1.306)	(1.212)	(1.186)	(1.357)	(1.362)
GDP per capita	−6.598***	−6.390***	−6.316***	−6.684***	−6.838***
	(0.884)	(0.887)	(0.892)	(0.887)	(0.894)
(GDP per capita)^2	0.447***	0.432***	0.424***	0.449***	0.456***
	(0.052)	(0.052)	(0.052)	(0.052)	(0.053)
Climate Vulnerability	4.099**	3.656**	3.221*	3.540**	3.227*
	(1.705)	(1.749)	(1.707)	(1.722)	(1.721)
Solar Potential	0.109	0.103	0.084	0.092	0.100
	(0.334)	(0.344)	(0.329)	(0.337)	(0.334)
Wind Potential	0.451**	0.504**	0.470**	0.489**	0.496**
	(0.195)	(0.201)	(0.195)	(0.194)	(0.193)
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120
No. of Years	26	26	26	26	26
Observations	1,695	1,682	1,681	1,682	1,680
Log Likelihood	−2,570.337	−2,542.418	−2,555.653	−2,533.707	−2,528.364
Akaike Inf. Crit.	5,170.673	5,114.836	5,141.305	5,101.414	5,094.729
Bayesian Inf. Crit.	5,252.205	5,196.252	5,222.712	5,193.685	5,197.833
Intra-Class Correlation (ICC)	0.80	0.81	0.80	0.80	0.80
Pseudo R^2 (*Marginal/Conditional*)	0.534/0.906	0.518/0.909	0.521/0.902	0.538/0.909	0.540/0.908

*p<0.1; **p<0.05; ***p<0.01

Figure B.1: Marginal Effect of State Oil Rent on Renewable Energy Development

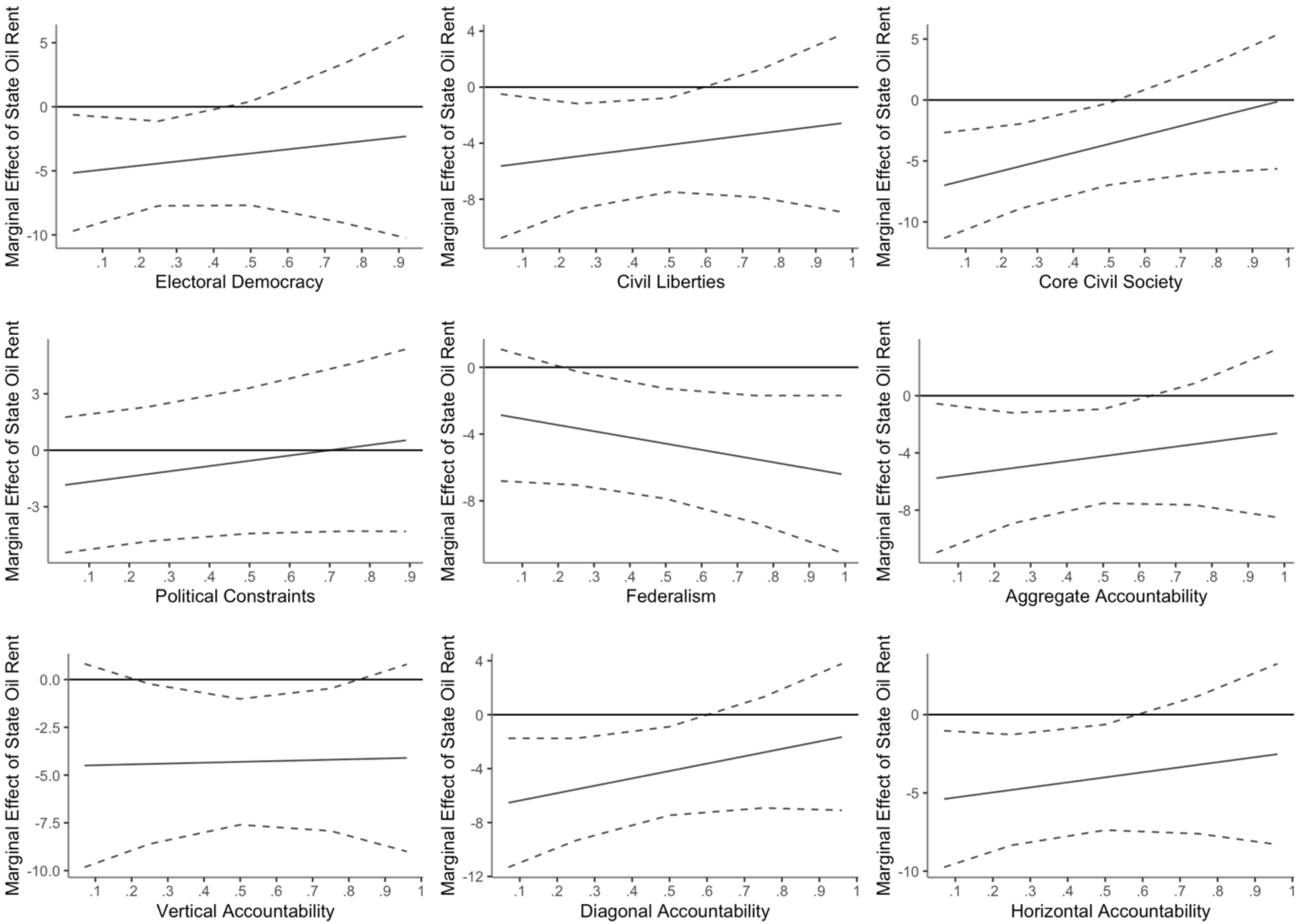


Table B.15: Linear Mixed Model Estimation for Non-Hydro Renewable Electricity Consumption

	Dependent Variable: Share of Non-Hydro Renewables in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Electoral Democracy	−0.523	−0.334	−0.519	−0.733**	−0.578*	−0.577*	−0.609*	−0.608*
State Oil Rent	−1.085	−1.990	−1.903	−1.203	−1.084	−1.526	−3.307**	−3.623**
Oil Richness	0.094	0.089	0.058	0.041	0.070	−0.011	−0.081	−0.147
Industry Share (*%GDP*)	−7.080***	−6.668***	−5.959***	−5.299***	−4.933***	−5.308***	−5.198***	−5.610***
GDP per capita	−0.678	−0.588	−0.700	−1.053	−1.106	−0.531	0.019	0.500
(GDP per capita)^2	0.142***	0.140***	0.151***	0.175***	0.174***	0.135***	0.094*	0.058
Climate Vulnerability	9.514***	9.918***	10.323***	10.601***	10.194***	9.636***	8.699***	7.779***
Solar Potential	−0.266	−0.259	−0.268	−0.243	−0.260	−0.306	−0.347	−0.406
Wind Potential	0.242	0.242	0.267	0.288	0.301	0.284	0.263	0.254
No. of Regions/Countries	9/106	9/105	9/104	9/104	9/104	9/104	9/104	9/104
No. of Years	20	20	20	20	20	20	20	20
Observations	1,826	1,766	1,705	1,644	1,583	1,519	1,449	1,378
Log Likelihood	−2,590.201	−2,460.598	−2,332.417	−2,203.166	−2,090.087	−2,004.290	−1,907.349	−1,818.892
Akaike Inf. Crit.	5,210.401	4,951.197	4,694.834	4,436.332	4,210.174	4,038.579	3,844.697	3,667.785
Bayesian Inf. Crit.	5,293.049	5,033.344	4,776.454	4,517.406	4,290.680	4,118.466	3,923.877	3,746.211
Intra-Class Correlation (ICC)	0.85	0.86	0.87	0.88	0.89	0.88	0.87	0.86
Pseudo R^2 (*Marginal/Conditional*)	0.332/0.901	0.344/0.907	0.347/0.914	0.344/0.923	0.340/0.925	0.337/0.920	0.335/0.913	0.328/0.906

*p<0.1; **p<0.05; ***p<0.01

Table B.16: Linear Mixed Model Estimation for Non-Hydro Renewable Electricity Capacity

	Dependent Variable: Share of Non-Hydro Renewables in Electricity Production Capacity							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Electoral Democracy	−0.202	−0.258	−0.261	−0.136	−0.121	−0.032	−0.092	−0.243
State Oil Rent	−4.593***	−5.376***	−7.033***	−7.958***	−7.600***	−5.992***	−3.786***	−1.875
Oil Richness	0.110	0.067	0.159	0.186	0.110	−0.060	−0.275*	−0.340**
Industry Share (*%GDP*)	−1.365	−0.862	−0.800	−0.730	−0.689	−0.599	−0.978	−2.375**
GDP per capita	−3.950***	−3.557***	−3.069***	−2.468***	−1.897***	−1.504**	−0.971	−0.314
(GDP per capita)^2	0.273***	0.262***	0.246***	0.218***	0.189***	0.164***	0.129***	0.084**
Climate Vulnerability	2.684*	3.905**	5.247***	6.253***	6.713***	6.593***	6.027***	5.121***
Solar Potential	−0.175	−0.194	−0.210	−0.236	−0.275	−0.310	−0.352	−0.388
Wind Potential	0.325*	0.297*	0.261	0.228	0.216	0.222	0.238	0.273*
No. of Regions/Countries	9/128	9/128	9/128	9/128	9/128	9/128	9/127	9/126
No. of Years	20	20	20	20	20	20	20	20
Observations	2,008	2,010	2,009	2,005	1,999	1,979	1,954	1,923
Log Likelihood	−2,721.437	−2,716.267	−2,704.328	−2,698.139	−2,692.094	−2,672.973	−2,652.168	−2,605.344
Akaike Inf. Crit.	5,472.875	5,462.534	5,438.657	5,426.277	5,414.188	5,375.945	5,334.335	5,240.687
Bayesian Inf. Crit.	5,556.948	5,546.622	5,522.738	5,510.328	5,498.194	5,459.800	5,418.000	5,324.112
Intra-Class Correlation (ICC)	0.84	0.84	0.84	0.84	0.83	0.83	0.82	0.81
Pseudo R^2 (*Marginal/Conditional*)	0.334/0.891	0.349/0.895	0.368/0.898	0.384/0.898	0.388/0.897	0.382/0.892	0.368/0.885	0.351/0.879

*p<0.1; **p<0.05; ***p<0.01

Appendix C: Additional Within-Between Estimations

Table C.1: V-Dem Democracy Components and Renewable energy Development (Within-Between Estimation)

	Dependent Variable:			
	Share of Wind & Solar in Electricity Consumption			
	(1)	(2)	(3)	(4)
Within:				
Liberal Component	0.615			
Deliberative Component		0.134		
Participatory Component			−0.728	
Egalitarian Component				2.304***
State Oil Rent	−4.033**	−4.162**	−4.054**	−3.823**
Oil Richness	−0.291	−0.280	−0.281	−0.288
Industry Share (*%GDP*)	−6.027***	−5.794***	−5.802***	−6.092***
GDP per capita	−9.616***	−9.548***	−9.449***	−9.226***
$(\text{GDP per capita})^2$	0.673***	0.669***	0.663***	0.651***
Between:				
Liberal Component	1.562*			
Deliberative Component		2.174**		
Participatory Component			1.540	
Egalitarian Component				0.709
State Oil Rent	−2.465	−1.568	−1.754	−2.974
Oil Richness	−0.552	−0.583	−0.688*	−0.648*
Industry Share (*%GDP*)	−1.275	−1.744	−1.815	−1.374
Climate Vulnerability	1.904	2.080	1.211	1.228
Solar Potential	−0.557*	−0.526*	−0.518*	−0.543*
Wind Potential	0.334**	0.327**	0.339**	0.350**
No. of Regions/Countries	9/120	9/120	9/120	9/120
No. of Years	26	26	26	26
Observations	1,695	1,695	1,695	1,695
Log Likelihood	−2,534.962	−2,534.733	−2,535.498	−2,532.502
Akaike Inf. Crit.	5,107.924	5,107.466	5,108.995	5,103.005
Bayesian Inf. Crit.	5,211.197	5,210.740	5,212.269	5,206.278
Intra-Class Correlation (ICC)	0.79	0.78	0.79	0.80
Pseudo R^2 (*Marginal/Conditional*)	00.444/0.882	0.448/0.880	0.442/0.881	0.430/0.883

*p<0.1; **p<0.05; ***p<0.01

Table C.2: Misc. Democracy Indices and Renewable energy Development (Within-Between Estimation)

	Dependent Variable: Share of Wind & Solar in Electricity Consumption				
	(1)	(2)	(3)	(4)	(5)
Within:					
Electoral Democracy	−0.120				
Machine Learning Democracy Index		0.201			
Polity2			−0.622		
Freedom House				0.460	
Vanhanen Index					−0.156
State Oil Rent	−4.153**	−4.082**	−4.354**	−4.134**	−4.068**
Oil Richness	−0.288	−0.234	−0.312	−0.227	−0.250
Industry Share (*%GDP*)	−5.801***	−5.966***	−5.613***	−5.847***	−5.717***
GDP per capita	−9.532***	−9.596***	−9.422***	−9.648***	−9.533***
(GDP per capita)^2	0.667***	0.673***	0.659***	0.675***	0.667***
Between:					
V-Dem Polyarchy	2.068**				
Machine Learning Democracy Index		0.278			
Polity2			0.647		
Freedom House				1.624**	
Vanhanen Index					0.706
State Oil Rent	−1.744	−3.506	−1.745	−2.586	−3.258
Oil Richness	−0.556	−0.552	−0.654*	−0.447	−0.561
Industry Share (*%GDP*)	−1.574	−0.938	−1.906	−1.028	−1.023
Climate Vulnerability	1.961	0.672	1.149	1.772	0.847
Solar Potential	−0.495	−0.540*	−0.436	−0.502	−0.498
Wind Potential	0.318*	0.319*	0.544***	0.265	0.310*
No. of Regions/Countries	9/120	9/121	9/118	9/121	9/121
No. of Years	26	26	26	26	26
Observations	1,695	1,703	1,682	1,703	1,702
Log Likelihood	−2,534.993	−2,550.107	−2,515.076	−2,547.202	−2,547.636
Akaike Inf. Crit.	5,107.985	5,138.214	5,068.152	5,132.404	5,133.273
Bayesian Inf. Crit.	5,211.259	5,241.577	5,171.279	5,235.767	5,236.624
Intra-Class Correlation (ICC)	0.78	0.79	0.78	0.78	0.79
Pseudo R^2 (*Marginal/Conditional*)	0.461/0.881	0.428/0.879	0.441/0.879	0.453/0.879	0.432/0.878

*p<0.1; **p<0.05; ***p<0.01

Table C.3: Misc. Qualities of Democracy and Renewable energy Development (Within-Between Estimation)

	Dependent Variable:			
	Share of Wind & Solar in Electricity Consumption			
	(1)	(2)	(3)	(4)
Within:				
Civil Liberty	−0.023			
Civil Society		−0.010		
Political Constraints			0.208	
Federalism				0.265
State Oil Rent	−4.164**	−4.150**	0.368	−4.203**
Oil Richness	−0.297	−0.299	−0.203	−0.310
Industry Share (*%GDP*)	−5.828***	−5.829***	−6.672***	−5.929***
GDP per capita	−9.564***	−9.571***	−9.251***	−9.611***
$(\text{GDP per capita})^2$	0.669***	0.670***	0.658***	0.671***
Between:				
Civil Liberty	0.702			
Civil Society		0.497		
Political Constraints			2.082**	
Federalism				0.462
State Oil Rent	−2.332	−2.449	−2.371	−2.294
Oil Richness	−0.661*	−0.660*	−0.465	−0.721*
Industry Share (*%GDP*)	−1.611	−1.640	−1.856	−1.619
Climate Vulnerability	1.157	0.957	1.586	0.981
Solar Potential	−0.571*	−0.582*	−0.518*	−0.583*
Wind Potential	0.347**	0.347**	0.246	0.364**
No. of Regions/Countries	9/120	9/120	9/119	9/120
No. of Years	26	26	26	26
Observations	1,695	1,695	1,685	1,695
Log Likelihood	−2,536.941	−2,537.585	−2,512.124	−2,537.602
Akaike Inf. Crit.	5,111.882	5,113.170	5,062.248	5,113.205
Bayesian Inf. Crit.	5,215.156	5,216.443	5,165.408	5,216.478
Intra-Class Correlation (ICC)	0.79	0.79	0.77	0.79
Pseudo R^2 (*Marginal/Conditional*)	0.436/0.882	0.434/0.882	0.463/0.878	0.432/0.881

*p<0.1; **p<0.05; ***p<0.01

Table C.4: Accountability and Renewable energy Development (Within-Between Estimation)

	Dependent Variable:			
	Share of Wind & Solar in Electricity Consumption			
	(1)	(2)	(3)	(4)
Within:				
Aggregate Accountability	−0.092			
Vertical Accountability		0.336		
Diagonal Accountability			−0.206	
Horizontal Accountability				0.070
State Oil Rent	−4.168**	−4.123**	−4.202**	−4.115**
Oil Richness	−0.295	−0.291	−0.298	−0.298
Industry Share (*%GDP*)	−5.793***	−5.900***	−5.757***	−5.881***
GDP per capita	−9.545***	−9.553***	−9.545***	−9.558***
(GDP per capita)^2	0.668***	0.670***	0.668***	0.669***
Between:				
Aggregate Accountability	1.090			
Vertical Accountability		0.991		
Diagonal Accountability			0.978	
Horizontal Accountability				1.090
State Oil Rent	−2.097	−2.478	−1.953	−2.726
Oil Richness	−0.631*	−0.642*	−0.660*	−0.579
Industry Share (*%GDP*)	−1.596	−1.350	−1.688	−1.378
Climate Vulnerability	1.296	1.246	1.139	1.369
Solar Potential	−0.560*	−0.566*	−0.564*	−0.553*
Wind Potential	0.343**	0.343**	0.345**	0.346**
No. of Regions/Countries	9/120	9/120	9/120	9/120
No. of Years	26	26	26	26
Observations	1,695	1,695	1,695	1,695
Log Likelihood	−2,536.713	−2,536.541	−2,536.869	−2,536.831
Akaike Inf. Crit.	5,111.426	5,111.083	5,111.739	5,111.662
Bayesian Inf. Crit.	5,214.699	5,214.356	5,215.012	5,214.936
Intra-Class Correlation (ICC)	0.79	0.79	0.79	0.79
Pseudo R^2 (*Marginal/Conditional*)	0.441/0.881	0.435/0.882	0.442/0.881	0.438/0.880

*p<0.1; **p<0.05; ***p<0.01

Table C.5: Liberal Democracy and Renewable energy Development (Within-Between Estimation)

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Liberal Democracy	−1.484***	−1.084**	−0.483	0.184	0.904*	1.740***	2.557***	3.046***
State Oil Rent	0.685	0.113	−1.799	−4.113**	−4.610**	−4.203**	−2.656	−1.345
Oil Richness	−0.703***	−0.690**	−0.499*	−0.284	0.028	0.139	0.216	0.454
Industry Share (*%GDP*)	−6.825***	−6.468***	−6.413***	−5.894***	−5.279***	−4.388***	−3.752***	−2.168
GDP per capita	−8.470***	−8.908***	−9.289***	−9.533***	−8.854***	−7.571***	−5.897***	−4.130***
(GDP per capita)^2	0.557***	0.599***	0.640***	0.668***	0.629***	0.550***	0.447***	0.329***
Between:								
Liberal Democracy	2.465***	2.483***	2.503***	2.551***	2.621***	2.659***	2.690***	2.790***
State Oil Rent	−2.716	−2.802	−2.652	−2.137	−1.952	−1.944	−2.406	−2.756
Oil Richness	−0.555	−0.540	−0.512	−0.481	−0.467	−0.490	−0.487	−0.501
Industry Share (*%GDP*)	−2.646	−2.254	−1.776	−1.446	−1.194	−0.973	−0.939	−1.017
Climate Vulnerability	2.850*	2.775*	2.710*	2.554*	2.340	2.059	1.791	1.645
Solar Potential	−0.426	−0.437	−0.460	−0.474	−0.475	−0.459	−0.445	−0.434
Wind Potential	0.289*	0.300*	0.305*	0.310*	0.315*	0.321**	0.329**	0.331**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,683.105	−2,646.166	−2,589.165	−2,533.541	−2,484.163	−2,432.523	−2,374.793	−2,309.225
Akaike Inf. Crit.	5,404.209	5,330.332	5,216.330	5,105.083	5,006.327	4,903.045	4,787.587	4,656.451
Bayesian Inf. Crit.	5,508.284	5,434.201	5,319.926	5,208.356	5,109.249	5,005.599	4,889.681	4,758.049
Intra-Class Correlation (ICC)	0.76	0.76	0.77	0.77	0.77	0.77	0.77	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.500/0.881	0.492/0.880	0.481/0.881	0.470/0.880	0.461/0.878	0.453/0.876	0.445/0.874	0.440/0.873

*p<0.1; **p<0.05; ***p<0.01

Table C.6: Deliberative Democracy and Renewable energy Development (Within-Between Estimation)

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Deliberative Democracy	−1.651***	−1.295***	−0.714*	−0.004	0.737*	1.442***	2.174***	2.570***
State Oil Rent	0.812	0.159	−1.843	−4.167**	−4.623**	−4.194**	−2.715	−1.479
Oil Richness	−0.706***	−0.691**	−0.498*	−0.280	0.037	0.154	0.245	0.496*
Industry Share (*%GDP*)	−6.892***	−6.522***	−6.380***	−5.821***	−5.155***	−4.257***	−3.556***	−1.959
GDP per capita	−8.520***	−8.929***	−9.288***	−9.518***	−8.843***	−7.574***	−5.869***	−4.113***
(GDP per capita)^2	0.560***	0.599***	0.639***	0.667***	0.629***	0.550***	0.445***	0.327***
Between:								
Deliberative Democracy	2.656***	2.695***	2.729***	2.799***	2.894***	2.960***	3.009***	3.101***
State Oil Rent	−2.277	−2.382	−2.263	−1.790	−1.649	−1.642	−2.083	−2.480
Oil Richness	−0.571	−0.556	−0.530	−0.496	−0.480	−0.501	−0.496	−0.510
Industry Share (*%GDP*)	−2.961	−2.532	−1.997	−1.619	−1.335	−1.107	−1.104	−1.163
Climate Vulnerability	2.826*	2.774*	2.717*	2.571*	2.361	2.081	1.823	1.687
Solar Potential	−0.427	−0.436	−0.455	−0.465	−0.463	−0.446	−0.431	−0.426
Wind Potential	0.277*	0.288*	0.295*	0.301*	0.307*	0.313*	0.319**	0.320**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,679.541	−2,643.734	−2,588.061	−2,533.312	−2,484.148	−2,433.111	−2,375.692	−2,311.277
Akaike Inf. Crit.	5,397.082	5,325.468	5,214.121	5,104.624	5,006.296	4,904.223	4,789.384	4,660.554
Bayesian Inf. Crit.	5,501.157	5,429.337	5,317.717	5,207.898	5,109.219	5,006.777	4,891.478	4,762.153
Intra-Class Correlation (ICC)	0.76	0.76	0.77	0.77	0.77	0.77	0.77	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.501/0.881	0.493/0.880	0.483/0.881	0.472/0.879	0.463/0.877	0.455/0.875	0.446/0.873	0.441/0.872

*p<0.1; **p<0.05; ***p<0.01

Table C.7: Participatory Democracy and Renewable energy Development (Within-Between Estimation)

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Participatory Democracy	−2.139***	−1.647***	−0.892	−0.116	0.858	2.034***	3.187***	3.971***
State Oil Rent	0.821	0.175	−1.777	−4.143**	−4.714**	−4.334**	−2.857	−1.596
Oil Richness	−0.682**	−0.671**	−0.487*	−0.278	0.031	0.152	0.247	0.493*
Industry Share (*%GDP*)	−7.014***	−6.586***	−6.434***	−5.823***	−5.120***	−4.198***	−3.505**	−1.920
GDP per capita	−8.555***	−8.967***	−9.314***	−9.545***	−8.887***	−7.623***	−5.917***	−4.151***
(GDP per capita)^2	0.565***	0.604***	0.642***	0.668***	0.630***	0.551***	0.446***	0.328***
Between:								
Participatory Democracy	2.979***	3.006***	3.042***	3.112***	3.201***	3.229***	3.275***	3.368***
State Oil Rent	−1.994	−2.107	−1.952	−1.401	−1.153	−1.084	−1.490	−1.947
Oil Richness	−0.612	−0.600	−0.576	−0.549	−0.539	−0.564	−0.562	−0.573
Industry Share (*%GDP*)	−3.291	−2.859	−2.363	−2.053	−1.844	−1.685	−1.719	−1.785
Climate Vulnerability	2.481*	2.385*	2.284	2.088	1.821	1.482	1.194	1.057
Solar Potential	−0.413	−0.423	−0.444	−0.455	−0.456	−0.440	−0.427	−0.419
Wind Potential	0.280*	0.291*	0.299*	0.306*	0.313*	0.321**	0.328**	0.330**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,682.146	−2,645.246	−2,588.510	−2,533.362	−2,484.760	−2,433.571	−2,375.516	−2,309.273
Akaike Inf. Crit.	5,402.292	5,328.493	5,215.019	5,104.725	5,007.520	4,905.143	4,789.032	4,656.546
Bayesian Inf. Crit.	5,506.366	5,432.362	5,318.615	5,207.998	5,110.442	5,007.697	4,891.127	4,758.145
Intra-Class Correlation (ICC)	0.76	0.76	0.77	0.77	0.77	0.77	0.77	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.501/0.881	0.493/0.880	0.482/0.881	0.471/0.879	0.463/0.877	0.456/0.875	0.448/0.873	0.444/0.872

*p<0.1; **p<0.05; ***p<0.01

Table C.8: Egalitarian Democracy and Renewable energy Development (Within-Between Estimation)

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Egalitarian Democracy	−0.990*	−0.701	−0.030	0.825	1.851***	2.808***	3.768***	4.175***
State Oil Rent	0.652	0.089	−1.803	−4.104**	−4.680**	−4.303**	−2.798	−1.537
Oil Richness	−0.710***	−0.690**	−0.495*	−0.272	0.051	0.172	0.271	0.503*
Industry Share (*%GDP*)	−6.882***	−6.531***	−6.460***	−5.916***	−5.264***	−4.359***	−3.600***	−1.935
GDP per capita	−8.686***	−9.070***	−9.334***	−9.439***	−8.604***	−7.176***	−5.353***	−3.587***
(GDP per capita)^2	0.571***	0.609***	0.643***	0.662***	0.615***	0.527***	0.415***	0.297***
Between:								
Egalitarian Democracy	2.848**	2.860***	2.888***	2.959***	3.065***	3.142***	3.199***	3.305***
State Oil Rent	−3.062	−3.143	−2.985	−2.470	−2.275	−2.240	−2.751	−3.193
Oil Richness	−0.559	−0.543	−0.516	−0.483	−0.465	−0.486	−0.480	−0.494
Industry Share (*%GDP*)	−2.263	−1.913	−1.453	−1.142	−0.922	−0.736	−0.726	−0.778
Climate Vulnerability	2.995**	2.918*	2.846*	2.693*	2.487	2.203	1.961	1.857
Solar Potential	−0.370	−0.380	−0.398	−0.404	−0.398	−0.373	−0.353	−0.344
Wind Potential	0.280*	0.291*	0.298*	0.305*	0.310*	0.318*	0.324**	0.326**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,593	1,552
Log Likelihood	−2,686.809	−2,648.033	−2,589.481	−2,532.585	−2,481.629	−2,429.205	−2,371.244	−2,307.224
Akaike Inf. Crit.	5,411.617	5,334.066	5,216.963	5,103.171	5,001.258	4,896.409	4,780.488	4,652.448
Bayesian Inf. Crit.	5,515.692	5,437.936	5,320.558	5,206.444	5,104.181	4,998.963	4,882.582	4,754.047
Intra-Class Correlation (ICC)	0.76	0.76	0.77	0.77	0.77	0.77	0.77	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.499/0.880	0.491/0.880	0.481/0.881	0.470/0.880	0.461/0.878	0.455/0.876	0.447/0.874	0.442/0.873

*p<0.1; **p<0.05; ***p<0.01

Table C.9: Within-Between Estimation Excluding Oil Richness

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Electoral Democracy	−1.598***	−1.545***	−0.986**	−0.288	0.234	1.029**	1.875***	2.147***
State Oil Rent	−0.173	−0.824	−2.600*	−4.659***	−4.634**	−3.864**	−2.013	−0.402
Industry Share (*%GDP*)	−6.848***	−6.382***	−6.373***	−5.844***	−5.287***	−4.628***	−4.376***	−2.911**
GDP per capita	−8.457***	−8.919***	−9.291***	−9.591***	−9.003***	−7.993***	−6.223***	−4.487***
(GDP per capita)^2	0.558***	0.601***	0.642***	0.675***	0.644***	0.583***	0.481***	0.369***
Between:								
Electoral Democracy	2.165**	2.235**	2.274**	2.331**	2.433***	2.519***	2.586***	2.681***
State Oil Rent	−6.786*	−6.701*	−6.442*	−5.778	−5.625	−5.799	−6.256	−6.865*
Industry Share (*%GDP*)	−3.170	−2.741	−2.185	−1.847	−1.629	−1.451	−1.410	−1.398
Climate Vulnerability	2.819*	2.800*	2.740*	2.548*	2.345	2.129	1.898	1.809
Solar Potential	−0.400	−0.412	−0.432	−0.441	−0.433	−0.411	−0.395	−0.386
Wind Potential	0.301*	0.310*	0.319*	0.328**	0.337**	0.347**	0.353**	0.357**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,769	1,751	1,727	1,699	1,669	1,639	1,602	1,562
Log Likelihood	−2,688.833	−2,652.608	−2,597.995	−2,545.253	−2,499.981	−2,456.603	−2,407.068	−2,347.681
Akaike Inf. Crit.	5,411.666	5,339.217	5,229.990	5,124.506	5,033.962	4,947.206	4,848.135	4,729.362
Bayesian Inf. Crit.	5,504.795	5,432.172	5,322.710	5,216.949	5,126.102	5,039.037	4,939.578	4,820.375
Intra-Class Correlation (ICC)	0.77	0.78	0.78	0.79	0.78	0.78	0.78	0.78
Pseudo R^2 (*Marginal/Conditional*)	0.486/0.883	0.477/0.883	0.465/0.883	0.452/0.882	0.442/0.879	0.432/0.876	0.421/0.873	0.414/0.871

*p<0.1; **p<0.05; ***p<0.01

Table C.10: Within-Between Estimation Excluding State Oil Rent

	Dependent Variable: Share of Wind & Solar in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Electoral Democracy	−1.604***	−1.468***	−0.877*	−0.106	0.562	1.348***	2.210***	2.537***
Oil Richness	−0.676***	−0.696***	−0.608**	−0.454*	−0.146	−0.009	0.149	0.445
Industry Share (*%GDP*)	−6.596***	−6.414***	−6.952***	−6.737***	−6.111***	−5.179***	−4.433***	−2.778**
GDP per capita	−8.569***	−8.964***	−9.258***	−9.434***	−8.754***	−7.476***	−5.759***	−4.026***
(GDP per capita)^2	0.563***	0.601***	0.637***	0.663***	0.626***	0.547***	0.443***	0.328***
Between:								
Electoral Democracy	1.968**	2.015**	2.047**	2.111**	2.216**	2.294**	2.369**	2.485***
Oil Richness	−0.731**	−0.715**	−0.681**	−0.652**	−0.639**	−0.654**	−0.655**	−0.676**
Industry Share (*%GDP*)	−4.056	−3.751	−3.363	−3.009	−2.745	−2.486	−2.541	−2.604
Climate Vulnerability	1.979	1.920	1.837	1.670	1.444	1.154	0.849	0.715
Solar Potential	−0.439	−0.448	−0.468	−0.479	−0.476	−0.456	−0.436	−0.430
Wind Potential	0.294*	0.304*	0.311*	0.320*	0.326**	0.333**	0.338**	0.337**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120	9/120	9/119	9/119
No. of Years	29	28	27	26	25	24	23	22
Observations	1,768	1,749	1,724	1,695	1,664	1,632	1,594	1,554
Log Likelihood	−2,687.773	−2,649.311	−2,593.955	−2,541.592	−2,493.842	−2,443.117	−2,386.128	−2,323.480
Akaike Inf. Crit.	5,409.547	5,332.623	5,221.910	5,117.183	5,021.684	4,920.233	4,806.257	4,680.961
Bayesian Inf. Crit.	5,502.666	5,425.559	5,314.601	5,209.585	5,113.772	5,011.992	4,897.615	4,771.887
Intra-Class Correlation (ICC)	0.76	0.76	0.77	0.77	0.77	0.77	0.77	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.500/0.880	0.492/0.879	0.481/0.880	0.469/0.879	0.461/0.876	0.455/0.873	0.447/0.872	0.443/0.870

*p<0.1; **p<0.05; ***p<0.01

Table C.11: Hydrocarbon Resources and Renewable energy Development (Within-Between Estimation)

	Dependent Variable: Share of Wind & Solar in Electricity Consumption				
	(1)	(2)	(3)	(4)	(5)
Within:					
Electoral Democracy	−0.120	−0.237	−0.119	−0.313	−0.332
State Oil Rent	−4.153**			−1.537	−1.675
Oil Richness	−0.288			−0.494*	−0.488*
State Gas Rent		−35.274***		−38.214***	−38.210***
Gas Richness		0.843***		0.786***	0.799***
State Coal Rent			2.050		2.668
Coal Richness			−0.036		−0.056
Industry Share (*%GDP*)	−5.801***	−5.202***	−6.122***	−4.783***	−4.669***
GDP per capita	−9.532***	−9.180***	−9.170***	−9.465***	−9.552***
(GDP per capita)^2	0.667***	0.644***	0.642***	0.661***	0.665***
Between:					
Electoral Democracy	2.068**	2.260**	2.614***	1.946**	2.047**
State Oil Rent	−1.744			−4.541	−4.922
Oil Richness	−0.556			−0.151	−0.162
State Gas Rent		−33.367		−29.508	−35.714
Gas Richness		−0.418		−0.317	0.088
State Coal Rent			28.210		25.152
Coal Richness			−0.633***		−0.588**
Industry Share (*%GDP*)	−1.574	−5.288**	−6.587***	−0.704	−0.096
Climate Vulnerability	1.961	0.920	0.960	1.689	1.497
Solar Potential	−0.495	−0.285	−0.312	−0.376	−0.350
Wind Potential	0.318*	0.388**	0.340**	0.375**	0.375**
No. of Regions/Countries	9/120	9/120	9/120	9/120	9/120
No. of Years	26	26	26	26	26
Observations	1,695	1,682	1,681	1,682	1,680
Log Likelihood	−2,534.993	−2,497.551	−2,515.050	−2,490.624	−2,479.368
Akaike Inf. Crit.	5,107.985	5,033.102	5,068.100	5,027.249	5,012.736
Bayesian Inf. Crit.	5,211.259	5,136.229	5,171.216	5,152.087	5,159.253
Intra-Class Correlation (ICC)	0.78	0.76	0.75	0.78	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.461/0.881	0.496/0.879	0.496/0.876	0.475/0.883	0.486/0.882

*p<0.1; **p<0.05; ***p<0.01

Table C.13: Within-Between Estimation for Non-Hydro Renewable Electricity Consumption

	Dependent Variable: Share of Non-Hydro Renewables in Electricity Consumption							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Electoral Democracy	−0.535	−0.303	−0.498	−0.721**	−0.579*	−0.574*	−0.593*	−0.627*
State Oil Rent	2.740	1.618	1.506	2.146	2.169	1.474	−0.278	−0.643
Oil Richness	0.359*	0.351	0.365	0.385*	0.422*	0.317	0.224	0.150
Industry Share (*%GDP*)	−6.425***	−6.082***	−5.254***	−4.420***	−3.992***	−4.574***	−4.629***	−5.166***
GDP per capita	−1.544*	−1.441*	−1.513*	−1.849**	−1.917**	−1.399	−0.961	−0.485
(GDP per capita)^2	0.221***	0.220***	0.230***	0.255***	0.254***	0.221***	0.190***	0.158***
Between:								
Electoral Democracy	2.294**	2.328**	2.356**	2.259**	2.288**	2.322**	2.375**	2.433**
State Oil Rent	−10.185	−9.887	−10.194	−11.018*	−10.977*	−10.890*	−10.626*	−10.639*
Oil Richness	0.255	0.237	0.222	0.201	0.166	0.149	0.132	0.113
Industry Share (*%GDP*)	−5.127	−4.855	−4.430	−4.059	−3.821	−3.746	−3.496	−3.362
Climate Vulnerability	0.740	0.632	0.659	0.649	0.617	0.582	0.588	0.566
Solar Potential	−0.428	−0.427	−0.424	−0.373	−0.385	−0.393	−0.401	−0.420
Wind Potential	0.150	0.164	0.177	0.178	0.184	0.185	0.187	0.190
No. of Regions/Countries	9/106	9/105	9/105	9/104	9/104	9/104	9/104	9/104
No. of Years	25	24	23	22	21	20	19	18
Observations	1,826	1,766	1,705	1,644	1,583	1,519	1,449	1,378
Log Likelihood	−2,557.693	−2,428.669	−2,297.854	−2,163.850	−2,050.421	−1,967.360	−1,874.562	−1,788.678
Akaike Inf. Crit.	5,153.387	4,895.338	4,633.708	4,365.700	4,138.842	3,972.721	3,787.123	3,615.357
Bayesian Inf. Crit.	5,258.074	4,999.391	4,737.094	4,468.393	4,240.816	4,073.911	3,887.417	3,714.696
Intra-Class Correlation (ICC)	0.82	0.82	0.83	0.83	0.84	0.83	0.83	0.82
Pseudo R^2 (*Marginal/Conditional*)	0.277/0.868	0.281/0.874	0.288/0.878	0.293/0.880	0.301/0.884	0.312/0.884	0.322/0.883	0.333/0.882

*p<0.1; **p<0.05; ***p<0.01

Table C.13: Within-Between Estimation for Non-Hydro Renewable Electricity Capacity

	Dependent Variable: Share of Non-Hydro Renewables in Electricity Production Capacity							
	Independent Variables lagged by:							
	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Within:								
Electoral Democracy	−0.645*	−0.644*	−0.579*	−0.390	−0.372	−0.268	−0.337	−0.494
State Oil Rent	−4.710***	−5.449***	−6.859***	−7.163***	−6.591***	−4.684***	−2.360*	−0.657
Oil Richness	0.661***	0.528***	0.531***	0.479***	0.387**	0.213	−0.008	−0.069
Industry Share (*%GDP*)	−0.724	−0.067	0.033	0.160	0.109	0.078	−0.409	−2.022**
GDP per capita	−5.694***	−5.317***	−4.794***	−4.146***	−3.436***	−2.941***	−2.261***	−1.221
(GDP per capita)^2	0.403***	0.397***	0.380***	0.351***	0.314***	0.285***	0.241***	0.168***
Between:								
Electoral Democracy	2.470***	2.520***	2.564***	2.601***	2.633***	2.652***	2.642***	2.725***
State Oil Rent	−0.589	−0.176	0.230	0.531	0.561	0.449	−0.082	−0.370
Oil Richness	−0.532*	−0.571*	−0.580*	−0.583*	−0.595*	−0.619**	−0.624**	−0.618**
Industry Share (*%GDP*)	−2.334	−2.150	−1.952	−1.758	−1.623	−1.608	−1.598	−1.795
Climate Vulnerability	0.551	0.484	0.464	0.436	0.438	0.442	0.437	0.445
Solar Potential	−0.370	−0.380	−0.397	−0.415	−0.423	−0.421	−0.409	−0.413
Wind Potential	0.265*	0.266*	0.266*	0.267*	0.269*	0.271*	0.271*	0.265*
No. of Regions/Countries	9/128	9/128	9/128	9/128	9/128	9/1128	9/127	9/126
No. of Years	20	20	20	20	20	20	20	20
Observations	2,008	2,010	2,009	2,005	1,999	1,979	1,954	1,923
Log Likelihood	−2,681.056	−2,674.606	−2,661.392	−2,655.788	−2,650.138	−2,632.070	−2,614.171	−2,573.290
Akaike Inf. Crit.	5,400.113	5,387.212	5,360.783	5,349.575	5,338.275	5,302.141	5,266.341	5,184.581
Bayesian Inf. Crit.	5,506.606	5,493.724	5,467.286	5,456.040	5,444.683	5,408.357	5,372.316	5,290.252
Intra-Class Correlation (ICC)	0.79	0.79	0.79	0.79	0.79	0.78	0.77	0.77
Pseudo R^2 (*Marginal/Conditional*)	0.277/0.868	0.281/0.874	0.288/0.878	0.293/0.880	0.301/0.884	0.312/0.884	0.322/0.883	0.333/0.882

*p<0.1; **p<0.05; ***p<0.01

Appendix D: Case Studies' Additional Charts Maps and Diagrams

Figure D.1: GDP per capita

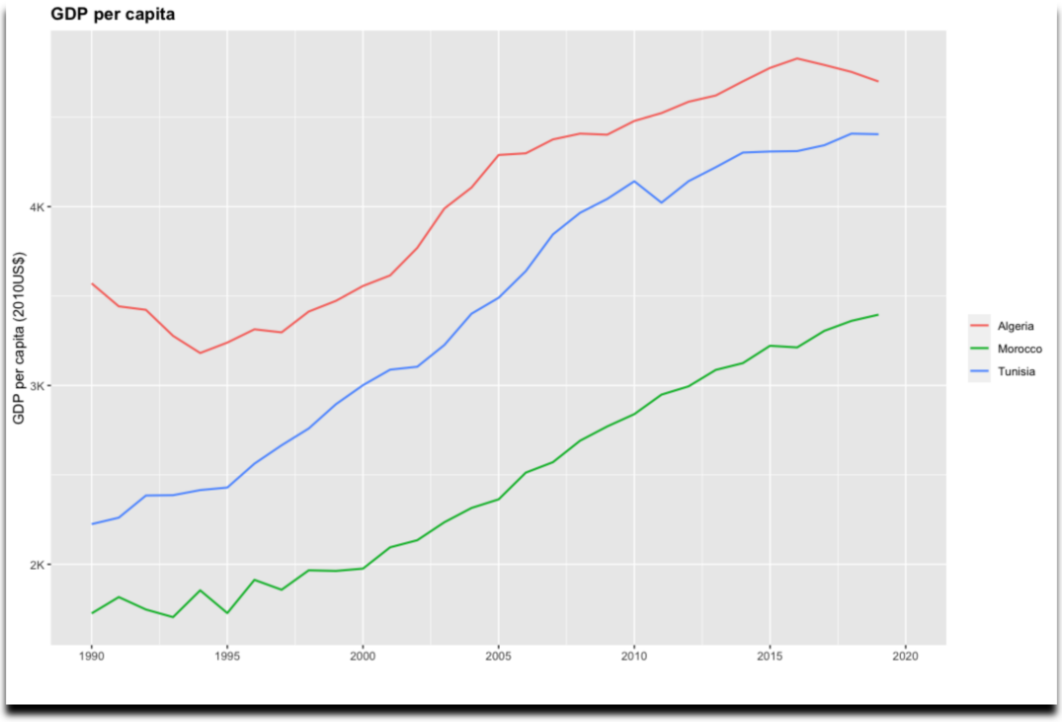


Figure D.2: Wind & Solar Potential Bar Charts (IRENA, 2021a, 2021b, 2021d)

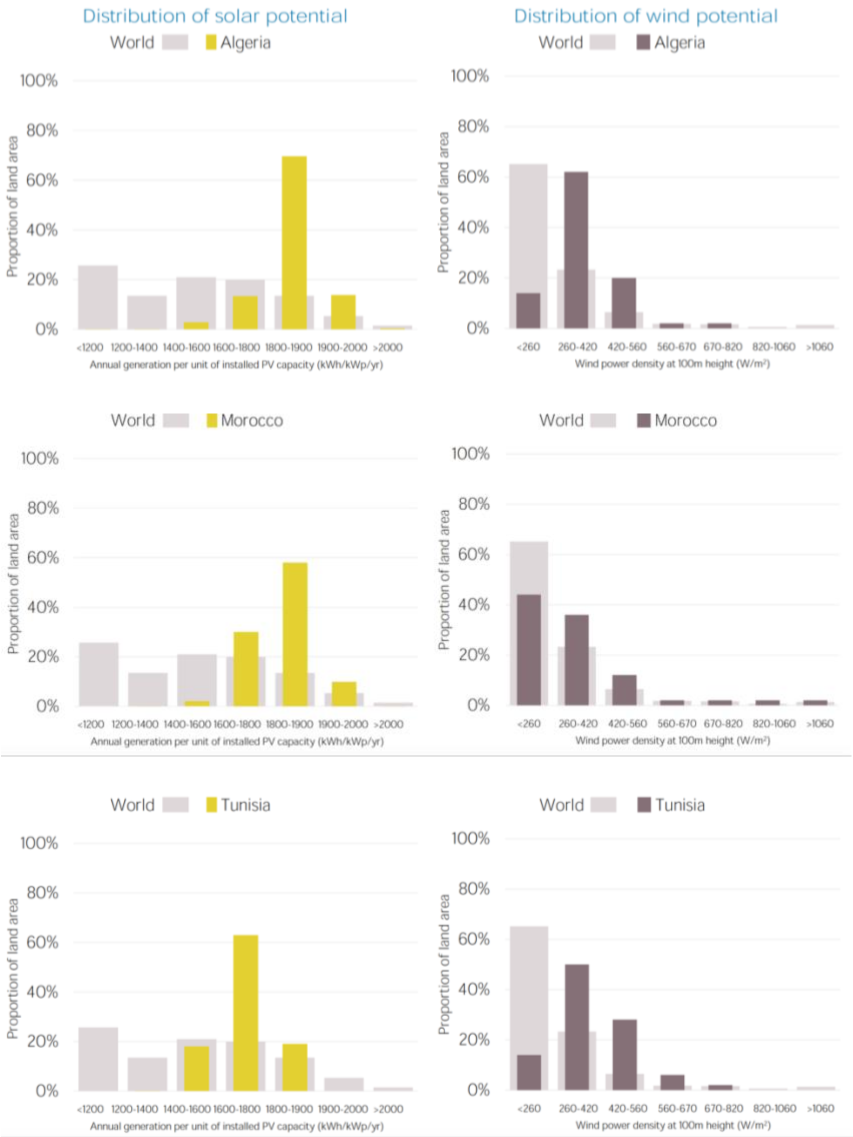


Figure D.3: Wind Potential Maps Algeria (top) Morocco (middle) & Tunisia (bottom) (Global Wind Atlas 3.0, 2022)

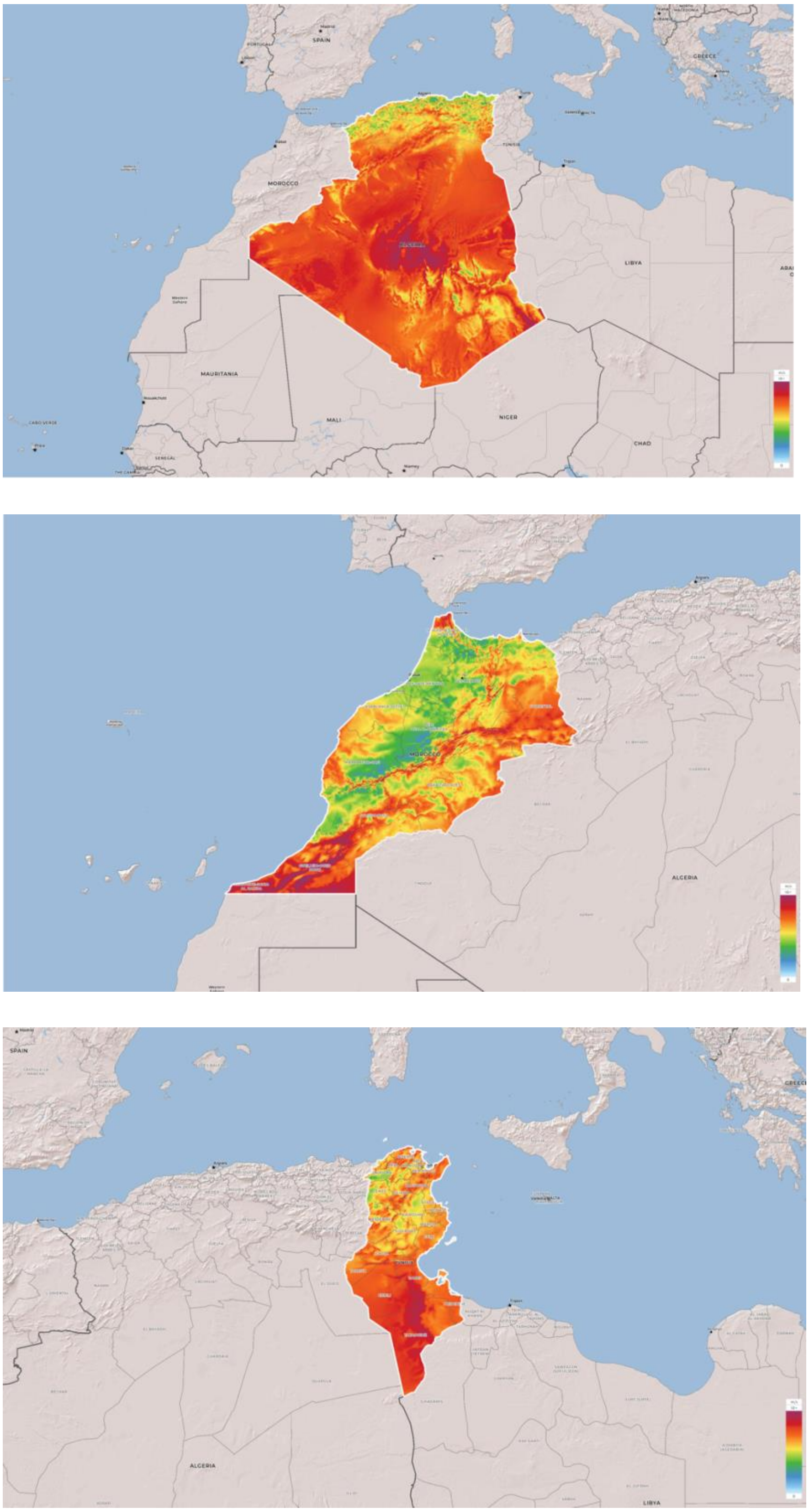


Figure D.4: Solar PV Potential (Global Solar Atlas 2.0, 2020)

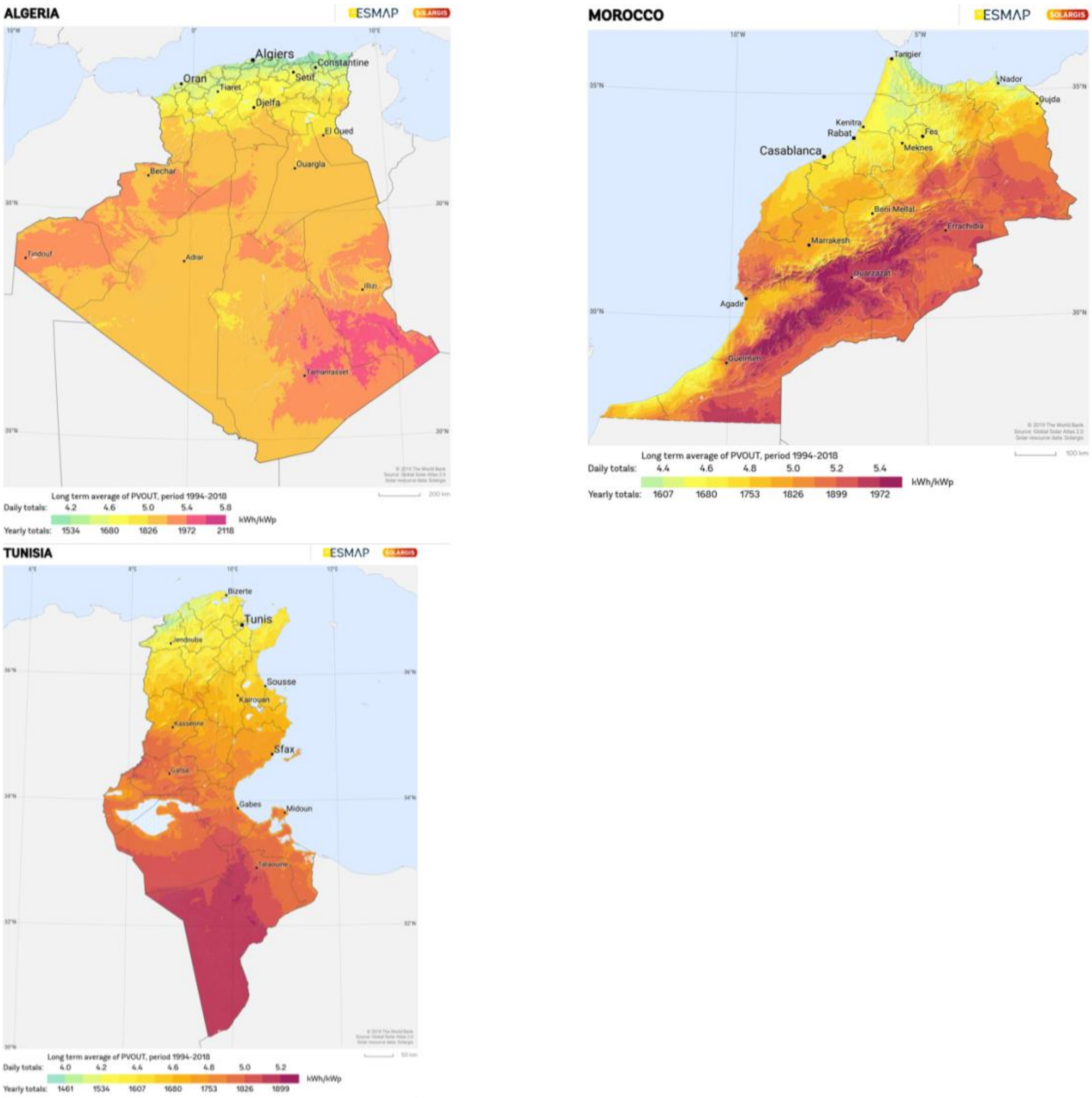


Figure D.5: Public Investment in Wind & Solar

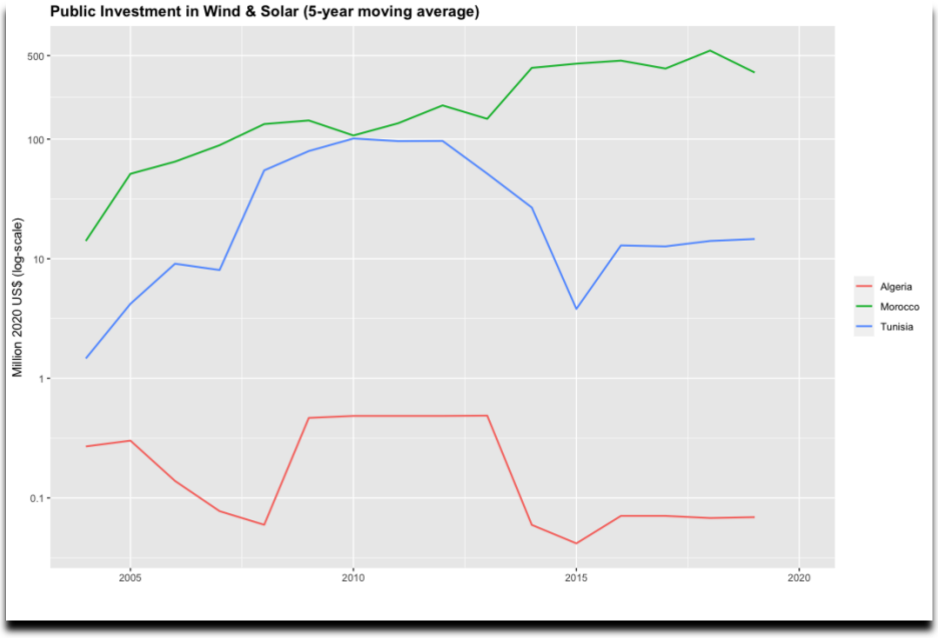


Figure D.6: Share of Total Natural Resource Rents (% of GDP)

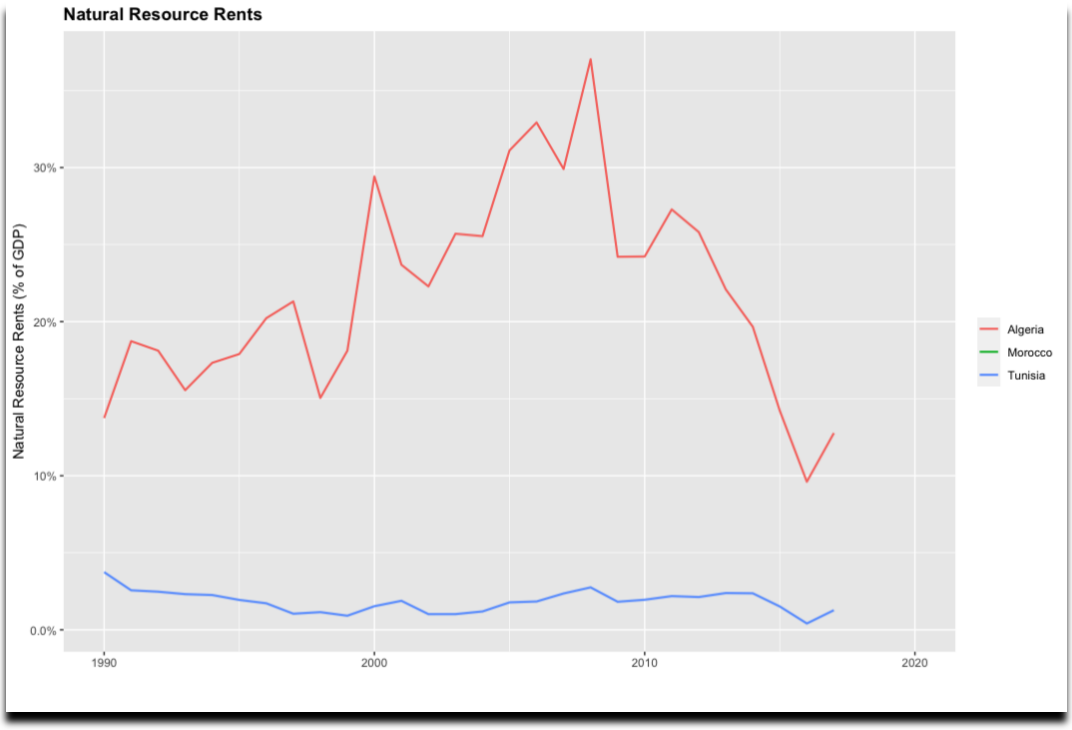


Figure D.7: Share of Industry (% of GDP)

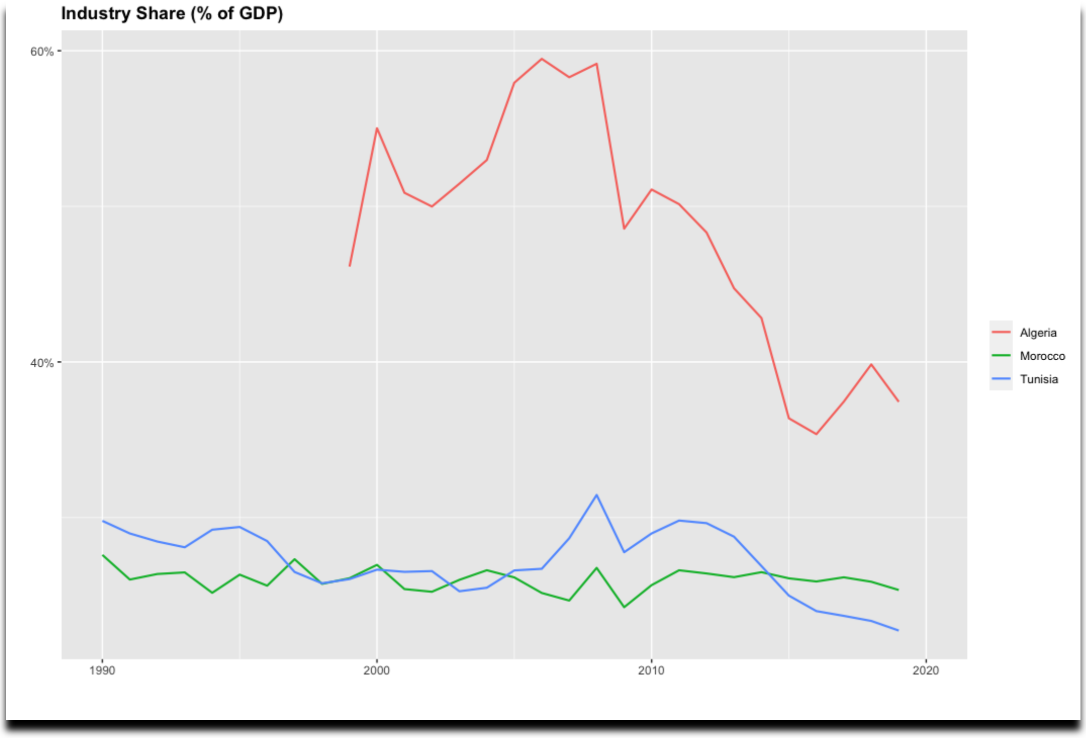


Figure D.8: Share of Manufacturing Value Added (% of GDP)

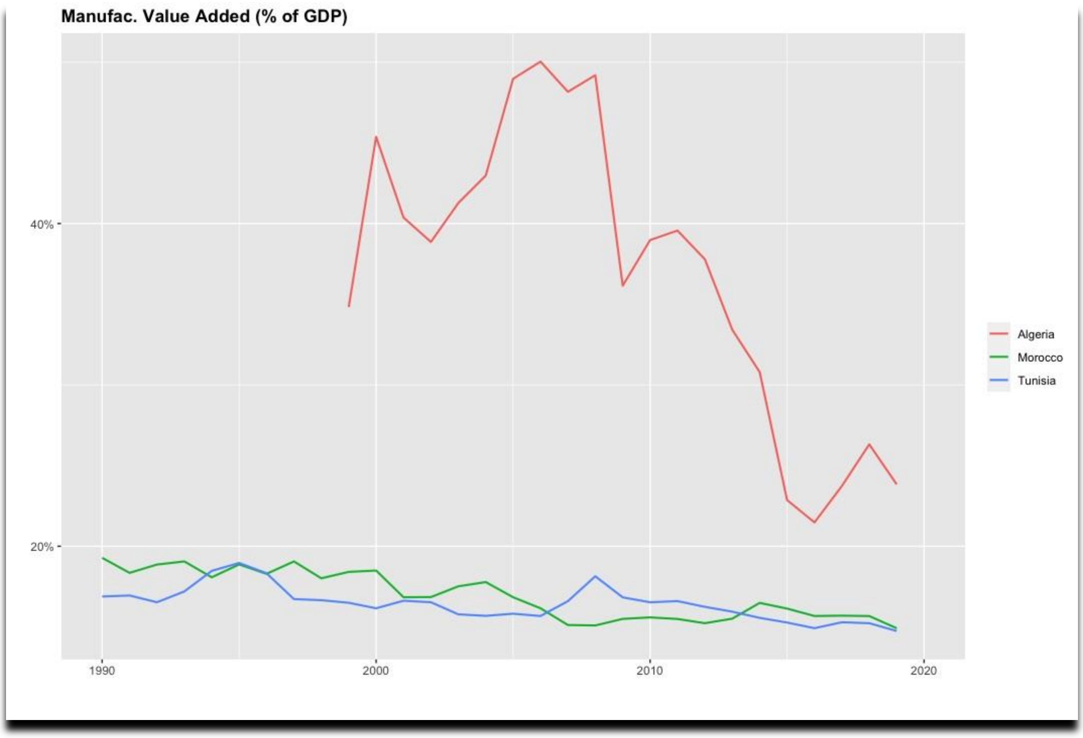


Figure D.9: Energy Consumption per capita

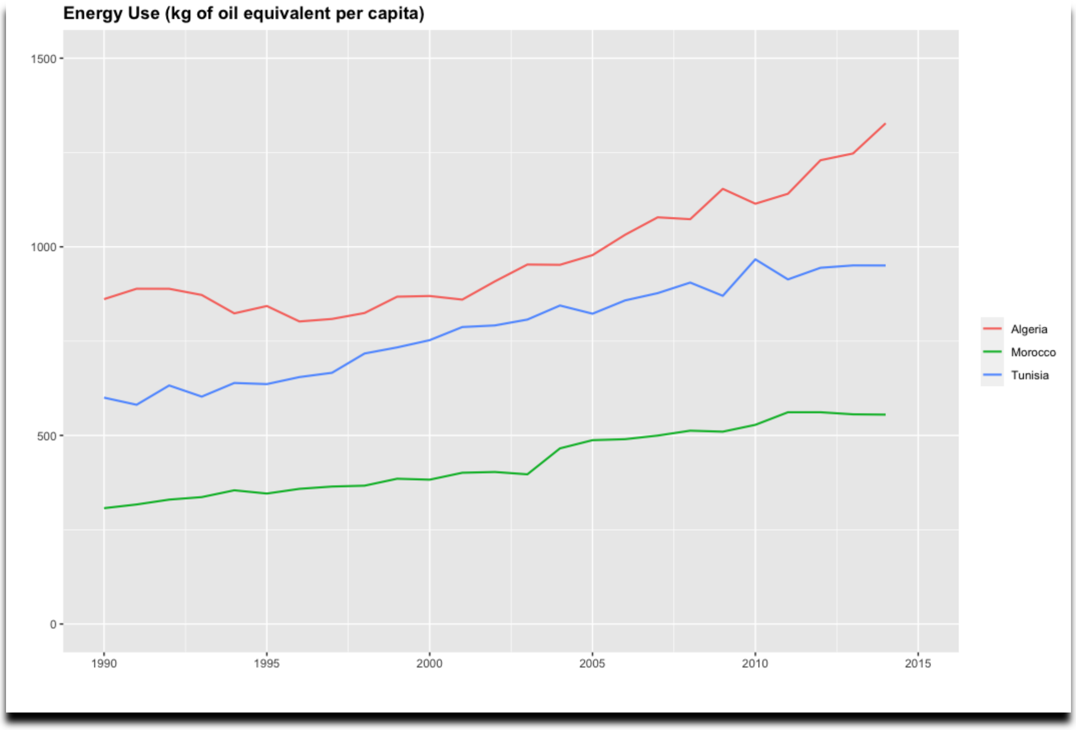
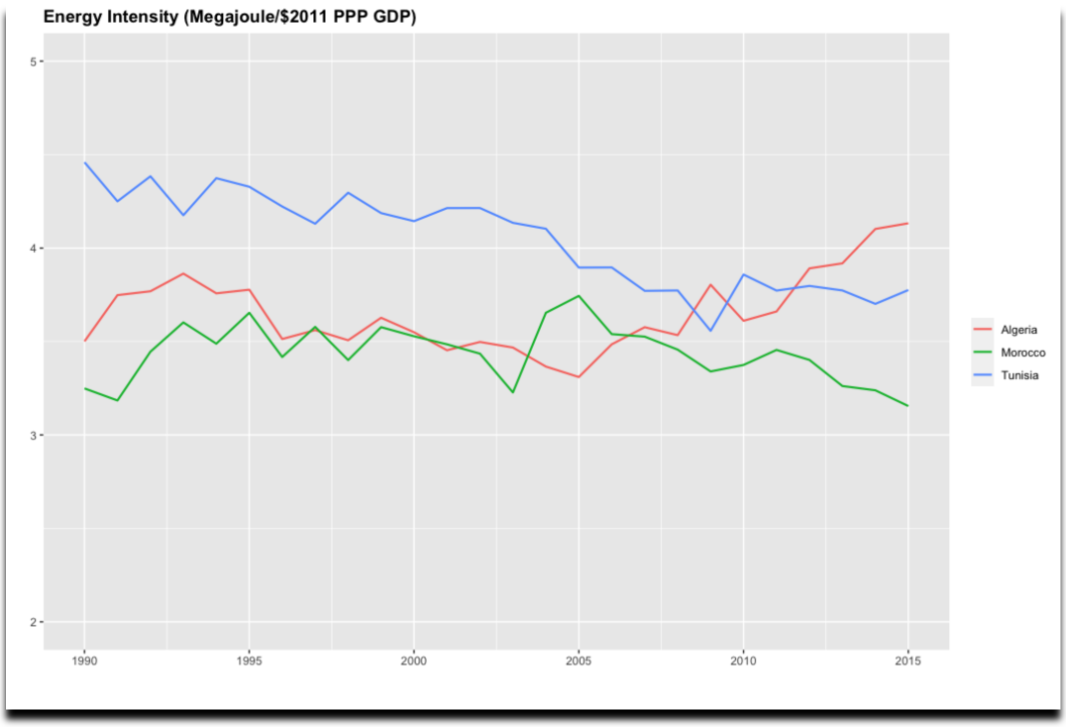


Figure D.10: Energy Intensity



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