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## ► To cite this version:

Anis Omri, Sami Ben Jabeur. Climate policies and legislation for renewable energy transition: The roles of financial sector and political institutions. 2024. hal-04569311

**HAL Id: hal-04569311**

**<https://hal.science/hal-04569311v1>**

Preprint submitted on 6 May 2024

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# Climate policies and legislation for renewable energy transition: the roles of financial sector and political institutions

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## *Abstract*

Given the urgent need to address global ecological degradation and its accelerating impacts, countries worldwide are increasingly prioritizing the acceleration of the transition to renewable energy sources. In this quest for green development, economies are motivated to enact enabling policies and supportive legislation to facilitate an expedited transition. Within this context, the present study seeks to investigate the roles of financial development and political institutions—particularly corruption control, civil society participation, and democracy—as conditional factors that support clean energy policies and climate change legislation (laws and regulations) in accelerating renewable energy transition in the top-10 polluting economies between 1996 and 2019. By applying the augmented mean group technique, the empirical findings indicate that clean energy policies and climate change laws and regulations alone are ineffective in driving the transition to renewable energy. However, financial development and certain political institutions—such as corruption control, civil society participation, and democracy—have been identified as key contributors to this transition. The effectiveness of clean energy policies in accelerating the renewable energy transition depends on a well-developed financial sector to implement and enforce these policies effectively. Enacting clean energy policies, along with environmental laws and regulations, while supported by a well-developed financial sector, accelerates the transition to renewable energy. Moreover, enacting such policies and laws, coupled with strong corruption control and higher active civil society participation, creates an environment that enables the transition to renewable energy.

**Keywords:** Environmental legislation; Renewable energy policies; Renewable energy consumption; Financial development; Political institutions

## 1. Introduction

Climate disruption represents an urgent environmental challenge in the modern world, primarily due to the reliance on fossil fuels and the ensuing carbon dioxide (CO<sub>2</sub>) emissions. These conventional energy sources account for over 80 percent of global energy consumption (Liu et al., 2023). However, increasing concerns regarding climate change have led to countries worldwide prioritizing the transition to sustainable energy sources, requiring fundamental change in the energy sector, in which traditional fossil fuels are replaced with zero-emission alternatives, such as geothermal, hydro, solar, wind, and bioenergy over the next half-century (Ren et al., 2023; Wei et al., 2023). Ultimately, the United Nations' 17 Sustainable Development Goals (SDGs) provide a universal roadmap for tackling pressing global issues, paving the way for a more sustainable and equitable future for all (Dhahri and Omri, 2018). They also represent a call to address the urgent need to redirect humanity's trajectory away from unsustainable development practices (Omri et al., 2022). The UN's 2030 Agenda for Sustainable Development emphasizes the importance of taking bold and transformative actions to guide societies toward a more sustainable and resilient future.

Renewable energy transition (RET) has been identified as a key driver of this transformation, enabling the shift toward cleaner and more sustainable energy sources. It holds vital importance in achieving SDG 7, which aims to ensure access to sustainable and clean energy for everyone. By increasing the share of renewable energy in the global energy mix, countries can improve access to affordable and sustainable energy, particularly in remote and underserved areas. This can have a positive impact on poverty alleviation, health outcomes, and overall well-being (Kahia et al., 2020: 2021). Furthermore, renewable energy also intersects with SDG 9, leading to adoption of renewable energy technologies to foster innovation, driving technological advancements, and supporting development of sustainable infrastructure. It also creates new job opportunities, promotes economic growth, and enhances industries' competitiveness in the clean energy sector (Cappellaro et al., 2022).

It also aligns with SDG 13, which calls for shifting away from fossil fuels to reduce carbon emissions and help mitigate impacts from climate change. Furthermore, renewable energy sources have smaller carbon footprints and offer a more sustainable pathway for meeting energy demand while reducing greenhouse gas emissions (He et al., 2023; Omri et al., 2023). Therefore, the transition to renewable energy is a crucial component in achieving SDGs, as it addresses climate risks, promotes sustainable economic development, enhances energy access, and fosters innovation and resilience. Governments, businesses, and communities can make significant strides toward a more sustainable and inclusive future by prioritizing REIT and integrating it into national and international policies.

Researchers from several domains are looking for the factors that influence the shift toward sustainable energy sources. For example, political scientists emphasize governmental policies and actions' crucial influence in reshaping a country's energy framework. They argue that the transition to renewable resources in a given country cannot be attributed solely to economic factors, underscoring the importance of political intervention. The transition to renewable energy sources depends on not only environmental and energy policies, but also strong and effective institutions (Mahmood et al., 2021; Gielen et al., 2019; Zheng et al., 2022; Ren et al., 2023). This article seeks to test existing theories and shed new light on how the implementation of clean energy policies (CEPs) through climate change regulations and laws stimulates the transition to renewable energy. Strong and well-developed institutions play a vital role in establishing and implementing regulatory frameworks for clean energy and environmental policies, developing clear and enforceable regulations, standards, and guidelines that govern renewable energy development, emissions reductions, pollution control, and other environmental objectives. A solid institutional framework provides a solid foundation for effective enforcement (Lægreid and Povitkina, 2018). In the same vein, Gunningham (2011) hypothesized that effective implementation of such policies and legislation requires institutions that can enforce laws and regulations effectively. Through a comparative analysis of intervention strategies that environmental organizations have employed in Australia, the Netherlands, the United Kingdom, and the United States, Gunningham underscored the need for governments to invest in and

strengthen enforcement institutions to guarantee the efficacy of ecological strategies and legislation. Similarly, Vowles (2008) has contended that well-established institutions are crucial to the successful implementation and enforcement of CLPs, including regulation of energy usage toward environmental sustainability. Specifically, he argued that robust, stable governance structures are vital to applying renewable energy initiatives effectively and managing consumption in a manner that upholds environmental standards. Therefore, environmental and political theory scientists assume that institutional quality is necessary for the efficient implementation of policies and laws supporting the transition to renewable energy.

However, economists tend to agree that this shift faces various challenges and barriers, including high investment costs associated with renewable energy deployment. In addition to local institutions, implementation and enforcement of clean energy and environmental policies also need more initial financial outlays compared with traditional energy sources. To support the advancement and implementation of renewable energy, a robust financial market is crucial. A well-functioning financial sector elicits substantial advantages for renewable energy industries, particularly those that depend on external financing (Habiba and Xinbang, 2023; Song et al., 2023). According to Minier (2009), expansion of financial markets can impact a country's investments through two main channels: a “level effect” and an “efficiency effect.” Regarding the level effect, as financial markets become more developed, investors are better able to obtain funding for their investment projects, leading to higher overall investment levels. As for the efficiency effect, developing financial markets fosters greater diversification of investments and increased liquidity of assets, thereby allowing funding to flow to riskier, but higher-return, projects. More specifically, a well-developed financial sector can be a driving force for shifting to renewable resources by channeling investment toward such promising technologies. Liu et al. (2023) conducted a study focusing on the G7 nations to analyze the impact of renewable energy investment, financial development, and environmental legislation on the transition to renewable energy. Their findings revealed that the interaction effect of ecological regulations and financial development on the shift to renewable energy makes a relatively more

powerful impact than each factor individually. Therefore, we can assume that by combining environmental and energy policies with financial development, stakeholders can harness the resources, expertise, and mechanisms provided by the financial sector to expedite the shift toward renewable energy sources and attain environmental sustainability objectives.

However, although much research has postulated such contingent relationships, these researchers have not modeled these conditional effects or used relevant econometric methods to examine the relationships empirically. To address this literature gap, this paper aims to answer the following question: (1) How do climate change legislation (CLL) and renewable energy policies influence renewable energy transition? Do financial development and institutional quality affect the transition to renewable energy? Do financial development and institutional quality complement these policies and legislation for the transition to renewable energy? To answer these questions, this paper aims to investigate CLPs and environmental legislation's influence on RET empirically, taking into account the conditional effects of financial sector development and political institution factors. The paper specifically focuses on investigating the roles of financial development and political institutions—particularly corruption control, civil society participation, and democracy—as conditional factors that support CLPs and CLL (laws and regulations) in accelerating RET in the top-10 polluting economies between 1996 and 2019. One of the main reasons for selecting these countries was because they are the highest carbon emitters and the largest contributors to global gross domestic product (GDP). According to the World Bank, these countries were responsible for nearly 66% of global carbon emissions and accounted for approximately 62% of global GDP in 2018 (Sun et al., 2022).

The paper makes several contributions to the literature in the following ways. First, the study incorporates insights from multiple disciplines, including economics, energy, and environmental politics. By integrating theories and perspectives from these diverse fields, the paper offers a more holistic understanding of the factors that influence RET. This interdisciplinary approach enhances the richness and comprehensiveness of the theoretical framework proposed in this study. Second, while previous studies have acknowledged environmental regulations' role in promoting the transition to

renewable energy, such as the enactment of ecological taxes (Fang et al., 2022) and stringent environmental regulations (Liu et al., 2023), there has been a notable lack of emphasis on the importance of CLPs and CLL. To the best of our knowledge, this paper represents one of the few studies that specifically investigates the effects of CLPs, as well as regulations and laws related to climate change, on the transition toward renewable energy. Third, we examine the underlying moderation mechanisms that explain how CLPs and environmental legislation promote RET. Investigating institutions and financial development's conditional effects contributes to the study's goal of uncovering the underlying mechanisms through which CLPs and environmental legislation promote RET. This analysis provides valuable insights for policymakers and stakeholders in designing effective strategies and interventions to accelerate the shift toward renewable energy sources.

This paper is organized as follows. First, we introduce the methods used, including the overall research design, data sources, and analytical approaches. We then reveal and discuss the obtained findings. We then summarize the main findings. Finally, we consider these findings' implications for practice and decision-making.

## **2. Literature review**

### *2.1. Determinants of renewable energy transition*

In light of climate change and energy crises, nations worldwide are taking action to limit their use of fossil fuels, curb their greenhouse gas emissions, and increase the transition to clean energy (Liu and Feng, 2023; Stef and Ashta, 2023; Acheampong et al., 2023). Previous research has identified numerous economic, technological, and political determinants that potentially could influence advancement of RET (Przychodzen and Przychodzen, 2020). Government plays a crucial role in fostering the growth of emerging markets associated with renewable energy production (Cao et al., 2022; Appiah et al., 2023; Estevão and Lopes, 2024). Making progress on renewables requires both supportive policies and legislation, as well as quality governance structures that facilitate policy creation, implementation and compliance. Sound institutions help determine how well a country can establish supportive renewable policies, translate plans into concrete actions, and ensure that policies

achieve their aims (Liu et al., 2023). Legislation is a crucial tool that governments have used to achieve their goals in environmental regulation (Watson, 1978).

Institutional theory serves as an alternative theoretical framework to prior studies that mostly have examined market dynamics, shedding light on how regulatory institutions can play a pivotal role in promoting renewable energy adoption (Glover et al., 2014). According to Damania (2002), the presence of inefficient bureaucracies and pervasive corruption not only hampers enforcement of environmental laws and regulations but also undermines any potential environmental benefits that could be derived from a democratic system. In this context, Tzankova (2020) examined corporate demand for renewable energy in private environmental and energy governance. The authors found that this engagement can accelerate energy transitions by altering the political landscape. By strengthening public-private coalitions for decarbonization and encouraging regulatory feedback, public-private governance interactions in the US electricity sector can destabilize carbon lock-in, directly increasing renewable generation and turning corporate buyers into advocates for decarbonization policies. Bashir et al. (2022) also investigated the impact of environmental taxes, regulations, and technologies on renewable energy consumption in 29 OECD countries from 1996 to 2018. Their analysis revealed that ecological regulations exerted a hindering effect on clean energy consumption in these economies. Biresselioglu and Karaibrahimoglu (2012) investigated government orientation's effect on clean energy consumption in Europe from 1999 to 2009 and found that left-leaning governments, regardless of whether they were single-party or coalition, exerted a significant positive effect on renewable energy consumption. However, right-leaning governments exerted a significant negative influence on clean energy consumption. In a growing movement, academics are advocating for a clearer distinction between ecological policy and environmental law (Heffron et al., 2018). As Liu and Feng (2023) pointed out, compared with environmental policy, environmental law offers greater predictability and longevity. Environmental regulations in each country are codified within its laws, necessitating rigorous oversight. However, legislation can guide and govern the creation and execution of regulatory policies. From a policy, legal, and regulatory perspective, Obeng-



Darko (2019) found that the absence of legislative tools within regulatory bodies was a major factor in Ghana's inability to implement a renewable energy policy. Overall, as Stef and Ben Jabeur (2020) pointed out, national environmental policy should prioritize two strategies: enhancing institutional quality and consistently updating environmental laws via amendments, decrees, and orders.

## *2.2. The roles of political institutions and financial sector development*

Formal (e.g., policies, regulations, and standards) and informal (e.g., norms and behavior) institutions play a crucial role in facilitating RET (Jacobsson and Lauber, 2006). Effective institutions reduce policy uncertainty and enable enforcement of environmental laws and quality standards, thereby giving investors' confidence to invest in renewable projects spanning decades (Stef and Ben Jabeur, 2020). In this context, Sovacool (2016) reviewed research on institutions' role in energy transitions and found that robust legal frameworks, transparent decision making, and effective enforcement structures facilitate innovations needed for stable renewable transitions. Similarly, Babayomi et al. (2023) reviewed how governance hinders or enables investments in renewable mini-grids in sub-Saharan Africa, and they concluded that secure property rights, streamlined regulations, and low corruption were linked to greater renewable electricity access. Using data from the Middle East/North Africa (MENA) region, Komendantova et al. (2012) conducted a study on risk perceptions within the renewable energy investment market, and they emphasized the significance of the legal environment and government effectiveness, particularly highlighting shortcomings in North African countries. They found that many MENA countries face obstacles in attracting investment due to complex and lengthy bureaucratic procedures and corruption, leading to unpredictable investment volumes. In addition to institutions, some other scholars have argued that financial sector development is integral to this transition (e.g., Irfan et al., 2023; Habiba and Xinban, 2023). Financial instruments, services, and institutions determine how renewable energy projects receive funding, the risks involved, and such ventures' overall economic feasibility (Wüstenhagen and Menichetti, 2012). Saadaoui (2022) studied the impact of institutional aspects and financial development on the shift toward sustainable energy sources in the MENA region between 1990 and 2018, finding that while

institutions play a significant role in the long-term transition to renewable energy, the present financial system is not providing adequate support for sustainability. Similarly, Liu et al. (2023) examined the importance of transitioning to renewable energy and its impact on reducing carbon emissions, focusing on G7 countries from 2000 to 2020 and identifying factors that influence this transition. Their findings indicate that increased investment in green energy, improved financial systems, and stricter environmental regulations contribute to sustainable energy transition.

Despite their direct effects on RET, an emerging strand of literature has been highlighting the complementarity effects between renewable energy and environmental policies, including how both the quality of governance and progression of finance affect the shift toward renewable energy. However, Mahmoud et al. (2021), Meya and Neetzow (2021), Adom et al. (2023), Appiah et al. (2023), and Omri and Boubaker (2024) have argued that the shift toward renewable energy depends not only on environmental and energy policies but also on strong and effective institutions. Therefore, a solid institutional framework plays a crucial role in ensuring effective enforcement of regulations and policies, providing the necessary structure, mechanisms, and processes to support and facilitate enforcement efforts (Laegreid and Povitkina, 2018). Lu et al. (2020) also concluded that an effective institutional framework provides the necessary tools and mechanisms to monitor compliance with renewable and environmental policies, enabling enforcement of regulations, standards, and penalties for non-compliance. A good governance framework focuses on building the capacity of institutions responsible for enforcing renewable and environmental policies by providing training, resources, and support to enhance their effectiveness in implementing and monitoring these policies (Stupak et al., 2021). Gunningham (2011) also theorized that for policies and laws to make their intended impact, institutions must have the ability to implement and uphold such directives effectively. Through a comparative study of various environmental groups' approaches in Australia, the Netherlands, the UK, and the US, Gunningham (2011) emphasized the importance of governments investing in and bolstering the enforcement bodies responsible for environmental compliance to guarantee that policies and statutes achieve their desired effects in improving sustainability outcomes. Recently,

Nachtigall et al. (2024) pointed out that countries enhanced their climate action from 1990 to 2022 by increased policy adoption and stringency. Policy adoption and stringency have varied throughout time across country groups. Moreover, their analysis indicates a significant correlation between more robust climate action and more considerable reductions in emissions. Moreover, Xi et al. (2023) examined the effect of climate policy uncertainty on renewables consumption. Their findings revealed that climate policy has a significant effect on solar and wind energy. Kahia et al. (2017) explored the impacts of renewable energy (RE) policies on economic growth in MENA countries. The authors found that in MENA regions that have adopted these energy policies, the treatment effect of RE policies has a significant and favorable influence on boosting and fostering economic development.

However, other scholars have argued that enforcement of such policies, and legislation requires a well-developed financial sector. For instance, Prempeh (2023) argued that financial development plays a vital role in implementing renewable energy policies by providing access to capital, facilitating investment and funding, mitigating risks, supporting market development, aligning financial incentives, fostering innovation, and building capacity in the renewable energy sector. In this sense, Kahia et al. (2019) demonstrated that increases in international commerce, renewable energy, and foreign direct investment contribute to reductions in carbon dioxide emissions. In this puzzle, Liu et al. (2022) noticed that integrating new technology and financial development is crucial for achieving long-term sustainable growth. Song et al. (2023) recommended that the government aggressively support contemporary financial innovations (such as green finance) to develop renewable energy. Financial institutions must help the renewable energy sector with even more green credits. Similarly, Liu et al. (2023) studied the influence of renewable energy investments, financial sector development, and environmental policies on the transition to renewable energy sources among G-7 countries. They found that the combined impact of environmental regulations and financial development on shifting to renewables exerted a comparatively stronger effect than individual factors. They assumed that by combining environmental and energy policies with financial development, stakeholders could leverage the resources, know-how, and systems available through financial channels to accelerate the switch to

renewable alternatives and reach environmental targets. This collaboration between regulatory frameworks and financial institutions empowers stakeholders to address the financial and economic aspects of renewable energy adoption effectively.

While good governance and financial development have been recognized as crucial factors in gauging the efficiency of sustainable energy and environmental regulations, previous studies have not demonstrated empirically how their interactions facilitate the transition to clean energy. The present study aimed to fill this literature gap by examining how the implementation of CLPs and CLL for RET depends on the country's governance quality and financial sector development.

### **3. Empirical strategy**

#### *3.1. Data and variable description*

This study used a sample of top polluting countries<sup>1</sup> from 1996 to 2019. Due to limited data availability regarding CLPs and climate change laws and regulations, China and Saudi Arabia—which are the first and ninth most polluting economies, respectively—were not included in the empirical analysis. The criteria for the countries that were selected entailed their status as top carbon emitters and significant contributors to global gross domestic product. The dependent variable was renewable energy transition (RET), which is measured as the share of renewable energy consumption in global energy consumption (Liu et al., 2023). *Politics*, the key independent variable, measured clean energy policies (*CLPs*) and climate change legislation (*CLL*). Following Zhao et al. (2013), *CLPs* were measured by integrating six distinct policy instruments: (a) investment incentives to reduce upfront investment costs associated with deploying clean energy technologies; (b) tax incentives to encourage the use and development of clean energy technologies; (c) feed-in tariffs to guarantee clean energy producers fixed and cost-based prices for the electricity they generate; (d) voluntary programs to encourage socially responsible actions, such as consumers' voluntary purchase of clean energy; (e) production quotas that mandate a minimum requirement for the supply of electricity generated from clean energy sources; and (f) tradable certificates to provide a market-based mechanism for meeting

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<sup>1</sup> China, India, Russia, Japan, Germany, the United States, Iran, South Korea, Saudi Arabia, and Indonesia.

clean energy commitments. A dummy variable (*CLP\_D*) took the value of 1 for a given country-year if that country implemented any of the listed policies during that time and 0 if none were in place (Carley, 2009; Zhao et al., 2013; Kahia et al., 2017). *CLL*, the second political variable considered in this study, refers to climate change laws and regulations. The variable *laws* quantified the annual total of new climate change-related statutes or regulations passed within a country. Meanwhile, *regulations* tallied the number of national climate change policies adopted in a given year, as measured by new legislation enacted at the domestic level. The variable *SUM* quantified the overall number of new laws and regulations implemented during the specified time period. *Laws\_D* is a dummy variable that equals 1 if a country implemented at least one new law related to climate change in a specific year, and 0 if no new laws were enacted. *Regulations\_D* is a dummy variable that equals 1 if a country implemented at least one new regulation related to climate change in a specific year, and 0 if no new regulations were enacted. *SUM\_D* is a dummy variable that equals 1 if a country adopted at least one climate change law and/or regulation in a specific year, and 0 otherwise.

The two conditional independent variables included are Financial Development index (FD) and political institutions (PINST). FD is a comprehensive metric that provides a comparative assessment of nations' financial institutions and markets, considering their depth, accessibility, and efficiency. It combines two sub-indices—the Financial Institutions index and the Financial Markets index—to provide a comprehensive assessment of a country's financial development. PINST is measured using three indicators: corruption control index; democracy index; and index of civil society participation. *Control of corruption* evaluates the degree to which public policies and institutions effectively prevent and fight corruption. It ranges from approximately -2.5 (worst) to 2.5 (best). A higher value means greater corruption control (Stef & Ben Jabeur, 2020). Democracy was measured using the *Polity IV index* (Kahia et al., 2017; Vaccaro, 2021), which has a 21-point scale ranging from -10 (high autocracy) to +10 (high democracy). The *civil society participation index* measures the strength and level of engagement of civil society within a particular society or country. It typically is scaled from 0 to 1, with a higher value indicating a greater degree of activity and involvement in civil society.

The model also used several control variables to address omitted variables' potential influence: GDP per capita growth; urbanization (as a percentage of total population); CO2 emissions per capita (as kg of oil equivalent); and human capital (as the number of students enrolled in secondary schools as a percentage of total student enrollment).

Table 1 presents the sources of the used variables and their descriptive statistics, including their means, standard deviations, and lowest and highest values. The data indicated that during the study period, the average annual rate of RET was approximately 13 percent, with India exhibiting the highest values and Indonesia the lowest. The average annual value of CLPs is around one policy per year, with Germany having the highest values. Furthermore, the average values for the number of laws and regulations are approximately 0.2 and 0.3 per year, respectively. It was found that the number of regulations surpassed the number of laws. This discrepancy can be attributed to the fact that developing entirely new environmental legislation requires significantly more effort than implementing amendments or decrees. It was plausible that some legislators opted to update existing environmental laws through decrees or amendments instead of drafting entirely new legislation. Regarding the institutional variables, it was found that the corruption control index had the lowest average value, at approximately 0.3. Conversely, the civil society participation and democracy indices exhibited the highest values, at around 0.7 and 6.6 on average, respectively. The average value of the FD was around 0.6 during the study period. According to Table 2, during the study period, the United States emerged as the most proactive country in implementing new CLPs, with a total of 56 policies. Following closely behind were India, with 50, and Germany, with 47. In terms of climate-related laws, Germany surpassed other countries with 20 laws, while two other countries, Iran and Russia, reported no new climate change laws. Furthermore, Germany emerged as the most active country in creating regulations to address climate change, with 22 regulations, followed by Indonesia, with 14, and Russia, with nine.

**{Insert Table 1 here}**

{Insert Table 2 here}

### 3.2. Model specifications and estimation strategy

This study aimed to examine CLPs and CLL's (laws and regulations) effects on RET in the presence of political institutions and financial development as conditional variables. We first estimated the impacts of these policies and legislation on RET using the following equation:

$$RET_{it} = \alpha + \beta Politics_{it} + \delta Z_{it} + \mu_i + v_t + \varepsilon_{it} \quad (1)$$

in which  $RET$  was a measure of RET as a percentage of renewable energy consumption in global energy consumption.  $Politics$  measured the natural logarithm of the number of CLPs and enacted climate change laws and regulations.  $Z$  indicates the vector of control variables.  $\alpha$ ,  $\beta$ ,  $\delta$ ,  $\mu$ ,  $v$ , and  $\varepsilon$  are the constant, the coefficients of the political indicators, the coefficients of control variables, the country's fixed effect, the time's fixed effect, and the error term, respectively. The symbols  $\beta$  and  $\delta$  represent the marginal effects of their associated variables on RET while holding other independent variables constant.

To consider financial development and political institutions' conditional effects on the relationship between the  $Politics$  indicators and renewable energy emissions, we rewrote Equation (1) as follows:

$$RET_{it} = \alpha + \beta Politics_{it} + \gamma COND_{it} + \theta (Politics_{it} * COND_{it}) + \delta Z_{it} + \mu_i + v_t + \varepsilon_{it}$$

(2)

in which  $COND$  indicates the conditional effects of financial development (FD) and political institutions (PINST). FD is measured by financial development index, which combines two sub-

indices, namely the financial institutions index and financial markets index. Different PINST measures—such as regime type, civil society participation, and corruption—were included to assess local institutions’ role in the execution of CLPs and CLL.  $Politics*COND$  is the interaction between the two conditional variables and both CLPs and CLL,  $\gamma$  is the coefficient of the conditional measures, and  $\theta$  is the coefficient of the interaction impacts. Thus, we expected that the political variables would drive the transition to renewable energy in the presence of the conditional variables.

When decomposing these conditional variables, the following equations were estimated:

$$RET_{it} = \alpha + \beta Politics_{it} + \gamma FD_{it} + \theta (Politics_{it} * FD_{it}) + \delta Z_{it} + \mu_i + v_t + \varepsilon_{it}$$

(3)

$$RET_{it} = \alpha + \beta Politics_{it} + \gamma PINST_{it} + \theta (Politics_{it} * PINST_{it}) + \delta Z_{it} + \mu_i + v_t + \varepsilon_{it}$$

(4)

in which FD is the Financial Development index, and PINST is political institution measures. As discussed above,  $\theta$  was expected to be positive.

Before estimating Equations (3) and (4), we began our analysis by testing for cross-sectional dependence. As Baltagi et al. (2012) noted, individual and temporal dependence can impact panel data analysis due to increasing interactions between countries over time. We employed the bias-adjusted LM (LMadj) test proposed by Pesaran et al. (2008) for this purpose. As Pesaran et al.’s (2008) results indicate, as does Baltagi et al.’s (2012) bias-corrected scaled LM test (the results of which are reported in Table 3), the variables included in the two models (Model 1: Equation 3; Model 2: Equation 4) exhibited cross-sectional dependence. In addition to addressing cross-sectional dependence, slope coefficients’ homogeneity in panel estimation models needs to be examined. Previous research often has assumed slope homogeneity, which may not reflect the reality of varying effects across different countries, firms, or other relevant variables. Failing to account for this heterogeneity can result in



biased predictions, particularly when studying the nexus of economic, environmental, and institutional variables. These variables' impacts on RET can differ from country to country due to variations in energy sources, development levels, and policy preferences. Assuming slope homogeneity among higher-polluting countries when analyzing the aforementioned variables can lead to misleading results. Therefore, it is crucial to assess slope homogeneity's validity before employing standard panel data methodologies to ensure reliable findings. Pesaran and Yamagata (2008) proposed using the delta tilde ( $\tilde{\Delta}$ ) and delta tilde-adjusted ( $\tilde{\Delta}_{adj}$ ) tests to evaluate slope homogeneity. These tests help determine whether the assumption of homogeneity is valid or whether significant variations exist in the effects across different entities within the panel data. Table 3 reports these tests' results, namely that slope homogeneity's null assumption also was rejected, suggesting that the slope coefficients of the examined variables exhibited significant variations across different entities within the panel data. When estimating panel data, addressing non-stationarity is crucial. To examine the variables' integration order, the cross-sectionally augmented IPS test (CIPS; Im, Pesaran, and Shin, 2007) was applied. This test is particularly useful, as it controls for cross-sectional dependence, which is not accounted for in first-generation unit root tests. The findings presented in Table 4 indicate that all variables were integrated at order one. To verify the existence of enduring connections among the variables used in the examination, it is advisable to employ the Westerlund (2008) panel cointegration test, which takes into account the potential cross-sectional dependence present in the data. The results, presented in Table 5, demonstrate that the null hypothesis, which suggests no cointegration, is rejected based on the models that were evaluated. This confirms the existence of a long-term relationship between RET and its determinants.

**{Insert Table 3 here}**

**{Insert Table 4 here}**

**{Insert Table 5 here}**

In this paper, we used the augmented mean group (AMG) estimator developed by Eberhardt (2012) to forecast RET's long-term elasticities. This estimator combines the advantages of the mean group (MG) estimator and dynamic fixed effects (DFE) estimator. The MG estimator assumes slope homogeneity across entities, while the DFE estimator allows for entity-specific slope coefficients but does not account for cross-sectional dependence. The AMG estimator addresses these limitations by incorporating both slope heterogeneity and cross-sectional dependency (Zaho et al., 2013). This two-step estimator is commonly used to estimate panel time series models with heterogeneous slopes (Neal, 2015). In the first step of the AMG method, the model is estimated by taking the first difference of the variables and including time dummies:

$$\Delta Y_{it} = \alpha \Delta x_{it} + \sum_{t=2}^T \delta_t \Delta D_t + \varepsilon_{it} \quad (5)$$

$$Y_{it} = \beta_i + \alpha_i x_{it} + d_i(\theta_i) + \varepsilon_{it} \quad (6)$$

in which  $\Delta$  is the first difference operator that measures the change over time,  $Y_{it}$  and  $x_{it}$  represent the dependent and independent variables,  $\alpha_i$  denotes the slope specific to each individual unit of observation,  $D_t$  signifies time dummy variables that control for economy-wide shocks and  $\delta_t$  are the coefficients attached to the time dummy variables. In the second step, the coefficients of the time dummy variables  $\delta_t$  are transformed into a new variable,  $\theta_i$ , in Equation 6, representing unobserved common factors that may influence underlying trends within each section/group, in line with the group-specific regressions.

#### 4. Results and discussion

The AMG estimates' results are reported in Tables 6–8. Table 6 reports the direct effects of CLPs, laws, and regulations pertaining to climate change, financial development, and the three indicators of political institutions (corruption control, civil society participation, and polity 2) in RET. The study's findings (Columns 1–4) suggest that while CLPs and climate change regulations exert a direct positive influence on moving toward renewable energy, this effect was not found to be statistically significant. The results are consistent with Hao and Shao (2021), who examined factors influencing renewable energy deployment across 118 countries. Their analysis similarly found climate policies' effects, particularly carbon tax policies, on stimulating renewable energy adoption to be positive yet statistically insignificant. Nevertheless, it was observed that nations exhibited more support for renewable energy when their economies reduced their reliance on fossil fuels and implemented appropriate incentive policies to promote growth in renewable energy sources. This indicates that while direct policy effects may be limited, broader economic and policy support contexts can amplify countries' RETs over time. This table also indicates that increases in financial development significantly increase RET. More specifically, a 1% increase in financial development increases the share of renewable energy in global energy consumption by 0.192 %. Prior research has demonstrated that advancements in the financial sector may be used to expedite the shift toward renewable energy (e.g., Olmos et al., 2012; Anton and Nucu, 2020; Falchetta et al., 2022; Liu et al., 2023). These studies indicated that access to finance plays a crucial role in enabling the transition to renewable energy due to its ability to mobilize both large pools of institutional capital required for major renewable infrastructure projects, as well as smaller amounts of private financing for households and businesses to invest in solutions such as solar panels or efficiency upgrades (Falchetta et al., 2022). A well-functioning financial system that provides access to long-term debt and equity financing helps address the high upfront costs of renewable technologies, supports innovation through risk capital for new renewable companies and technologies, and increasingly allows green bonds and specialized green financing vehicles to channel investments into clean energy projects that require patient capital to realize returns. Public policy measures aimed at developing targeted green

financial instruments and incentivizing private climate finance through investment mandates or loan programs can further reinforce the link between robust financial markets and higher deployment of renewable resources (Olmos et al., 2012).

Regarding the political institutions' indicators, the findings also indicate that solid political institutions' structures facilitate the transition to renewable energy. Specifically, a 1% increase in corruption control, civil society participation, and democracy increase the share of renewable energy in global energy consumption by 0.154%, 0.133%, and 0.151%, respectively (Columns 6–8 in Table 6). These results align with Abeka et al. (2022), who examined economic and political institutions' impacts on renewable energy production in 41 African countries. Their findings indicated that robust economic institutions are pertinent to boosting renewable energy levels deployed within Africa. Specifically, they found that both the size of government and the freedom to engage in international trade positively influenced renewable deployment, while stronger legal systems and property rights reduced production. Furthermore, the study's findings also indicated that political institutions moderated the link between renewable energy deployment and economic institutions. Thus, to progress toward achieving SDG 12 targets, African governments should bolster economic governance actively to increase energy deployment responsibly. However, such efforts are likely to yield much more significant benefits if accompanied by parallel improvements to political institutions. Within this framework, institutional theory—a different theoretical lens than earlier research that concentrated on market dynamics—might be viewed as an alternative. It highlights how regulatory institutions may make a crucial impact on advancing the use of renewable energy (Glover et al., 2014).

In all calculated models, the transition to renewable energy is impacted positively and statistically significantly by CO<sub>2</sub> emissions with regard to control factors, ranging from 0.193% to 0.303%. This result is in line with Szetela et al. (2022), who argued that high levels of CO<sub>2</sub> emissions and their negative consequences have raised global awareness about the need to transition to renewable energy sources. This heightened awareness has resulted in increasing backing and allocation of resources toward renewable energy technology and programs. Furthermore, the need to decrease

CO2 emissions has stimulated innovation and technical progress in the renewable energy industry. As countries and industries strive to reduce their carbon footprints, they invest in research and development of more efficient and cost-effective clean energy technologies. In all the models considered, a positive and statistically significant relationship exists between economic growth (measured by GDP per capita) and the shift to renewable energy, ranging from 0.183% to 0.256%. This result confirms the conservation hypothesis, indicating that economic growth can drive demand for energy, including renewable energy, as countries strive to meet their energy needs while reducing carbon emissions. However, economic growth also can pose challenges to RET due to the potential consequences of heightened energy use and dependence on non-renewable energy sources. Similarly, urbanization was found to make a positive and statistically significant impact on RET in all estimated models, ranging from 0.144% to 0.191%. This result indicates that urbanization can accelerate the transition to renewable energy by increasing energy demand, providing opportunities for infrastructure development, fostering technological innovation, enabling supportive policies, benefiting from economies of scale, and promoting public awareness and engagement (Dilanchiev et al., 2023). Human capital development exerts a consistently favorable and statistically significant effect on the transition to renewable energy in most of the calculated models, ranging from 0.117% to 0.173%. This result aligns with Akram et al. (2023), who argued that investing in human capital through education and training programs is crucial for building a skilled workforce in the renewable energy sector. Training programs can provide individuals with the knowledge and skills needed to design, install, operate, and maintain renewable energy systems. This helps create a pool of qualified professionals who can drive RET.

**{Insert Table 6 here}**

The results from the indirect effects of CLPs and CLL (laws and regulations) on RET are presented in Tables 7 and 8, respectively. The results presented in Table 7 indicate that financial development interacts with CLPs to facilitate the transition to renewable energies. The magnitude of 0.207 indicates that we expect an increase of approximately 0.21% in the share of renewable energy in

global energy consumption for a one-unit rise in financial development when at least one clean energy policy is implemented. This result indicates that the effectiveness of renewable energy policies should be accompanied by a well-developed financial sector to enforce such policies effectively. This result is in line with Liu et al. (2023), who studied the effects of renewable energy investments, financial sector development, and environmental policies on RET in G-7 countries. They demonstrated that the combined impact of environmental regulations and financial development on shifting to renewables exerted a comparatively stronger effect than individual effects. They assumed that by combining environmental and energy policies with financial development, stakeholders could leverage the resources, know-how, and systems available through financial channels to accelerate the switch to renewable alternatives and reach environmental targets. This collaboration between regulatory frameworks and financial institutions empowers stakeholders to effectively address renewable energy adoption's financial and economic aspects. Therefore, we can argue that countries with well-developed financial sectors may be better equipped to implement renewable energy policies effectively and reduce carbon emissions. Specifically, countries with well-developed financial sectors possess efficient finance systems that facilitate the availability of funds for renewable energy initiatives, including access to loans, grants, and other financing forms that can support the development and deployment of renewable energy technologies. These countries also attract more investment in renewable energy. Investors are more likely to invest in countries with stable financial systems and favorable investment climates. A surge in investment may facilitate the financing of renewable energy infrastructure and bolster the execution of renewable energy regulations. Such countries also have the capacity to design and implement effective renewable energy policies, including feed-in tariffs, tax incentives, renewable energy targets, and regulatory frameworks that encourage growth in renewable energy. The availability of financial resources and expertise in these countries can facilitate the development and implementation of such policies. These countries also have the resources to invest in research and development (R&D) on renewable energy technologies, which can lead to technological advancements, cost reductions, and improved efficiency in renewable energy systems. These countries

also can support innovation and collaboration through partnerships between research institutions, private companies, and government agencies.

Regarding the conditional effects of the three indicators of political institutions, Table 7 indicates that the interaction between corruption control and CLPs significantly impacts the transition to renewable energy. From the perspective of marginal effects, we anticipate an increase of approximately 0.18 % in the share of renewable energy in global energy consumption for a one-unit rise in corruption control when at least one clean energy policy is implemented, indicating that when countries prioritize both CLPs and effective corruption control, they provide a climate conducive to promoting development and acceptance of renewable energy technology. This result aligns with Adom et al. (2023), who investigated the influence of corruption control and regulatory quality on the transition to energy efficiency in Africa. They found that African nations may enhance their likelihood of upgrading from a low-energy-efficiency condition by enhancing regulatory quality and efficiently managing corruption. When corruption is controlled effectively, investors are more likely to trust that their investments will be protected and that the renewable energy sector will operate in a fair and transparent manner. This confidence attracts more investment, leading to increased funding for renewable energy projects (Lu et al., 2021). Therefore, enacting CLPs associated with higher corruption control can accelerate RET significantly. By addressing corruption and promoting transparency, countries can attract investment, ensure efficient policy implementation, reduce costs, promote fair competition, and enhance public trust, all of which contribute to the successful adoption of renewable energy technologies. This table also indicates that the interaction between civil society participation and CLPs significantly impacts the transition to renewable energy. The value of 0.166 suggests that for every one-unit improvement in the civil society index, accompanied by the implementation of at least one piece of clean energy legislation, we anticipate a roughly 0.17% rise in the percentage of renewable energy in global energy consumption. This result indicates that civil society organizations—including environmental groups, community-based organizations, and nongovernmental organizations (NGOs)—play a vital role in advocating for CLPs. They raise

awareness about renewable energy's benefits, educate the public, and mobilize support for sustainable energy solutions. They often collaborate with governments, private sector entities, and international organizations to drive RET. These partnerships foster knowledge exchange, resource sharing, and collective action toward achieving renewable energy goals (De Nigris and Giuliano, 2023). In a study that examined Tunisia, Akremi and Triki (2017) investigated the relationship between civil society participation and green energy transition, and they found that civil society stakeholders' opinions on energy sources have started to influence CLP formation and implementation. They play a significant and complementary role alongside the central government in increasing awareness about the transition to clean energy and positioning themselves in the movement toward a sustainable energy future.

**{Insert Table 7 here}**

The results presented in Table 8 indicate that financial development interacts with the three indicators of CLL (laws, regulations, and SUM) to accelerate the transition to renewable energies. The magnitudes of 0.179 (Column 1), 0.184 (Column 5), and 0.155 (Column 9) indicate that we expect increases of 0.179%, 0.184%, and 0.155%, respectively, in the share of renewable energy in global energy consumption for a one-unit rise in financial development when at least one law or regulation dealing with climate change is implemented, i.e., enacting environmental laws and regulations, along with well-developed financial sectors, accelerates RET by providing financial support, reducing risks, and stimulating innovation in renewable energy industries. These findings are consistent with Liu et al. (2023), who examined how investments in renewable energy, financial sector growth, and environmental regulations affected the switch to renewable sources among G-7 nations. Their findings revealed that the combined impact of environmental regulations and financial development exerted a stronger effect on the shift to renewables compared with individual factors. They suggested that by combining environmental and energy policies with financial development, stakeholders can leverage resources, knowledge, and systems available through financial channels to accelerate the adoption of renewable alternatives and achieve environmental targets. This collaboration between regulatory frameworks and financial institutions empowers stakeholders to effectively address renewable energy



adoption's financial and economic aspects. Similarly, Prempeh (2023) found that financial development plays a central role in implementing renewable energy policies, providing access to capital, facilitating investment and funding, mitigating risks, supporting market development, aligning financial incentives, fostering innovation, and building capacity in the renewable energy sector. Therefore, we can argue that a robust legal framework that includes policies, incentives, and regulations related to environmental protection creates a favorable environment for renewable energy investments. These laws and regulations can promote clean energy development, encourage the implementation of eco-friendly practices, and provide certainty and stability for investors. Furthermore, a well-established financial sector can facilitate financing of renewable energy projects through various mechanisms, such as green bonds, venture capital, and project financing. The combination of effective environmental regulations and a strong financial sector creates an environment that enables the rapid growth and deployment of renewable energy technologies, ultimately supporting the shift toward a greener and lower-carbon future (Mehmood, 2023).

Regarding the conditional effects of the three political institutions' indicators, Table 8 revealed that the interactions between these indicators and CLPs significantly accelerated the transition to renewable energy. From the perspective of marginal effects, we anticipated an increase of approximately 0.16% (Column 2), 0.154% (Column 6), and 0.144% (Column 10) in the share of renewable energy in global energy consumption for a one-unit rise in corruption control when at least one CLL (laws, regulations, and SUM) is implemented, indicating that when countries prioritize both environmental laws and regulations and control corruption effectively, they create an environment that fosters growth and adoption of renewable energy technologies. This finding is consistent with Stef and Ben Jabeur (2020), who asserted that achieving desired environmental outcomes necessitates government implementation, execution, and control of environmental regulations. Similarly, Damania et al. (2002) stated that even well-designed environmental regulations may prove ineffective if public officials are susceptible to corruption. Therefore, it can be inferred reasonably that governments with

stronger anti-corruption measures are more adept at enacting and enforcing regulations pertaining to environmental challenges, leading to accelerating the transition to renewable energy sources.

In addition to corruption control, interactions between civil society participation and the three indicators of environmental legislation significantly increase the transition to renewable energy. The magnitudes of 0.153 (Column 3), 0.171 (Column 7), and 0.143 (Column 11) indicate that we expected an increase of approximately 0.15%, 0.17%, and 0.14%, respectively, in the share of renewable energy in global energy consumption for a one-unit increase in the civil society participation index when at least one law or regulation dealing with climate change is implemented. These results indicate that combined efforts to enact environmental laws and regulations, along with active civil society participation, create an enabling environment for RE.T. This can lead to increased investments in renewable technologies, expanded deployment of clean energy projects, and a faster shift away from fossil fuels. In the end, this cooperative strategy may help alleviate climate change, decrease greenhouse gas emissions, and attain a more sustainable and resilient energy future. The present study's findings appear to be consistent with those of Akermi and Triki (2017), Nigris and Giuliano (2023), and Sadik-Zada and Gatto (2023), among others, who argued that civil society plays a vital role in raising awareness, advocating for renewable energy, and mobilizing public support. NGOs, community groups, and concerned citizens can engage in grassroots campaigns, education initiatives, and public outreach to promote the benefits of renewable energy. Their involvement helps create a groundswell of support and demand for renewable energy, pushing policymakers and industry stakeholders to prioritize its development. By engaging actively in monitoring and oversight, civil society can hold governments and industry accountable for their actions, ensuring that environmental laws and regulations are implemented and enforced effectively. This helps prevent greenwashing and promotes the genuine transition to renewable energy sources. Therefore, by combining supportive policy frameworks, active civil society engagement, and practical implementation, the transition to renewable energy can be accelerated, leading to reduced greenhouse gas emissions, improved energy security, and a more sustainable and robust energy system.

To sum up, Table 8 indicates that enforcement of such policies and legislation requires two key components to expedite the shift toward sustainable energy sources: a well-developed financial sector and a solid political institutional structure. A robust financial sector is essential to providing the necessary investment, funding, and financial mechanisms to support the transition to renewable and clean energy sources. This includes access to capital, innovative financing models, and mechanisms for attracting private sector investments in renewable energy projects. A well-functioning financial sector can help mobilize essential financial resources and reduce financial barriers associated with the transition. Moreover, a strong political institution's structure is necessary to establish and enforce effective environmental policies and legislation. It involves having transparent, accountable, and stable governance systems that promote good governance practices and ensure the implementation and enforcement of environmental regulations. This includes clear roles and responsibilities, effective coordination mechanisms, and the ability to make informed decisions based on scientific evidence and the public interest.

**{Insert Table 8 here}**

## **5. Policy implications**

These findings allow us to suggest some policy implications. As we found that the effectiveness of energy policies and environmental legislation in RET depends on the level of financial development, policymakers seeking to accelerate the uptake of renewable energy would be well-served to recognize the importance of developing enabling financial systems and implementing mechanisms that can unlock and direct more outstanding private capital flows toward clean energy investments. Measures such as expanding lending programs from commercial institutions, promoting green bonds, establishing public-private infrastructure funds, utilizing risk mitigation tools (e.g., guarantees and feed-in tariffs), and providing long-term policy predictability and stability are essential for attracting investors and lowering finance costs. International cooperation through strengthened multilateral development funding can also help address financing constraints in countries with weaker financial sectors. Regulators need policies that account for the unique risk-reward dynamics of renewable

projects compared with fossil fuels. Therefore, policymakers should establish clear and supportive regulatory frameworks that foster financial development in the RET. This includes implementing policies that promote transparency, accountability, and stability in the financial sector. Furthermore, regulations should be implemented to ensure that financial institutions consider environmental and social factors when making investment decisions, thereby facilitating the allocation of funds toward renewable energy projects (Li and Shao, 2023). In addition to financial development, we also found that CLPs and environmental laws and regulations should be accompanied by strong political institutions, particularly in terms of corruption control and civil society participation, to accelerate RET. Therefore, controlling corruption is crucial, as it ensures transparency, accountability, and fair competition in the renewable energy sector. Implementing anti-corruption measures—such as robust governance frameworks, effective enforcement mechanisms, and transparent procurement processes—can help prevent corruption and promote trust in the industry, attracting both domestic and foreign investment. Furthermore, active civil society participation plays a vital role in holding governments accountable and advocating for renewable energy policies. Governments should create avenues for public engagement, encourage dialogue, and involve civil society organizations in decision-making processes to ensure that community and environmental interests are represented. Furthermore, fostering an environment that protects and empowers civil society actors, including NGOs and grassroots organizations, enables them to contribute their expertise, mobilize public support, and ensure effective implementation of renewable energy initiatives. Finally, considering that climate change and renewable energy technologies are global in nature, international cooperation is paramount. The policymakers should endeavor to be part of international structures, agreements, and knowledge-sharing platforms that foster sharing of best practices, innovative technologies, and successful policy models around the globe. This partnership can enable nations, particularly those with developing economies, to skip to more sophisticated renewable energy systems and policies.

## 6. Conclusion

Ongoing discourse has been growing around the relative importance of strong state action vs. market-led solutions in enabling the widespread adoption of renewable resources. As a contribution to this discussion, this inquiry attempted to demonstrate whether political institutions and financial sector development were effective in implementing government policies and legislation to accelerate the transition to renewable energy in highly polluted economies between 1996 and 2019. Inspired by the literature gaps in this research area, this study empirically investigated the effects of national environmental policy and legislation on RET in interactions with financial sector development and a wide range of political institutional features, including democracy, corruption control, and civil society participation. Specifically, it examined whether implementing CLPs and CLL (laws and regulations) for the transition to renewable energy depends on the financial sector's developmental level and the quality of political institutions.

The results from the AMG estimator revealed that CLPs and CLL (laws and regulations) that deal with climate change alone were not found to be effective in driving the transition to renewable energy. Instead, financial development and certain political institutions—particularly corruption control, civil society participation, and democracy—were identified as key contributors to this transition. CLPs' effectiveness in accelerating RET was dependent on being accompanied by a well-developed financial sector to implement and enforce these policies effectively. The interaction between CLPs and both corruption control and civil society participation significantly impacted the transition to renewable energy, indicating that countries which prioritize CLPs and practice strong governance that promotes effective corruption controls and civic participation establish conditions that are conducive to renewable energy technology growth and adoption at scale. Financial development interacts with climate change laws and regulations to accelerate the transition to renewable energies, i.e., enacting environmental laws and regulations alongside a well-developed financial sector accelerates RET. The interaction between climate change laws and regulations, and both corruption control and civil society participation significantly impacted the transition to

renewable energy, indicating that combined efforts to enact environmental laws and regulations, along with strong corruption control and higher active civil society participation, create an enabling environment for RET.

In addition to this study's valuable contributions and implications, its limitations must also be examined. While financial development and institutional quality have been identified as key factors, future research in this area could examine additional transmission channels that influence the transition to renewable energy. Furthermore, investigating the thresholds at which these channels effectively reduce carbon emissions would provide valuable insights. Furthermore, the measure of RET used in this study is not exhaustive, suggesting a need for future research that incorporates alternative measurements to cultivate a more comprehensive understanding of the subject

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**Table 1**

Data definition and descriptive statistics (1996–2019).

Variable	Source	Observations	Average	Std.dev.	Min	Max
Renewable energy transition	WDI	192	13.066	15.670	0.44	49.26
Clean energy policies	IEA	192	1.072	1.914	0	14
Laws	FAOLEX		0.197	0.521	0	3
Regulations	FAOLEX	192	0.322	0.716	0	3
SUM (laws and regulations)	Authors' calculation	192	0.521	0.987	0	6
Polity IV index	Polity IV Project	192	6.630	5.004	-7	10
Control of corruption index	WGI	168	0.315	1.070	-1.176	2.053
Civil society participation index	V-Dem	192	0.742	0.237	0.12	0.986
Financial development index	IMF	192	0.606	0.207	0	1
Carbon dioxide emissions	WDI	192	6.665	5.580	0.787	20.469
GDP per capita	WDI	192	20276.834	18251.7	651.958	60698.011
Urban population	WDI	192	68.018	18.384	26.817	91.698
Human capital	WDI	155	85.665	17.086	43.035	104.506

Notes: this table presents the average, median, minimum, and maximum values of the variables used over the period 1996–2019. WDI, IEA, FAOLEX, WGI, V-Dem, and IMF indicate World Development Indicators, International Energy Agency, Food, Agriculture and Renewable Natural Resources Legislation Database, World Governance Indicators, Varieties of Democracy, and International Monetary Fund.

**Table 2**  
Number of CLP, laws, and regulations by country (1996–2019).

Country	CLP	Laws	Regulations	SUM (laws and regulations)
India	50	2	5	7
Indonesia	17	3	14	17
Iran	1	0	3	3
Germany	47	20	22	42
Japan	14	5	1	6
Russia	6	0	9	9
South Korea	16	5	2	7
United States	56	2	6	8

Notes: This table presents the total number of clean energy policies (CLP), laws, and regulations dealing with climate change implemented from 1996 to 2019.

**Table 3**  
Cross-sectional dependence and homogeneity tests results

	Cross-sectional dependence test			Slope homogeneity test		
	Test	Stat	p-value	Test	Stat	p-value
Model (1)	LM <sub>adj</sub>	23.276***	0.000	$\tilde{\Delta}$	23.981***	0.000
				$\tilde{\Delta}_{adj}$	27.074***	0.000
Model (2)	LM <sub>adj</sub>	19.083***	0.000	$\tilde{\Delta}$	21.144***	0.000
				$\tilde{\Delta}_{adj}$	23.849***	0.000

Notes:  $\tilde{\Delta}$  is delta tilde;  $\tilde{\Delta}_{adj}$  is delta tiled-adjusted; Model (1):  $RET=f(\text{Politics, FD, Politics*FD, Z})$ ; Model (2):  $RET=f(\text{Politics, PINST, Politics*PINST, Z})$ .

**Table 4**  
CIPS unit root test results.

Variables	CIPS ( $Z_t\text{-bar}$ )			
	Level		First difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend

Renewable energy transition (RET)	-1.233	-1.722	-4.478***	-6.115***
Clean energy policies (CLP)	-2.108	-2.405	-5.749***	-7.328***
Laws	-1.190	-1.642	-4.839***	-5.358***
Regulations	-1.839	-2.023	-5.103***	-5.933***
SUM	-1.414	-1.779	-4.370***	-6.402***
Polity IV index (Polity 2)	-1.089	-1.493	-4.648***	-5.321***
Control of corruption index (CC index)	-1.921	-2.115	-4.937***	-5.728***
Civil society participation index (CSP index)	-2.028	-2.352	-5.320***	-5.118***
Financial development index (FD)	-3.289***	-3.739***	-5.217***	-6.044***
Carbon dioxide emissions	-0.879	-1.289	-3.488***	-5.491***
GDP per capita	-1.128	-1.746	-4.003***	-5.374***
Urban population	-1.446	-1.772	-4.349***	-4.285***
Human capital	-1.791	-1.993	-4.321***	-5.566***

Note: The superscript \*\*\* indicates the significance at 1% level. All variables are in logarithms, except financial development index.

**Table 5**

Westerlund (2007) panel cointegration test results.

	Model (1)		Model (2)	
	Value	p-value	Value	p-value
Gt	-7.348***	0.000	-2.678	0.534
Ga	-23.677***	0.000	-11.457***	0.000
Pt	-19.274***	0.000	-18.840***	0.000
Pa	-13.506***	0.000	-12.006***	0.000

Note: The superscript \*\*\* indicates the significance at 1% level. H0: no cointegration. Leads and lags in the error correction test are automatically selected by the Akaike (AIC) criterion.

**Table 6**

Direct effects of Politics (CLP, laws and regulations) and conditional factors on renewable energy transition.

Variables	Renewable energy transition (RET)							
	Politics				Conditional factors			
	1	2	3	4	5	6	7	8
Clean energy policies (CLP)	0.128 (0.046)							
Laws		0.089 (0.028)						
Regulations			0.094 (0.116)					
SUM				0.119				

				(0.007)				
Financial development index (FD)					0.192*** (0.033)			
Control of corruption index (CC index)						0.154*** (0.026)		
Civil society participation index (CSP index)							0.133** (0.172)	
Polity IV index (Polity 2)								0.151*** (0.069)
Carbon dioxide (CO <sub>2</sub> ) emissions	0.295*** (0.079)	0.203*** (0.066)	0.193*** (0.055)	0.244*** (0.062)	0.303*** (0.103)	0.254*** (0.083)	0.198*** (0.092)	0.217*** (0.095)
GDP per capita	0.240*** (0.023)	0.275*** (0.058)	0.250*** (0.019)	0.197*** (0.046)	0.183*** (0.008)	0.256*** (0.072)	0.209*** (0.033)	0.248*** (0.051)
Urban population	0.158** (0.005)	0.139 (0.019)	0.161** (0.038)	0.144*** (0.003)	0.191*** (0.040)	0.162* (0.059)	0.121 (0.134)	0.183*** (0.024)
Human capital	0.093 (0.002)	0.117** (0.011)	0.136** (0.029)	0.064 (0.000)	0.146*** (0.056)	0.157** (0.038)	0.173*** (0.040)	0.146*** (0.060)
Constant	6.233*** (1.156)	5.168*** (0.948)	3.451*** (0.739)	4.048*** (0.729)	7.116*** (1.937)	5.003*** (1.037)	5.427*** (1.470)	4.345*** (0.844)

Notes: Standard errors in parentheses; \*, \*\*, and \*\*\* indicate the significance at 10%, 5%, and 1% levels, respectively.

**Table 7**

Indirect effects of clean energy policies on renewable energy transition.

Variables	Renewable energy transition (RET)			
	FD	CC	CSP	Polity 2
Clean energy policies (CLP)	0.102 (0.149)	0.079 (0.212)	0.094 (0.150)	0.115 (0.126)
Financial development index (FD)	0.177*** (0.036)			
Control of corruption index (CC index)		0.173*** (0.008)		
Civil society participation index (CSP index)			0.147*** (0.021)	
Polity IV index (Polity 2)				0.156*** (0.049)
CLP*FD	0.207***			

	(0.089)			
CLP*CC		0.184*** (0.093)		
CLP*CSP			0.166*** (0.049)	
CLP*Polity2				0.131 (0.104)
Carbon dioxide (CO <sub>2</sub> )emissions	0.214*** (0.083)	0.240*** (0.070)	0.195*** (0.058)	0.234*** (0.060)
GDP per capita	0.233*** (0.012)	0.184*** (0.045)	0.154** (0.039)	0.182*** (0.019)
Urban population	0.147* (0.006)	0.158** (0.001)	0.154* (0.018)	0.166*** (0.027)
Human capital	0.194*** (0.028)	0.181*** (0.034)	0.204*** (0.046)	0.178*** (0.031)
Constant	2.115*** (0.635)	1.748*** (0.543)	1.947*** (0.0592)	2.230*** (0.622)

Notes: Standard errors in parentheses; \*, \*\*, and \*\*\* indicate the significance at 10%, 5%, and 1% levels, respectively.



**Table 8**

Indirect effects of climate change legislation (laws, regulation and SUM) on renewable energy transition.

Variables	Renewable energy transition (RET)											
	Laws				Regulations				SUM			
	1	2	3	4	5	6	7	8	9	10	11	12
Laws	0.085 (0.004)	0.103 (0.032)	0.092 (0.010)	0.096 (0.021)								
Regulations					0.120 (0.032)	0.089 (0.057)	0.102 (0.037)	0.111 (0.045)				
SUM									0.074 (0.001)	0.067 (0.000)	0.091 (0.025)	0.072 (0.011)
Financial development index (FD)	0.194*** (0.039)				0.203*** (0.047)				0.239*** (0.051)			
Control of corruption index (CC index)		0.158** (0.028)				0.173*** (0.026)				0.155** (0.013)		
Civil society participation index (CSP index)			0.140* (0.058)				0.182*** (0.039)				0.133*** (0.001)	
Polity IV index (Polity 2)				0.187*** (0.044)				0.163*** (0.027)				0.149** (0.021)
Laws*FD	0.179*** (0.033)											
Laws*CC		0.160*** (0.040)										
Laws*CSP			0.153*** (0.028)									
Laws*Polity2				0.111 (0.091)								
Regulations*FD					0.184*** (0.041)							
Regulations*CC						0.154*** (0.027)						
Regulations*CSP							0.171*** (0.033)					
Regulations*Polity2								0.095 (0.023)				
SUM*FD									0.155*** (0.039)			

SUM*CC										0.144*** (0.030)		
SUM*CSP											0.143*** (0.024)	
SUM*Polity2												0.131 (0.093)
Carbon dioxide (CO <sub>2</sub> ) emissions	0.220*** (0.022)	0.184*** (0.049)	0.177*** (0.004)	0.194*** (0.037)	0.203*** (0.064)	0.232*** (0.051)	0.188*** (0.039)	0.205*** (0.042)	0.175*** (0.027)	0.181*** (0.029)	0.170*** (0.011)	0.195*** (0.066)
GDP per capita	0.168** (0.112)	0.190*** (0.006)	0.209*** (0.022)	0.192*** (0.018)	0.179*** (0.031)	0.186*** (0.040)	0.204*** (0.059)	0.221*** (0.38)	0.197*** (0.024)	0.200*** (0.047)	0.194*** (0.016)	0.211*** (0.037)
Urban population	0.099* (0.002)	0.145*** (0.014)	0.119* (0.000)	0.168*** (0.029)	0.174*** (0.021)	0.140** (0.036)	0.159** (0.006)	0.174*** (0.033)	0.157** (0.001)	0.139** (0.039)	0.104 (0.156)	0.093 (0.139)
Human capital	0.159*** (0.033)	0.170*** (0.048)	0.168*** (0.019)	0.182*** (0.038)	0.151*** (0.011)	0.206*** (0.074)	0.193*** (0.044)	0.163*** (0.030)	0.184*** (0.039)	0.173*** (0.041)	0.154*** (0.020)	0.201*** (0.069)
Constant	10.104*** (2.354)	9.830*** (2.119)	7.466*** (1.366)	11.006*** (2.801)	9.147*** (1.937)	7.393*** (1.118)	5.499*** (0.986)	8.192*** (1.877)	9.051*** (1.903)	8.873*** (1.894)	8.640*** (1.739)	7.116*** (1.093)

Notes: Standard errors in parentheses; \*, \*\*, and \*\*\* indicate the significance at 10%, 5%, and 1% levels, respectively.