THE POLITICS OF CO_2 EMISSIONS

A Dissertation

presented to

the Faculty of the Graduate School

at the University of Missouri-Columbia

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

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December 2020

The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

THE POLITICS OF CO_2 EMISSIONS

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candidate for the degree of Doctor of Philosophy, and hereby certify that, in their opinion, it is worthy of acceptance.

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DEDICATION

This dissertation is dedicated to the loving and respectful memory of my father,

Md. Hassanat Miah,

Who had a deep respect for the academic profession and dreamed of us to join academia and dedicate to research and scholarship in our professional life. He is a perennial source of inspiration and guide for all the times.

To my ever-caring mother,

Amena Khatoon,

Who sacrificed innumerably for our success in higher studies abroad and whose blessings and prayers wrapped us like a warm blanket all the time.

ACKNOWLEDGEMENTS

Any doctoral researcher on a five-year journey incurs a great many debts. I wish to thank my committee members, who were more than generous with their expertise and precious time. I could not have completed this project without the academic support and insights I received from my committee. A special thanks to Dr. Jonathan Krieckhaus (Vanya), my committee chair, and Dr. Lael R. Keiser, my committee co-chair, for their countless hours of reflecting, reading, encouraging, and most of all patience throughout the entire process. Thank you, Dr. Alasdair S. Roberts, and Dr. Benjamin C. Herman, for agreeing to serve on my committee. When I was toying with many dissertation ideas during my coursework and was verily confused, Dr. Roberts helped me find out this dissertation topic and convinced me why it is worth pursuing. His inputs at various stages, during conference meetings, and at the defense stage were invaluable. At a critical juncture of my doctoral journey, Professor Keiser agreed to serve as my committee chair, and eventually as co-chair. Professor Keiser and Professor Krieckhaus – both continue to be an inspiration. They consistently challenged me from the start to think critically, were always accessible, and quickly provided feedback. I am immensely benefitted by their style of guidance and feedback –most of the time, they did not directly provide me with readily available inputs; instead, they superbly guide me the way so that I can find answers myself I am looking for. I believe this is an unparallel mode of learning for me with an extraordinary academic benefit.

I am grateful for the funding support of the Harry S Truman School of Public Affairs during this entire study and the extension of funding beyond the commitment period. Thank you, Dr. Ronald G. McGarvey, Ph.D. coordinator, and my advisors for their

funding support. I would also like to thank Dr. Colleen Heflin, our former Ph.D. coordinator, for her relentless care and guidance during her time.

I would also like to thank all my course instructors both at Truman school and at the Department of Political Science. Furthermore, I want to thank all my respected teachers from my early childhood to the university level. Professor Syed Giasuddin Ahmed, Professor Aka Firowz Ahmad, and Professor Mobasser Monem of University of Dhaka deserve special mention. The list is too big to mention, but many of them encouraged me to continue learning and sharing with others.

Finally, I am very grateful to my colleagues and officials at Truman school and IPP, friends, and fellow Bangladeshi students at Mizzou from whom I have received support, critique, working accountability, inspiration, and advice: Emily Johnson, Kathleen Miller, Dr. Kate Olson, Dr. Sarah Parsons, Christal Hamilton, Dr. Aaron Kushner, Trang Pham, Dinesh Dhakal, Dr. Hari Poudel, Whitney Keller, Leanne Tippett Mosby, Solaiman Islam Robin, Tapas Paul, Mohammad Hasan Mobarak, Bodruzzaman Sarker, Shoriat Ullah, Tanhaul Islam (Micil), Jayedi Aman (Ayon), Shakil Sohrab, Mohammad Kamrul Hasan (Miraj), Dr. Jebunnessa (Jeba), and many others.

Last but not least, I would like to thank people from outside academia for their support, for without it the writing process would have been much harder or even impossible. I am deeply grateful to my uncle, Matiur Rahman (Matin kaka) and my elder brother, Mohammad Ehsan, for their constant encouragement. Furtehrmore, I would also like to record my gratitude to Mohammad Mobarak Hossain (Mobarak mama), Kaniz Fatema (Tanaka), Taufiq Imam Hossain (Mamun), Mohammad Maruf Hossain (Biplob), and Rakib Hasan (Semi) for their various support when I was away from home and they

extended their kind help to my mother. A special thanks goes to my in-laws, Golam Gause Saklain (Emdad bhai), Khwaja Asheq Ahmed, Amatul Kawnine (Ruhi apa) for their constant encouragement. Finally, and most importantly, I am enormously grateful and thankful to my wife, Sayyedatus Sakline (Naveen), for her endless support and kind patience during this whole process of my doctoral journey. Without her support, I could not finish this challenging project. I am also thankful to my sons, Wasil Muin and Ryan Muin, for their love and warm affection. They provided me great comfort, strength, and motivation to continue and finish my dissertation project.

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ABSTRACT

Climate change poses a severe threat to humanity for the last few decades. Various forms of natural disasters, extreme weather events, the outbreak of deadly diseases, life, and food insecurity are among common threats of climate change. The dissertation examines the relationships between political institutions and climate change. The three political institutions examined are political regimes, federalism, and political ideology. The study provides data analysis that has implications for understanding the relationship between governance structures and responses to climate change.

Given the conflicting theoretical arguments and contrary empirical findings of the role of these political institutions in existing literature, the results of the dissertation expect to improve existing knowledge by increasing our understanding of how different measures and statistical methods affect research findings. With this view into consideration, the study provides robustness of existing findings for the relationship between democratic institutions, federalism, and partisan ideology and climate change at a cross-national perspective using multiple measures and multiple models to cross-check the consistency of the empirical findings of the existing literature.

The first study of the dissertation investigates whether democracy as a political institution performs better in reducing per capita CO_2 emissions than non-democracies.

Applying seven different empirical research designs, including the TSCS and multilevel model, the study intends to understand if consistent results are found in favor of any specific regime type between democracy- authoritarian spectrum when using different measures of democracy. Using the World Bank data and five different democracy indices, the study estimates the effect of political regimes on the per capita CO_2 emissions. The study finds a moderate relationship between democracy and per capita CO_2 emissions.

The second study of the dissertation estimates the relationship between political decentralization through federalism and per capita CO_2 emissions. The analysis is based on three different measures of federalism for 176 countries from 1990 to 2014. The results show a null effect. This is not surprising given the argument that federalism may create both a race to the bottom and a race to the top tendencies in its various subnational units culminating into a net insignificant result at a national level.

The third study of the dissertation examines the relationship between partisan ideology and per capita CO_2 emissions to explore if any variation exists in the levels of emissions in response to differences in the left-right political ideology spectrum. The study applies three different indices of political ideology to analyze the effect of partisanship on per capita CO_2 emissions behavior of 120 countries from 1990 to 2014. Using time-series cross-sectional research designs, the study finds a less-than-moderate effect of political ideology in tackling the climate change problem.

Scholars underscore the importance of institutions because they provide guiding norms and incentive structures that shape the actions of human and organizational behaviors. Steinmo and Tolbert (1998) hold that institutional context frame actor's

strategic choices and thereby shape public policy. With that goal into consideration, the dissertation provides empirical tests of existing theories that improve upon the literature. The findings of the studies inform that some of the institutions may matter in responding to tackling climate change problems. Therefore, investment and strategic intervention for maintaining institutional quality and adopting institutional reform where needed merit more in-depth research initiatives.

1. Introduction

THE POLITICS OF CO_2 EMISSIONS[1]

1.1 A General Introduction

The global climate is changing rapidly. The change in this climatic system is mainly due to an increase in global temperature and the emissions of greenhouse gases. One of the significant challenges of the world governments now and in the coming future would be to limit the warming of earth to 1.5 degrees Celsius (Silberg, 2016). Meeting these challenges need concerted and committed efforts by the national governments around the world with the policy intervention that responds to climate change. To understand the ability of the world to respond to environmental change, it is helpful to understand how different governance and political structures affect the likelihood that any particular country will work to reduce emissions.

No doubt that the problems of climate change spread across all parts of the world. The nature of these problems varies in types and severity across countries (A. Buis, 2019). The problem of climate change includes, among others, intense heat waves, droughts, acid rain, changes in precipitation patterns, damaging winds, severe flooding, snowstorms, heavy rainfall, high-intensity hurricanes, wildfires, melting of glaciers and ice, sea-level rise, thunderstorms - just to name a few (Lutz, 2019; NASA, 2019; NASA

[1] The dissertation uses the term CO2 to mean carbon dioxide. The term CO2 should be read as CO_2.

Earth Observatory, 2005). The implications of these problems pose threats to various aspects of human survival, ranging from a natural disaster to agricultural productivity to scarcity of natural resources to numerous forms of social, cultural, and physical health hazards. In recent decades, in the wake of the growing severity of the impact of climate change and the continued apathy by various countries in the world, the need for policy intervention of governments becomes an urgent priority.

There is no shortage of researches that indicates the occurrence of various problems induced by climatic changes. Just a few among them are extreme weather events, lower agricultural production and food insecurity (Ai, Orking, & Clima, 2008; Anand & Khetarpal, 2015; Lal, 2004; Liang et al., 2017), the spread of infectious diseases (Cho, 2014; Jordan, 2019), increased suicidal rates (Ng, Stickley, Konishi, & Watanabe, 2016; M. Wen & Gu, 2012), increased cases of depression (Gao, Xu, & Sun, 2015), sleep disorder (Rifkin, Long, & Perry, 2018), life dissatisfaction and mental health problem (Giovanis, 2019; Gu, Yan, Elahi, & Cao, 2019; MacKerron & Mourato, 2009; Mendoza, Loyola, Aguilar, & Escalante, 2019), memory loss (Powdthavee & Oswald, 2020), increases in environmental refugee and migration (Heslin, Deckard, Oakes, & Montero-Colbert, 2019; Kniveton, Schmidt-Verkerk, Smith, & Black, 2008; Warner, Hamza, Oliver-Smith, Renaud, & Julca, 2010) and so many other problems.

The social scientific inquiry into the problem of climate change is still in its infancy. Early studies demonstrated how economic development, urbanization, trade policies, and demographic factors contribute to the challenges of climate change (Adams, Adom, & Klobodu, 2016; Dinda, 2004; Levinson, 2009; Obydenkova & Salahodjaev, 2017; Shahbaz & Sinha, 2019). In recent years, scholarly efforts to understand the institutional

effect of climate change gained prominence among social scientists. No doubt that public administration and governments around the world have a critical role to play in delivering the solution to the national and global climate change problems. Because both national and subnational governments provide the legal and regulatory framework to control individual, firm, and domestic actors' behavior in the use of natural resources and public goods, the national government, as well as the state government, have the responsibilities to ensure basic provisions of environmental goods to the citizens.

There are, however, many challenges in front of the government to ensure these provisions of environmental public goods. From an economic and market perspective, one of the problems is that providing quality air, water, and other ecological goods requires massive investment with the possibility of long-term implementation. Besides, there always remains uncertainty about the expected outcomes of the financing for environmental sustainability. Because of these, private markets usually remain less willing to provide these services (Fukuyama, 2014; Neumayer, 1999; Povitkina, 2018b). Besides, these environmental public goods frequently encounter the problem of free-riding and negative externality. From a governance perspective, one of the other challenges is ensuring these services require complex coordination mechanisms among various agencies and across federal to state-level or central to local levels of government. Therefore, both the national government, as well as the provincial government, have vibrant roles to play to address these problems of climate change and provide essential environmental public goods to the citizens.

However, there seems a vicious cycle of climate policy that comes as a roadblock for its effective implementation. Since the private market remains less willing to provide

environmental public goods, it becomes hard to thwart the problem of free-riding and positive externality accrued from governmental supplies of environmental goods. When governments provide environmental public goods, all stakeholders benefit from the solution irrespective of investors and free riders of environmental goods. Therefore, countries and subnational units have good reasons to free ride, letting others pay for solutions while they continue to work on their businesses (Povitkina, 2018b). Thus, countries often do not want to invest in environmental goods. Consequently, this vicious cycle leads the world national governments to become reluctant to provide a concerted solution to global climate challenges.

However, efforts to provide a solution to climatic challenges do not fail everywhere. Some countries and subnational units show exemplary instances by delivering effective solutions to climate change problems. The issue is not whether we should persuade laggard states to take actions for climate policy, but how we can create capable instruments to improve environmental quality through institutional reform and policy advocacy consistently.

The main goal of this dissertation is to test the rigorousness of previous findings on the efficacy of three different political institutions on the problem of climate change using a coherent methodological approach with multiple indices of the same measure. The study argues that our prior understanding of institutional approaches to environmentalism is insufficient and fraught with methodological limitations. This leads to a critical research gap in testing the robustness of empirical findings using advanced statistical techniques with the application of multiple measures of political institutions under study. This approach contributes to the literature by examining the consistency of

the results for more reliable and accurate estimates of the effect of political institutions on the problems of climate change. This test of robustness and consistency have strategic implications for the way the advocacy for institutional reform and policymaking should be made to meet the global challenges of climate change.

Ensuring habitable earth by taking appropriate measures to tackle climate change problems and providing safe environmental public goods like quality air, potable water, quality arable soil, natural marine resources, etc. are responsibilities of national governments. In this dissertation, I argue that understanding the differences in how countries respond to the problem of climate change is affected by the institutions that shape governmental decision making. Institutions influence how and whether popular demand for climate policy appears on political agendas and whether policies are adopted and implemented. Despite this crucial role of government and administration, the social scientific inquiry into the role of institutions to address the challenges of environmental and climate change provides inconsistent results in various research by scholars in policy and public administration, political science and other social sciences (Barry & Eckersley, 2005; Duit, 2014; Lundqvist, 1974; Povitkina, 2018b).

Previous researches that make an institutional analysis of environmentalism with political regime, federalism, and political ideology have a variety of issues, including data limitation, model selection, and methodological approaches. The use of various DVs to represent the idea of the climate change problem produces both conflicting and confusing results. Besides, some of the empirical strategies used in prior studies replete with statistical biases and thus prone to provide unreliable estimates. In sum, the existing literature offers explanations that make sense of parts of the role of government

institutions but does not explain a full and coherent picture. Therefore, the aggregate wisdom derived from the prior scholarship is conflicting.

The goal of this dissertation is to bridge this gap by employing the following three strategies in its investigation into institutions-climate change relationships. First, to investigate the effect of three institutions, the dissertation uses the CO2 emissions per capita as the standard DV for its empirical analysis so that it can explain how consistent the institutional effect is for this proxy of climate change problems. The CO2 emissions per capita are probably not the best measure to represent the idea of how we perceive climate change problems, but it is one of the best indicators scientifically attested that causes global warming leading to various issues of climate change (Hansen, 2001; Lindsey, 2020). Second, the dissertation applies multiple estimation strategies to investigate the three institutions-CO2 relationships addressing the diagnostic errors of time-series design. The use of numerous estimations serves as a check of the robustness of results across different estimation techniques. Third, the dissertation uses the multiple quantitative indices of the same predictor variable for each institution, which further provides robustness check of the empirical findings and provide evidence if the results are consistent irrespective of multiple institutional indices. The application of all these strategies is expected to provide a reliable estimate of institutions-climate policy relationships and improve upon much of the literature in terms of data coverage, model specification, and statistical techniques.

The first study of the dissertation investigates the relationship between political regimes and per capita CO2 emissions (in metric tons) using various empirical designs. The study uses the World Bank data and five different democracy indices to examine the

relationship. The study finds a moderate effect of democracy in reducing the problem of climate change – compared to authoritarian regimes.

The second study of the dissertation estimates the effect of federalism on the per capita CO2 emissions behavior. It also applies multiple estimation techniques and various indexes of federalism. The study, however, did not find any conclusive evidence that federalism has any differential effect in the levels of CO2 emissions.

The third study of the dissertation examines the relationship between partisan ideology and per capita CO2 emissions. Like the other two studies, it also applies three different indices of political ideology to analyze the effect of partisanship on per capita CO2 emissions behavior. Using time-series cross-sectional research designs, the study finds a weak relationship between political ideology and emissions.

While the dissertation intends to argue that it improves the understanding of how differing regime types, multilevel governance and political split of partisanship may affect environmental achievement, but it does not claim that the findings are definitive in the quest for the institutional impact of climate change nor does it provide any conclusive evidences for the findings that it presents. In fact, the most appropriate way to assert the conclusions are that they are correlational, not primarily causal due to the research design.

More research is needed using some advanced statistical design to investigate the institution-climate change relationship in the future. So, the directions of possible future research agenda would be, (1) employing some quasi-experimental models to investigate the institutional analysis of climate change, (2) using a more appropriate dependent

variable that can better represent the idea of climate change protection or climate policy, and, finally (3) some qualitative methods, such as longitudinal case study and process tracing can be applied to obtain mechanism-based explanations of the effect of various political institutions on climate policy.

The dissertation is organized into five chapters, along with several sub-sections in each chapter. The dissertation proceeds as follows.

Chapter 1 provides a general introduction to the dissertation. It covers a brief introduction to three political institutions that the dissertation focuses on to investigate their effect on climate change problems. It also includes the status of institutional analysis in environmental politics literature and identifies the potential research gap and discusses why the research questions of the present dissertation are important. It then proceeds to discuss the political institutions of political regime, federalism, and political ideology in greater detail, including the portrayal of the existing theories and a thorough discussion of previous literature followed by summarizing the trends and patterns of research findings. It then identifies the gaps in the literature for each political institution and explains how the study of each political institution may improve the understanding of our present knowledge about the role of each political institution in addressing the problem of climate change.

Chapter 2 covers the empirical model illustrating in detail the measurement and operationalization of independent variables, dependent variables, and controls and how they fit into the research context.

Chapter 3 presents various estimation strategies that the study applies, including the discussion of the advantages and pitfalls of some estimation techniques. It also discusses the diagnostic tests of the models that the study has used in the dissertation and the relative strength of some estimation techniques for the TSCS data that the study applies.

Chapter 4 presents the empirical results for each of the three studies separately, including the results of the robustness check with alternative indices of the political institution under study.

The dissertation ends with the final chapter on discussion and conclusion in which the study urges more research is needed for causal explanation, micro-level explorations, and policy guidelines.

1.1.1 Introduction: Democracy and Climate Change

1.1.1 Introduction: Democracy and Climate Change

The existing literature that investigates the relationship between political regimes and climate change generates a considerable debate in recent years. Scholars present contradictory views on the role of democracy vs. non-democracy in climate policy. Some scholars argue that democracy is not capable of promoting environmental quality (Beeson, 2010; Heilbroner, 1974; Jonas, 1984; Ophuls, 1997; Shearman & Smith, 2007) while some scholars suggest that democracy works as a safeguard to protect environmental degradation (Downey, 2015; Dryzek, 1987, 1992; Eckersley, 1999; Goodin, 2013; Jacobs, 1993; Paehlke, 1996; Stehr, 2015; Wissenburg, 2013). Between these positive and negative findings, many empirical studies conclude that the effect of democracy provides mixed results, which are often conditional on various other factors (U. Desai, 1998). These complex and contrary findings are available both in empirical as well as qualitative studies. Using multiple measures of democracy with some appropriate empirical methods, the dissertation investigates (1) the robustness of current findings of the political regime-environment relationships, (2) and if the results are consistent across different democracy indices at a cross-national level.

1.1.2 Theory

Those who think democracy heralds good to the environment and provide better climatic conditions presents four major arguments in favor of democracy-climate policy relationship. One, *abundant political rights and freedom of expression and association*. It is argued that in a democracy, political rights are exercised freely by citizens, media, and interest groups. Because the information flows freely and the media operates relatively independently, the environmental interest groups can sensitize public awareness about the

harmful effect of climate change. This generates a more significant public support for environmental legislation (Payne, 1995; Schultz & Crockett, 1990).

Two, *electoral accountability*. Some scholars present the importance of electoral accountability in environmental policymaking. Democratic authority deems accountable to its citizenry more strongly than authoritarian regimes do. Therefore, they pay greater attention to the demand of citizens and environmental interest groups for better environmental quality. Consequently, democratic governments tend to adopt more and stricter environmental legislation compared to authoritarian governments. (Farzin & Bond, 2006; Kotov & Nikitina, 1995).

Three, *political learning and policy diffusion*. Scholars argue that democratic countries tend to learn more from environmental successes and failures than non-democracies (Moltz, 1993; Payne, 1995). Democratic nations that provide exemplary environmental benefits or strategies for pollution control serve as a model for other democratic countries for policy diffusion. Because democratic countries share more or less the same political virtues and almost follow same political processes. Non-democratic countries, on the other hand, maintain a different political motive and administrative procedure, often allegedly guided by elite-interest.

Four, *internationalism and globalization*. Scholars argue that democracies tend to support the convention of international organizations more favorably, and they are more willing to develop cooperation among democracies to solve the problem of global commons. Payne (1995) suggests that international organizations provide a kind of second-order democratic mechanism for the resolution of common and shared problems. Scholars in international relations (IR) literature explain why democracies are more likely

to join in the shared efforts of global climate governance and follow international environmental agreements (Young, 1989, 1994). They offer two possible explanations to this trend: (1) the similarity of political culture across democracies, and (2) adherence to the market-based economic systems (Lidskog & Elander, 2010; Payne, 1995).

Like this pro-democracy-environment relationship, scholars also present arguments about why democracy may not bring good to the environment. Dominant discussions among those are one, *market economy*. Some scholars view that the forces of the market economy may spell a detrimental effect on the steady progress of environmental quality. Most of the world democracies maintain market economy as their state economic principle, unlike non-democracies and socialist countries. This market economic principle opens the floodgates for unfettered economic activity, including transboundary trade and businesses. Lindblom (1977) argues that the market mechanism tends to serve large corporate interests. Scholars say that the free market economy, together with a strong corporate presence, eventually bring harmful consequence to the environment (Dryzek, 1987; Sagoff, 2007), unlike non-democracies.

Two, *individual liberty*. Scholars argue that democracy's emphasis on individual liberty and the ownership of private property fosters climate change problems. They suggest that these two virtues of democracy tend to exaggerate in pollution, consumption, and procreation leading to impediments to put a limit to the growth (Heilbroner, 1974; Ophuls, 1997). The net effect of this is overexploitation of natural resources leading to damage to the global "commons."

Three, *policy inertia*. From a public policy standpoint, some scholars argue that democracy often tends to follow 'go slow' or 'no action' policy when it comes to

formulating laws and regulations relating to climate policy (Dolsak, 2001; Dolšak, 2009; Midlarsky, 1998). Democracy tends to adhere to a consensual political path to reach to a coherent policy goal. But the anti-environmental interest groups and lobbies of giant corporations often appear to create bottlenecks to reach agreed-upon climate policymaking, eventually leading to a standstill which usually is not the case with non-democracies.

These arguments of the 'pro' and 'anti' democracy-climate policy relationship can be summarized in the following table.

Table 1: Theories on Democracy- Climate Change Relationship

(a) Mechanisms of Democracy- Climate Change Positive Relationship				
	Input	***Throughput***	***Output***	***Outcome***
Model 1	Unfettered political and civil rights	Free flow of information Proactive media responses	Activism of environmental interest group Public awareness climate policy legislation	Better environmental quality
Model 2	Electoral accountability	Better citizen-government social contract	Conducive milieu for environmental legislation Less struggle of industrial lobby	Climate change problems being addressed quickly
Model 3	Political learning	Countries and states work as a laboratory for successful and failed policy	Climate policy diffusion	Climate policy improvement
Model 4	Internationalism and globalization	Principles of market economy International organizations provide resolution of common and shared problems	More signatory to international environmental agreements Global environmental governance	Pollution control Emissions reduction Ecological balance
(b) Mechanisms of Democracy- Climate Change Negative Relationship				
	Input	***Throughput***	***Output***	***Outcome***
Model 1	Emphasis on market economy	Profit maximizing tendencies Serving corporate interest	Antipathy to climate policy	Damage to environmental sustenance
Model 2	Individual liberty Private property ownership	Overexploitation of natural resources	Lack in the interest of environmental conservation	Environmental damage
Model 3	Policy inertia Obsessive with 'go-slow' policy	Corporations and environmental groups are at loggerheads	Policy initiatives at standstill Word-action gap	Low concerns of climate change issues

However, between these pro and anti-climate policy stances, some theories propose the emergence of a normative theory of ‘green authoritarianism’ or ‘authoritarian environmentalism’ in climate policy literature which presupposes that challenges of climate change should be addressed with a non-participatory and top-down approach (Beeson, 2010; Gilley, 2012; Han, 2015, 2016). This model is most evident in East Asian and Southeast Asian regions where various environmental and climate change problems are acute, and governance style is more resembling to authoritarian or semi-authoritarian regimes (Beeson, 2010). Contrarily, however, in some cases, this model is also found to exist in some democratic governments too. For example, Han (2015) studies South Korea’s *Four Major Rivers Restoration Project* (FMRRP) and explains how previous path-dependent legacies of authoritarian developmental state influenced the policy context in which policymakers in democratic Korea adopted authoritarian environmentalism as its approach to environmental governance.

Apart from the example of South Korea, Han, in his 2016 paper, analyzes how the garden city of Singapore adopted a non-participatory stringent climate policymaking approach that reflects major postulations of authoritarian environmentalism in its environmental governance. In fact, Singapore’s climate policy appears to become a model for other countries in terms of expansion of green spaces and infrastructure, which has been achieved through a strict climate policy approach. This reflects the developmental state's deliberate planning and management, especially in the areas of emergency management (Han, 2016).

1.1.3 Literature Review

The theoretical framework that proposes both positive and negative influence of democracy on climate change problems is analyzed in various quantitative and qualitative studies. The study of Congleton (1992), one of the earlier empirical studies to offer democracy's positive effect to the environment, argues that political institutions affect both domestic and international environmental policies and these political institutions largely determine the legal environmental framework rather than technological features of pollution control or market structure. Using data of CFCs for a total of 118 countries, Congleton suggests democratic regimes are more likely to adopt stringent environmental regulations than authoritarian regimes. His study further suggests that global environmental agreements will attract more signatories with the increase of democratic governments around the world.

Congleton (1992) explains why democracy may behave positively toward environmental performance. To him, policymakers in democratic regimes have a smaller marginal cost for pollution abatement than authoritarian regimes do. Besides, authoritarian regimes face uncertain career path for political success coupled with a relatively shorter term of office. Foreseeing these uncertain political career and brief tenure of office, authoritarian regimes relatively become reluctant to take risks than democratic authorities do. As a result, authoritarian regimes remain less willing to adopt higher environmental standards.

Neumayer, another prolific empirical researcher in the field of institutional analysis of environmental politics, explores if democratic regimes demonstrate greater commitment to international environmental agreements than non-democratic regimes. Using four different measures of democracy on various outcome variables, Neumayer (2002) shows a positive association of democracy with environmental commitment. He finds strong evidence that democratic countries sign and ratify more international climate change agreements, take part in more environmental intergovernmental organizations, and fulfill the enhanced commitment of reporting requirements and provide more environment related information to international organizations than non-democratic countries.

Winslow (2005) investigates the effect of democracy on three air pollutants: Sulphur dioxide (SO2), suspended particulate matter (SPM), and smoke. Using the Freedom House and Polity III measures, the author finds that higher levels of democracy are associated with lower levels of air pollution. Likewise, Mayer (2017b) studies the effect of democracy on carbon dioxide emissions, and he finds that democracy tends to reduce emissions moderately, but the intensity varies significantly across countries.

Farzanegan and Markwardt (2018) investigate whether an investment in democratic development is a useful tool to make economic development environmentally compatible. Their study covers the Middle East and North Africa (MENA) countries who are among the world's top emitters of CO2 and SO2 per capita. The study uses panel data on the income-emissions-democracy relationship for 17 MENA countries from 1980 to 2005. They find that the promotion of democratic development in the MENA regions tend to reduce environmental problems. Their study demonstrates that the qualitative

improvement of democratic institutions has a positive effect on local environmental problems compared to global environmental issues in the MENA region.

The study of Obydenkova and Salahodjaev (2017) also shows a positive association of democracy with the establishment of the environment-friendly legal framework. In their study of 94 countries, they estimate that a 1-point increase in the democracy index is associated with about 5 points increase in the adoption of the *Climate Laws, Institutions and Measures Index* (CLIMI). Likewise, Barrett and Graddy (2000) find that an increase in civil and political freedoms enhances environmental quality. To them, the combined effect of political and civil liberties that they term as 'democratic freedoms' reduce environmental pollution monotonically.

In contrast to the above findings, a few studies show that instead of doing good to the environment, democracy may be detrimental to the climate change policy. Mao (2018) studies the effect of the democratic transition on carbon intensity (carbon dioxide emissions per unit of GDP) in Indonesia. Using a synthetic control method for the post-transition period (1999-2010) in Indonesia, Mao, in his study, suggests that instead of reducing, the democratic transition may exacerbate the level of CO2 emissions. He estimates that the democratic transition in Indonesia increases carbon intensity by approximately 25.34%.

Mayer (2017a) studies the effect of democratic institutions on energy consumption. Using a random intercept mixed-effect model for 138 countries covering a period from 1990 to 2008, the author reveals to get a null finding. The study concludes that democracy does not improve sustainability conceived as the energy intensity of well-being.

The study of Midlarsky (1998) and Dolšak (2009) provide evidence for democracy's tendency of policy inertia and a word-action gap for policies relating to environmental interest. From a public policy standpoint, Midlarsky (1998) argues that democracy often tends to follow 'go slow' or 'no action' policy when it comes to formulating laws and regulations for environmental performance. According to Midlarsky, in a democracy, corporations and environmental groups often fight each other to a standstill and thus creates a decision-making vacuum instead of adopting quick policy intervention for climate change problems. Some other studies, on the other hand, suggest that while democracies are good at making more promises than autocracies, they often fail to implement the policy as they intend (Bättig & Bernauer, 2009; Böhmelt, Böker, & Ward, 2016; Dolsak, 2001).

Some studies, however, show a blend of uncertain, conditional, and mixed results for the effect of democracy on climate policy. These uncertainties and mixed results of democracy are attributed to a country's economic trajectory (Gaarder & Vadlamannati, 2017; Li & Reuveny, 2006; Lv, 2017), variation in the consolidation of democratic institutions (Buitenzorgy & Mol, 2011) and regional geographic variation (Arvin & Lew, 2011).

Adom, Kwakwa, and Amankwaa (2018) investigate the effect of democracy on CO2 emissions, taking data from various industry sectors in Ghana. They find that higher levels of democracy tend to lower the actual and potential CO2 emissions in the aggregate (insignificant) and in specific in the transport sectors, but not in the manufacturing and construction sector. For the other industry sectors, the effect remains

inconsistent. They also find that urbanization tends to raise aggregate actual and potential CO2 emissions, but the result is inconsistent for the transport sector.

Li and Reuveny (2006) investigate the effect of democracy on five different types of environmental degradation. Their main finding is that at the formative phase, democracy does not reduce all five types of environmental indicators they studied, but democracy spells a positive effect in reducing environmental degradation when the country reaches a threshold point of national income. They conclude that the net impact of democracy is positive across all five types of environmental degradation. Lv (2017), in his studies, also finds that income levels drive a non-linear pattern between democracy and pollution. His results indicate that democracy reduces CO2 emissions, but only if the country reaches a certain income level.

The study of Adams et al. (2016) reveals that urbanization and trade openness are positively correlated with environmental degradation. But in the long run, when these two are moderated by quality institutions (or democratic institutions), they tend to improve environmental performance (Adams, Adom, & Klobodu, 2016).

The study of You, Zhu, Yu, and Peng (2015) investigates that if greater democracy and more financial openness steadily reduce emissions among the most and least emissions countries. They find that among the high polluting nations, countries with greater democracy tend to reduce emissions, but wider financial openness does not reduce the emissions. Interestingly, they also find that among the least polluting nations, both higher levels of democracy and broader financial openness do not seem to reduce emissions. They conclude that blanket emissions control policies are less likely to succeed equally across countries with different emissions levels. They suggest that policy

interventions for pollution control should be tailored differently across the highest and least emissions countries.

Fredriksson and Wollscheid (2007) compare the effect of presidential versus parliamentary democracy on environmental policy stringency. Using a propensity score matching method, they find that environmental policy stringency is largely driven by the parliamentary democracies at a national level as opposed to the presidential, congressional, proportional, or majority systems. Also, they further claim that, to some extent, the way the presidential or congressional systems set environmental policies are often not substantially different from that of autocracies.

Buitenzorgy and Mol (2011) find that countries that undergo a transition to democracy negatively affect the environment. They explored how the maturation of democracy affect the rate of deforestation. Their study shows an inverted U-shaped relationship between these two. They suggest that the deforestation rate increases as countries move toward higher levels of democracy. Besides, they also note that countries experiencing the democratic transition yields the highest deforestation rates compared to non-democracies and mature democracies.

The study of Arvin and Lew (2011) argues that democracy may improve environmental quality, but it depends on the measure of environmental quality and the geographic location being studied. The authors examine a large sample of developing countries covering the period from 1976 to 2003 with three environmental measures: carbon dioxide emissions, water pollution, and deforestation damage. They find that democracy is positively associated with cleaner air in middle-income countries, but not elsewhere. They also report that higher levels of democracy lead to cleaner water only in

some areas of Asia, the Pacific, and Eastern Europe. Likewise, he further suggests that democracy cuts down the level of deforestation only in certain regions, but not elsewhere. The first step in understanding how methods and measures have influenced the study of the relationship between governance and climate change is to systematically identify the measures, methods, and findings of a different research project exploring this relationship.

In the following, a quick overview of these previous empirical findings is presented in table 2.

Table 2: Summary of Empirical Literature for the Study of Democracy and Climate Change

Author(s)	Geographic/ temporal coverage	DV/IV	Controls	Empirical model
Positive Findings between Democracy and Climate Change				
Farzanegan & Markwardt (2018)	17 MENA countries/ 1980 - 2005	DV Sulfur dioxide (SO2) per capita Carbon dioxide (CO2) per capita	GDP per capita Trade Openness Urbanization Population density	OLS Panel data analysis GMM
		IV		*Statistical significance*
		Polity2 Vanhanen democracy index Civil liberty score of Freedom House Data		Yes
Mayer (2017b)	55 Countries/1988-2011	DV Total carbon dioxide emissions in a country (measured in metric tons)	logged population (100,000) Military Expenditure (% of GDP) Agricultural Employment (% of total) Exports (% of GDP) Natural Resource Rents (% of GDP) log GNI per capita log GNI per capita squared Urban Population (% of total) Electricity Production (% of total) Capital formation (% of GDP) Fossil fuel energy consumption (% of total)	Random intercept and random coefficient generalized linear models (GLM)
		IV		*Statistical significance*
		Levels of democratization (Polity IV)		Mixed with different treatment
Obydenkova & Salahodjaev (2017)	94 countries	DV (1) Climate Laws, Institutions and Measures (CLIM) Index (2) Cognitive skills at a national level	GDP per capita at PPP (log) CO2 emissions per capita Trade as % of GDP	Cross-sectional OLS with robust & WLS
		IV		*Statistical significance*

		Democracy Index (Freedom House)		Yes
Adams, Adom & Klobodu (2016)	Ghana/1965-2011	DV CO2 emissions (CO2) - CO2 emissions (kilogram per 2005US$ of GDP) IV Regime type (polity2)	Population as a percent of total population Income - GDP per capita (constant 2005 US$) Trade openness- Ratio of sum of imports and exports to GDP Urbanization Regime durability	Cointegration test and the Fully Modified Phillip-Hansen (FMPH) Technique *Statistical significance* Yes
Bernauer and Koubi (2008)	107 cities of 42 countries/1971-1996	DV Sulfur dioxide (SO2) IV Level of democracy (Wover's) Labor union Strength Green party shares in national parliaments Civil liberties Parl-Pres (Bueno de Mesquita et al) - Presidential vs. Parliamentary	Income (lagged real GDP per capita) Degree of trade openness Topographical and climatic conditions Topographical conditions Climate (temperature, precipitation) Time trend (year)	Fixed and random effects estimations *Statistical significance* Yes
Fredriksson & Wollscheid (2007)	163 countries/ 1990s	DV ESI (Environmental Sustainability Index) Institutional capacity Environmental governance Global Stewardship International Participation Greenhouse Gases IV GDP/capita Trade Openness Age Age 65+ Pop Density Independence Muslim Africa East Asia Latin America UK Colony French Colony Cropland Forest Roads paved Urbanization	*Treatment Variable* Democracy Democratic - Parliamentary Presidential-Congressional Majoritarian Proportional Investiture	Propensity score matching *Statistical significance* Mixed
Farzin & Bond (2006)	45 Countries/ 1972-1994	DV CO2 emissions (Kg per capita) Nitrogen oxides (NOx) ('000 metric tons per million persons Non-methane volatile organic compounds (VOC) ('000 metric tons per million persons) Sulfur dioxide (SO2) ('000 metric tons per million persons)	Population density (00,000 persons/sq. km) Urban population Gini Index, 0 (equal), -100 (unequal) Youth population (14 yrs or under) Illiteracy rate Year	Fixed effect model

		GEMSSO2 (Ambient concentration, parts per million		
		IV		*Statistical significance*
		Polity index (Polity IV) - 0 (autocratic), -20 (democratic)		Yes
Winslow (2005)	107 cities from 46 countries/ 1971-1992	DV	-	Multiple regression
		Sulfur dioxide (SO2) Suspended particulate matter (SPM) Smoke		
		IV		*Statistical significance*
		Democracy (Freedom House and Polity III)		Yes
Neumayer (2002)	Various	DV	lnGDP lnPOP POPdens	OLS regression
		Sum of MEAs Number of EIOs % of CITES requirements met % land area under protection Number of ESI variables available		
		IV		*Statistical significance*
		FREE (Freedom House) POLIT (Polity variable) GOV (Governance variable) VAN (Vanhanen variable)		Yes
Barrett & Graddy (2000)	Various	DV	Income Time and physical features of pollution sites Coast Desert Central city Industrial Residential Population density	Generalized least squares with random effect & Fixed effect
		Air quality (sulfur dioxide, smoke, heavy particles) Water quality (dissolved oxygen, Biological oxygen demand, Chemical oxygen demand, nitrates, Fecal coliforms, Total coliforms, lead, Arsenic, cadmium, lead, mercury, nickel		
		IV		*Statistical significance*
		Civil and political freedoms – Freedom House data		Mixed
Congleton (1992)	Various, some samples are drawn from 46 countries and some from 118 countries	DV	GNP per capita Coal reserve Oil reserve Gas reserve Area Population	Logit model OLS Two-stage least squares
		CFCs		
		IV		*Statistical significance*
		Democratic country Capitalist country		Yes
Negative Findings between Democracy and Climate Change				
Mao (2018)	1/1999-2010	DV	Quality of government Political stability Log (GDP per capita) Log (GDP per capita) squared Industrial structure Trade openness Fossil Fuel energy consumption Energy intensity Urbanization Log (total population) Education	Synthetic control method
		CO2 emissions per capita (ln)		
		IV		*Statistical significance*
		Democracy (electoral democracy index) from V-Dem		Yes
Mayer (2017a)		DV		

	138 Countries/1990-2008	Ratio of energy use per capita (measured as a kilogram of oil equivalent) IV Elected executive Elected legislature Political competition Full democracy	Military expenditures (% of GDP) Exports (% of GDP) Renewable energy consumption (% Total) GDP per capita (log) GDP per capita squared (log) Urban population (% total) Life expectancy at birth (in years)	Multi-level generalized linear model (GLM) *Statistical significance* No
Midlarsky (1998)	108 Countries/ 1981-1990	DV Deforestation Carbon dioxide emissions Soil erosion by water Protected land Freshwater availability Soil erosion by chemicals IV Democracy (Polity III)	Agricultural density Population growth GDP per capita Log Age Deaths per capita European Location Precipitation	Multivariate OLS regression *Statistical significance* Mixed
Clulow (2018)	147/1990-2012	DV Emissions level (Annual CO2 emissions in a given country in MtCO2e) IV Level of democracy (Freedom House)	Per capita GDP Level of export diversification in the national economy Percentage of GDP dependent on fossil fuel income Annual proportion of renewable energy consumption as a percentage of total energy consumption National population level in a given year The ratio of change in CO2 emissions to change in GDP	Multivariate OLS Regression, Random intercept model (RIM), Random coefficient model (RCM) *Statistical significance* Yes
Povitkina (2018)	144 Countries/1970–2011	DV CO2 emissions per capita (ln) IV Democracy (electoral democracy index) from V-Dem	Real GDP per capita in constant 2005 prices Population density Urban population Merchandise exports in PPP Oil production per capita Latitude Kyoto ratification Island dummy	Time-series cross-sectional *Statistical significance* Yes
Adom, Kwakw, Amankwaa (2018)	Ghana, 1970 - 2014	DV Actual CO2 Potential CO2 IV Price of electricity Real price of crude oil Political regime (POLITY2) Financial development	Real gross domestic product per capita Population (total number of population) Population density Rate of urbanization (URB)	Stock-Watson dynamic OLS (DOLS) Covariance (Bartlett Kernel, Newey-West Fixed bandwidth) & Newey-West robust standard errors. Optimal lead and lags selected based on Akaike Information Criterion (AIC) *Statistical significance* Mixed
Gaarder & Vadlamannati (2017)	139 Countries/1990-2012	DV Forest coverage IV	Per capita GDP (log) Population (log) Trade openness	OLS regression *Statistical significance*

		Democracy dummy Autocracy dummy	NGOs (log) Mineral rents/GDP Rents Rule of law	Yes
Lv (2017)	19 Countries/1997-2010	DV LnCO2 IV Democracy (Freedom House)	Real per capita GDP (ln) Total population (ln) Trade openness Industrialization Urbanization	Quantile regression *Statistical significance* Mixed
You et al. (2015)	1985-2005	DV CO2 - Carbon dioxide emissions (metric tons per capita) IV Polity2 - The difference between the sub-indexes for democracy and autocracy Freedom - Sum of the Freedom House Political Rights and Civil Liberties Indices	GDP - GDP per capita (constant 2005 US$) POP - Population size Trade - Ratio of imports plus exports to GDP Indux - The share of industry in GDP Kaopen - Financial openness measuring the extent of openness in capital account transactions	Quantile regression methods *Statistical significance* Yes
Buitenzorgy and Mol (2011)	177 Countries/1990-2000	DV Rate of deforestation (average annual rate of change in forest cover in the studied period) IV Level of democracy (Polity index) Democracy-sq	Education Rural population Land area (ln) Control of corruption Income (PPP) Income-sq	OLS regression *Statistical significance* Yes
Arvin and Lew (2011)	141 developing countries/1976-2003	DV CO2 emissions Water pollution emissions Deforestation damage IV Democracy (Freedom House)	Per capita GDP (ln) Per capita GDP-sq Percentage of Urban population Growth rate Population density	Generalized Least Squares (GLS) with a country and year fixed effect *Statistical significance* Mixed
Li and Reuveny (2006)	CO2/143/1961-1997 NOx/118/1990	DV	Trade openness Conflict (dummy) Real GDP per capita Real GDP per capita squared Population density (population divided by land area) Lagged 1 year	Cross-sectional time Series (pooled) analyses
	Water pollutants/112/1980-1998 Deforestation/134/1980s, 1990s	Per capita CO2 emissions logged NOx emissions per capita Organic water Pollutants Per km3 Annual deforestation rate Forest area share of land area Degraded area share of land area		*Statistical significance*
	Forest areas/134/1980, 1990, and 2000	IV		Mixed
	Degradation/105/1980s	Level of democracy (Polity IV)		

Looking at the discussion of empirical studies and the table above, it appears unclear if environmental performance varies systematically because of the governance and regime characteristics of a government. One possible explanation of this lack of clarity

lies in the model specification and methodological approaches that various scholars adopted in their studies.

Scholars have used multiple DVs in their studies to explore the effect of regime types. For example, a range of environmental indicators have been used in those empirical studies covering SO2, CO2, NOx, CFCs, carbon intensity, actual emissions level, logged CO2, various climate indexes, deforestation, and many more. The effect of political regimes on these several DVs may not be representative of a standard environmental indicator and may not produce a coherent outcome for the predictor variable.

Besides, like these multiple DVs, different democracy indices also have different weighting scales and operationalization schemes across different studies. Therefore, the use of different measures of democracy on various environmental indicators may produce conflicting and mixed results.

Apart from the issue of model specification, various estimation strategies that have been used in different studies may affect the results. It is evident that many existing literature is afflicted with methodological limitations as well as limitations in data quality and coverage.

With all these backdrops in context, the present study encounters two gaps in the existing empirical literature in its inquiry into the political regime-environment relationship. They are: (1) there is a need for testing the rigorousness of the existing empirical results using multiple democracy indices, and (2) employing various empirical strategies of the same model(s) with an advanced time-series cross-sectional design.

Therefore, the study intends to contribute to testing the democracy-CO2 relationship using various indices of democracy and examining if the results are consistent regardless of multiple democracy indices. Besides, the study also attempts at improving upon much of the literature in terms of data coverage, model specification and statistical techniques. The results of these statistical models are presented and discussed in Chapter 3.

1.2.1 Introduction: Federalism and Climate Change

1.2.1 Introduction: Federalism and Climate Change

Does the federal system of government respond differently to the problem of climate change than countries with unitary forms of government? Empirical studies that examine the relationship between federalism and environmental outcomes and policy are mixed. Some studies demonstrate that federalism or multilevel governance improves environmental standards while some other studies suggest the opposite. In addition to empirical investigations, some qualitative studies also indicate some mixed and conflicting results about the role of the federal structure in combating climate change problems. The present study investigates if the countries' CO2 emissions are related to whether countries have a unitary or federal structure.

1.2.2 Theory

Since the 1990s, major international environmental agreements (IEAs) emphasize in national-level policy efforts the goal of reducing greenhouse gas emissions. This is because greenhouse gases cause global warming and are responsible for several forms of climate change effects. But many of the world's powerful nations have not actively reduced greenhouse gas emissions. Most of these large countries are institutionally fragmented into a federal system. These federal countries together contribute a lion share of carbon emissions in the earth's atmosphere. Collectively, the top 10 carbon-emitting countries account for nearly three-quarters of global emissions. These top emitters who are structurally arranged as federal systems emit a total of about 60% of global emissions

- China[2] (26.83%), United States (14.36%), India (6.65%), Russia (5.03%), Japan (3.09%), Brazil (2.33%), Canada (1.69%) (Friedrich, Ge, & Pickens, 2017).

The increasing trend of CO2 emissions by all these federal-system countries raises the question of whether 'federalism' as an institution is responsible for this increased emissions behavior. Existing literature suggests two diametrically opposing theories about the effect of federalism in climate change problems. One theory suggests that federalism brings a 'race to the bottom' tendencies in the country, leading to the softening of environmental regulatory stringency at the cost of environmental quality. On the other hand, a different theory suggests that federalism brings a positive effect on the environment with instead a 'race to the top' effect (Gamso, 2017; Holzinger, 2007; Konisky, 2007).

What do these two opposing theories tell about the role of federalism in tackling climate change problems? The race to the bottom approach argues that in a federal country, subnational units compete with other state governments to attract trade shifts and businesses. To attract the shifting of businesses, they tend to relax their environmental regulation. This laxity in environmental regulation and lack of competitive environmental regulatory framework among several subnational units eventually leads to an increased level of aggregate pollution and more significant environmental damage at the national level. In the wake of unhealthy competition between and among sub-national units or neighboring countries for businesses, the growing loosening of stringency in

[2] Although debates prevail, but many scholars consider China to maintain a federal system (Feigenbaum & Ma, 2014; Montinola, Qian, & Weingast, 1995). The empirical estimation of this study, however, does not consider China to be a federal country because the original source of data did not define China as a federal system.

environmental standards, in cumulative, reduce overall national environmental performance.

In contrast to this argument, some scholars propose an opposite hypothesis which they call as the 'race to the top' (Gamso, 2017; Holzinger, 2007). The race to the top theory argues that subnational units attract residents by being more environmentally friendly. The more standard and stricter the environmental regulations are, the healthier the environment is. In a competition for a cleaner environment, states maintain stringency in environmental regulation to attract potential residents. This leads to the expectation that federal countries maintain stricter environmental control leading to lower levels of pollution (Holzinger, 2007; Konisky, 2007).

In sum, the core argument of the race to the bottom theory is that confronted with interstate economic competition, subnational units have incentives to adopt excessively lax environmental regulation to create environment so that businesses transfer their capital investment. These incentives, coupled with the state government's pursuance of economic development, will likely lead subnational units to relax their standards to advance a competitive advantage over other states. If all subnational governments within the federal system reason in the same fashion, the result will be a gradual bottoming out of environmental standards across the country.

The reasons why subnational units might choose to relax environmental regulation may be influenced by several factors. Apart from economic incentives that the states pursue, two other vital factors may influence in untightening of environmental regulatory standards, as demonstrated in scholarly literature are (1) state-elected official's electoral incentives to ease environmental standards. The elected officials want to ensure future

chances for reelection and sustain popularity from positive economic news. Most models of voting behavior suggest that economic factors play a central role in explaining individuals' vote choices (Atkeson & Partin, 1995; Ebeid & Rodden, 2006). (2) The other factor that also influences in relaxing the environmental regulation is the lobbying of the business-interest group to weaken states' environmental management. The business lobbies are more likely to influence subnational governments to lower the costs of doing business by limiting the regulatory requirements in their states (Davis & Davis, 1999; Engel, 1996; Lowry, 1991).

These two theoretical arguments can be summarized in the following table:

Table 3: Theories the Federalism-Climate Change Relationship

(a) Mechanisms of race to the bottom theory				
	Input	***Throughput***	***Output***	***Outcome***
Model 1	Interstate economic competition	Relaxed environmental regulation	Business shifting Transfer of Capital investment	Poor national environmental performance More pollution and environmental damage
(b) Mechanisms of race to the top theory				
	Input	***Throughput***	***Output***	***Outcome***
Model 1	Competition for cleaner environment	Stringency in environmental regulation	Attracting potential residents More taxpayers	Lower levels of pollution Better environmental performance

1.2.3 Literature Review

There are abundant studies that evaluate the effect of federalism on various economic issues (Caplan, 2001; P. J. Grossman & West, 1994; Huber, Ragin, & Stephens, 1993; Jensen & McGillivray, 2005; Keen & Kotsogiannis, 2002; Treisman, 2000) and social issues (Chappell & Curtin, 2012; Christin & Hug, 2012; Franceschet & Piscopo, 2012; Lang & Sauer, 2012; Mahon & Brennan, 2012; Ruibal, 2018), but the research on the

effect of federalism on the problems of climate change, especially the empirical one is very limited. Some qualitative studies, however, explored the effect of federal systems on different aspects of environmental management and performance.

A few empirical studies that investigate what drives the environmental performance are available both for the cross-national level of analysis as well as within subnational jurisdiction in a federal system. In the context of the United States, Konisky conducts several empirical investigations on whether a race to the bottom or a race to the top prevails in the United States.

In his 2007 paper, Konisky (2007) assesses some strategic interaction model if a state's environmental regulatory behavior is shaped by the regulatory behavior of the states with which it competes for economic investment. Using annual state-level enforcement of federal air, water, and hazardous waste pollution control regulation for the period from 1985 to 2000, he suggests a mixed finding of this study. His empirical model presents clues that a race to the bottom tendency may drive the subnational unit's environmental regulatory standards. However, he further suggests that there is no evidence against a race to the top among the competing subnational units. Konisky explains that states tend to respond quickly (within the same year) to the regulatory behavior of the states with which they compete for economic investment. In particular, Konisky finds strong evidence that states react to the regulatory enforcement effort of competitor states in instances where their enforcement attempts may put them at a disadvantage position for attracting economic investment.

However, in this paper, Konisky also presents arguments which are supportive of a race to the top hypothesis. In contrast to the above assertion, Konisky provides arguments

that states may compete for mobile capital in nonpolluting industry sectors, such as those in the service sector. For example, states may promote their public education and infrastructure to attract new firms. In so doing, they may advertise and emphasize their "clean" environments. Konisky explains that there are complexities in understanding which strategic interaction is at play, and there is a possibility of a race to the top too among the competing subnational units.

Slightly different, Konisky, in his 2008 paper, provides evidence that a race to the bottom may prevail in the subnational units. In this paper, Konisky evaluates a series of attitudinal hypotheses of the state regulators. The focus of the empirical query was if state regulators express beliefs that are indicative of race to the bottom dynamic within the state regulatory decision-making process. Using data from the State Environmental Managers Survey, Konisky finds that state regulators express knowledge of the regulatory practices of other states. They also believe that environmental regulations matter to industry establishment or industry retaining, although not to the extent for factors like market proximity and labor cost. Besides, the study also found that concerns about the probable impact of environmental regulation on industry cause agencies to relax their regulatory burdens. Overall, the findings suggest that the way that state regulators think is consistent with the race to the bottom argument (Konisky, 2008).

The study of Holzinger and Sommerer (2011) tests the theory of race to the bottom in the European context. Using environmental output data for 24 countries from 1970 to 2005, they study the actual documents of environmental legislation including changes and modification of law and regulation related to environment, and they examine if a race to the bottom exists based on that legal modification. Contrary to the conventional

wisdom of ‘race to the bottom’ in regulatory competition, they instead discover a clear ‘race to the top’ trends in the environmental legal framework. Their study of environmental policy documents shows that about 94 percent of all changes in regulations are upward moves in favor of environmental performance, with only 6 percent indicating downward movements.

Rasli, Qureshi, Isah-Chikaji, Zaman, and Ahmad (2018) examine three types of environmental Kuznets curve (EKC) including ‘new toxics,’ ‘race to the bottom,’ and ‘revised’ EKC in a total of 36 developed and developing countries from 1995 to 2013. They find a cross-country race to the bottom phenomenon in which ‘pollution haven’ industries relocate their businesses, preferably to developing countries where environmental considerations are compromised with flexible regulations. In specific, Rasli et al. (2018) find the evidence of ‘race to the bottom’ for nitrous oxide emissions (N2O) and carbon monoxides (CO) emissions.

Gamso (2017), in his 2017 paper, investigates the effect of trade on the environmental performance of developing countries. Although it is not about the study of federalism on climate policy, the study provides some crucial lessons on how trade may bring a diversified effect on trading partner countries in the question of environmental performance. The findings of the study suggest that business creates a positive impact on the environments of developing countries. At the least, some trade creates improvements in environmental performance, in particular, when the developing countries partner with the governments and businesses in the United States and the European Union. The study, however, further suggests that other trade relationships do not appear to generate any environmental gains.

In the same context, the findings of Gamso (2017) are found to be contradictory to the study of Xing and Kolstad (2002). They examine the effect of the laxity of environmental regulation on foreign direct investment. The foreign direct investment (FDI) of several US industries has been evaluated into two categories. One, industries that incur high costs of pollution control (chemicals and primary metals) and the other, industries with a relatively modest cost of pollution control like electrical and non-electrical machinery, food products and transportation equipment, etc. The study uses aggregate national sulfur dioxide emissions as the pollutant, which appears to be positively associated with FDI determination. They conclude that lax environmental regulation affects the US FDI inflows to the host country. The effect is significant for heavily polluting industries while it is not significant for less-polluting industries.

In another study, Gamso (2018) examines if China's trade with Latin American and Sub-Saharan African countries have a race to the bottom effect. Since China usually does not impose any strict environmental standards with its trading partners like the United States and the European Union do, the resulting effect is likely a race to the bottom tendencies because of the pollution-intensive industries operating in trading partner countries. Using data that covers 58 Latin American and Sub- Saharan African countries from 2001 to 2010, Gamso finds that trade with China tends to spell a race to the bottom in the environmental policies since China does not impose any stringency of environmental regulation to its trading partner countries. Gamso, however, further finds that the effect is moderated by features of good governance like bureaucratic capacity (2018).

To a little different context, Aşici and Acar (2015) investigate the effect of income on the environment. Their study seeks to understand if countries tend to relocate their ecological footprint with the expansion of the economy. Using the production and import components of the environmental footprint data for a panel of 116 countries from 2004 to 2008, they find that import footprint continues to grow monotonically as the income increases. Besides, their study also finds that environmental regulations of the home country do not influence the importation of environmentally damaging products from abroad; rather, they affect domestic production characteristics. The study, hence, offers two-fold findings that (1) as countries get richer, they tend to replace local production of environmentally hazardous goods by imports, and, (2) they export the ecological cost of their consumption to weaker economies. Both of these trends indicate a probable race to the bottom hypotheses.

Wälti (2004) investigates the effect of federalism on the environmental performance of industrialized countries from a multilevel governance perspective. Walti operationalizes ‘federalism’ as a proxy for the degree of sub-national autonomy in policymaking. Her study offers two competing hypotheses for the effect of federalism on environmental protection. The first hypothesis stresses that institutional fragmentation and regulatory unpredictability are detrimental to the protection of the environment. The second hypothesis emphasizes that multilevel systems may provide better environmental performance because they can effectively respond to local needs and encourage innovation at the subnational level. Based on OECD air pollution data, the study finds that multilevel structures affect the way in which important determinants of environmental performance work.

Walti argues that the effect of federalism often depends on how we perceive federalism as a predictor variable. She points to the two distinguishing forms of federalism as Keman, Crepaz, and Benz outline. Keman (2000) provided two types of federal distinctions. They are 'right to decide' vs. 'right to act.' Crepaz (1995) called these distinctions as 'cooperative' vs. 'competitive' veto points. Benz (2000) named this distinction as 'tight' vs. 'loose' coupling. To a broader sense, these distinctions of different brands essentially convey more or less the same things, and they are the distinction between 'policymaking' and 'policy implementation'. Based on these typologies, Walti finds the federalism may instead have an indirect effect on the environment, and the effect largely depends on the stages of the policy process and the kind of externality the environmental problems pose.

Walti argues that sub-national autonomy drives environmental performance during policymaking, while intergovernmental coupling contributes to environmental policy implementation. As an example, she presents that the impact of federalism is more often indirect when it relates to issues like identifying the 'point source pollution' as opposed to 'mobile source pollution'. Because actor-related federalism or 'policy implementation' type of federalism can easily respond to the problem of the geographic concentration of point source pollution.

Her core findings on the effect of federal structures on environmental performance are based on differentiating two other variables or, in other words, based on two other system characteristics. They are the effects of income and corporatism. Centering on two air pollutants (NO2 and SO2) data, Walti finds that the effects of federalism interact with these two system characteristics. Like the other studies, she finds positive relationships

among environmental performance, income, and corporatism. That is, wealthier and more corporatist countries perform better. Walti observes that in a weak multilevel context, high economic development accounts for good environmental performance. She argues as multilevel governance increases, economic development essentially has either no effect or a negative effect on the environmental performance. In contrast, Walti further claims that the corporatism promotes high environmental performance in the context of strong multilevel systems. But when multilevel governance decreases, this positive effect of corporatist structure tends to diminish or even reverse.

The following table summarizes major studies that explored the relationship between federalism, environmental policy, and climate change.

Table 4: Summary of Empirical Literature for the Study of Federalism and Climate Change

Author (s)	Geographic/ temporal coverage	DV/IV	Controls	Empirical model
Negative Findings between Federalism and Climate Change				
Rasli et al. (2018)	36 developed and developing countries/1995 -2013	DV CO2 (Carbon dioxide emissions in per capita Gigagrams CO2 equivalent) CO (carbon monoxides) N2O (nitrous oxide emissions) NOX (mono-nitrogen oxides) SO2 (sulfur dioxide) TRAFFIC (Railways Traffic passenger carried in per capita million passengers-km (served as a proxy for traffic volume) IV GDPPC (GDP per capita (GDPPC) in million constant 2005 US $) INDVAD (industry value added (INDVAL) as % of GDP)	ENRG (Energy Use in kg of oil equivalent per capita) LAC (the later development of the economy) PCFPROD (per capita food production variability in 1$ per person constant 2004-06) TOP (trade openness as % of GDP)	Panel robust least square MM-regression estimates *Statistical significance* Yes
Gamso (2018)	58 Latin American and Sub-Saharan African countries/2001 -2010	DV SO2 Intensity (the natural log of SO2 as a share of GDP) EPH (Environmental Public Health) portion of EPI (Environmental Performance Index) IV Trade with China as a share of GDP Environmental Performance Index (EPI) IV Trade partner EPI Northern Trade Partner EPI	Democracy Trade with China * Democracy Bureaucratic Capacity Trade with China * Bureaucratic Capacity Trade with USA Other Trade FDI Inflows GDP Per Capita GDP Per Capita Squared Population Density Veto Players MEAs PTAs with US & EU	Panel regression models *Statistical significance* Mixed

		Non-Northern Trade Partner EPI High-income trade partner EPI Low-income trade partner EPI OECD trade partner EPI Non-OECD trade partner EPI Foreign Direct Investment		
Aşici and Acar (2016)	213 Countries/ 1970-2008	DV Per capita pressure on nature, in constant 2005 US Dollar defined as carbon dioxide damage p.c. +mineral depletion p.c. +energy depletion p.c. +net forest depletion p.c. IV Real per capita income (log)	Population density (Total population divided by land area (km2)) Education (Average total years of schooling in the population age 25 and over) Enrollment rate (Secondary school enrollment rate, total) Openness (Merchandise trade (% of GDP)) Rule of law Capital account openness Democracy	Fixed-Effects Instrumental Variable (IV) method *Statistical significance* Yes
Konisky (2008)	United States/ June-July 2005; also, September 2005	DV (1) Dependent variable is response to question: "Again, thinking about the primary industry your office regulates, how much of an effect would relaxing the environmental standards for companies in this industry have in improving their competitiveness compared to similar companies operating in other states?" (2) Dependent variable is response to question: "Next, I'd like to know whether other states' environmental regulations affect the environmental regulations in your state. Thinking about the primary industry that your office regulates, do other states' regulatory actions have no effect, a modest effect, or a significant effect on the actions that your office takes regarding your primary industry?" IV Interstate competition	Personal attributes: Education Income Position tenure Agency tenure Democrat Republican Independent Other Political ideology Environmental ideology Environmental media managed: Air pollution control-related office Water pollution control-related office Land/waste pollution control-related office Other office Political party affiliation (dummy)	Ordered logit model *Statistical significance* Yes
Xing and Kolstad (2002)	22 countries including 7 developing countries and 15 developed countries/1985 and 1990	DV Regulatory laxity; Instruments: Chemicals and allied products Primary metal industries Food and kindred products Industrial machinery and equipment Electronic and other electric equipment Transportation equipment IV FDI inflows	GDP per capita, in thousands of 1985 US dollars per person Annual SO2 emissions, in thousands of tonnes Annual capital outflows of the U.S. industry i, in millions of 1985 US dollars Corporate tax rates Annual income of U.S. industry i foreign affiliates, in millions of 1985 US dollars Population, in thousands Share of industry outputs in GDP, percent Electricity structure index Population density	OLS regression and Instrumental variable model *Statistical significance* Yes
Positive Findings between Federalism and Climate Change				
Gamso (2017)	83 developing countries/2000 -2010	DV Environmental Performance Index (EPI) IV	GDP per capita GDP per capita squared Trade Regime Type Foreign Aid IGOs INGOs	Fixed effects linear regressions *Statistical significance*

		Trade partner EPI Northern Trade Partner EPI Non-Northern Trade Partner EPI High-income trade partner EPI Low-income trade partner EPI OECD trade partner EPI Non-OECD trade partner EPI Foreign Direct Investment	Conditional PTAs with US Conditional PTAs with EU	Mixed
Holzinger and Sommerer (2011)	24 Countries/1970-2005	DV Regulatory upward movement	Accession to international institutions EU membership Environmental ministry Political constraints Green party success Greenpeace national bureau Energy use per capita (ln) Income per capita (ln)	Negative binomial regression model with country random effects
		IV		*Statistical significance*
		Trade openness (Imp + Exp/GDP) FDI net inflows (%GDP) Fraser index freedom of trade		Mixed
Mixed Findings between Federalism and Climate Change				
Konisky (2007)	United States/ 1985-2000	DV (1) Inspections: The annual number of sampling inspections; (2) Punitive actions: The unweighted sum of informal and formal punitive actions (informal actions include notifications of violation, while formal actions include measures to move violators back into compliance, such as administrative orders, consent decrees, and civil penalties).	Competitors' enforcement Dem. Governor Dem. Legislature (% both chambers) State ideology Unemployment (%) Fiscal health Manufacturing GSP (% of total GSP) Mining GSP No. facilities (1000s) Per capita income Population (millions) Population density (per sq. mile) Urbanization (%) Party affiliation of state-elected officials Party composition of the state legislature	Two-stage least squared instrumental variables approach (2SLS-IV)
		IV		*Statistical significance*
		Strategic interaction (a weighted average of competitors' environmental enforcement effort)		Mixed
Wälti (2004)	23 OECD countries	DV NO2 SO2	GDP growth	Multiple regression with interaction
		IV Multilevel governance index Federalism Bicameralism Decentralization Interlocking		
		Interactions		*Statistical significance*
		Level of economic development Corporatism		Mixed

Apart from the empirical findings discussed above, some qualitative studies also investigate the effect of federalism on environmental protection and policymaking. The scope of these studies spans from the discussion of the effect of federalism in general (Fiorino, 2011; Scruggs, 2003) to different country case studies including the United

States (Rabe, 2004b, 2010; Schlager, Engel, & Rider, 2011), Canada (Bernstein, 2002; Blair, 2008; Dusyk, Axsen, & Dullemond, 2018; Litfin, 2000; Samson, 2001), the EU (Schreurs, 2011), Switzerland (Casado-Asensio & Steurer, 2016), Austria (Niedertscheider, Haas, & Görg, 2018) etc. Like the empirical studies, qualitative studies also demonstrate mixed findings for the effect of federalism on environmental performance and management.

Scruggs, in his book, studies the effect of different institutions on environmental performance covering 17 industrial countries. For the impact of federalism, he investigates whether multiple avenues of representation or centralized channels better serve environmental interests. He conceptualizes federalism as 'geographical separation of power.' While he provides a succinct summary of why federalism may help as well as impede environmental performance, he concludes that being federalist or unitary or having a bicameral or unicameral legislature does not render a difference (Scruggs, 2003).

Fiorino attempts to study the effect of four different institutional characteristics on environmental performance. These are economic growth, democracy, neo-corporatism, and federalism. In his qualitative exploratory paper, Fiorino (2011) indicates a mixed finding for the effect of federalism on environmental performance. Fiorino argues that federalism appears to generate a "multiple competitive dynamics" in the United States, at least at the subnational levels, as well as in the European Union (EU), but created a hindrance in Canada for efforts of emissions reduction. Fiorino holds that a variety of complex factors may be at work for federalism to affect both positively and negatively to environmental performance.

Wheeler (2001), in his qualitative case study, analyzes trends of air quality in the United States and three other countries in the developing world, e.g., China, Brazil, and Mexico. Because these countries receive a substantial amount of FDI inflows, Wheeler examines if there is any evidence for a race to the bottom hypothesis as a result of significant among of FDI inflows in those countries. Based on the data of foreign direct investment and air quality, Wheeler (2001) concludes that the most hazardous form of air pollution declined in major cities of all the four sampled countries in the era of trade openness. Citing other research, Wheeler argues that the race to the bottom model is flawed because its basic premises do not represent the realities of the political economy of pollution control in the developing world.

The specific country case studies, as mentioned above, mostly covers a fundamental question: how federalism or multilevel governance affects in environmental policymaking and performance. Barry Rabe, one of the leading authorities in the field of American federalism and climate change policy provide evidence that many state governments play a significant role in environmental sustainability (2004b). In his study, he identifies that many state agency bureaucrats play a critical role in improving environmental quality (Rabe, 1999). While there are many laudable pieces of evidence for American state governments becoming a role model for other states for a possibility of policy diffusion, Rabe also draws a grim pen-picture of the American federal government's poor performance in adhering to national emissions standard (Rabe, 2008, 2010). He argues that the federal role of environmental performance as "a blend of hyperbole and inertia (p.147)" (Rabe, 2004a, 2011).

Canadian experience with climate change policy often mirrors the U.S. policy strategy when it comes to adhering to international environmental agreements (Burke & Ferguson, 2010). When Canada compared with the U.S, many scholars describe that American states are faring much better in climate change policy development than their Canadian provincial counterparts (Rabe, 2005). In the face of economic globalization and the related effects of NAFTA, provincial actors and "local" industries in Canada consider themselves as global actors to deal with environmental concerns in trade and businesses. The provincial subnational units in Canada hold that the federal government should not lead in international efforts to reducing GHG emissions, but rather should "provide a competitive infrastructure to attract investment" (Hyndman et al., 1996, quoted in Litfin, 2000). This attitude provides an abundant source of conflict between the provincial government and the federal government on environmental concerns (Samson, 2001). The opposing role of Ontario and Alberta on various environmental issues is prominent in the context of the Canadian federal government's efforts to maintain environmental regulatory standards (Berman, 2017; Leahy, 2019).

In Austria, federalism emerges as a stumbling block in the implementation of the Climate Strategy 2002 (Niedertscheider et al., 2018; Steurer & Clar, 2015). For many sectoral policy issues, the federal state and the Länder come in conflict on policy design and proper implementation. For example, in Austria, "spatial planning" and "housing" sectors are under provincial jurisdiction, but Länder appears to intervene in the traffic, industry, and energy sectors in such a way that it indirectly affects the provincial policy preferences in those two sectors. Moreover, there is other evidence of policy conflict where it is found that Länder's subsidy policies for building new houses and

refurbishment cuts thwarted the success of the 2009 federal refurbishment program (quoted in Niedertscheider et al., 2018).

In brief, the empirical and qualitative inquiry into the role of federalism on environment suggests that the major reasons for this federal inefficiency and inaction are: (1) the interstate competition for the transfer of businesses that leads to compromise in adopting stringent environmental legislation by the subnational units. The effects are the proverbial race to the bottom across the nation. (Posner, 2010; Rabe, 2004b), (2) constitutional autonomy and ambiguity on environmental management between the state and federal government (Campbell & Thomas, 2002), (3) high adjustment costs by states who have a high level of emissions records. The subnational units emitting higher levels of emissions tend to remain less willing to adhere to national emissions standard (Rabe, 2004b, 2008), (4) divergent policy preferences between subnational and federal authority and adjustment costs for the maintenance of national environmental standard (Lundqvist, 1974), (5) Overlapping authorities within the federal system which may increase the cost of reaching out a coherent environmental policy (Holland, Morton, & Galligan, 1996), and (6) the complexity of multilevel governance in managing climate policy including carbon tax, carbon cap and trade, divestment and other environmental affairs (Rabe, 2010; Woods, 2006).

In contrast, the arguments that are often placed in favor of federalism include (1) subnational unit's competition for providing cleaner and healthy environment to its citizens by ensuring stringent environmental standards leading to race to the top effect, and (2) the possibility that federalism would ultimately generate an effective environmental policy at the wake of various innovations concurrently being experimented

in different subnational jurisdictions. Eventually, the innovations would culminate into the most effective policy instrument for climate change protection diffused across nationally.

At the backdrop of all these theoretical arguments that show the federal structure may improve or impede or leave a mixed effect on the climate change protection is reflected in various empirical and case studies that explore the role of federalism in dealing with climate change problems. The essence of such a multiplicity of results lies in the dynamic relationship between the federal entity with its subnational counterparts and the context, interest, and policy preferences of both entities.

The analysis of the above empirical and qualitative studies demonstrates all forms of the possibility of the effect of federalism on climate change problems with positive, negative, and mixed findings. It is important to note that those studies have used a variety of dependent variables in its quest to investigate the federalism-environment relationship. The only empirical research that specifically focuses on the effect of federalism on environmental performance is found in Wälti (2004). However, the present study is different from Walti's in several ways.

First, in Wälti's paper, federalism is conceptualized more like a combination of 'devolution of power' and 'decentralization of fiscal resources' in a federal system while the present study operationalizes the federalism variable as the institutional fragmentation of countries being federal versus unitary. In fact, Wälti uses 'federalism' variable as a proxy for the degree of sub-national autonomy in policymaking using the federalism scale of Keman (2000) while the present study focuses on creating a binary variable for

federalism variable, with the value 1 denoting that the country constitutionally has a federal structure and 0 being the country follows a unitary form.

Second, Wälti's paper covers only 23 OECD countries, while the present study includes all of the countries in the world.

Third, Wälti uses the air pollutant of sulfur oxides (SO_X) and nitrogen oxide (NO_X) as dependent variables for her study. In contrast, the present study uses CO2 (carbon dioxide) as its dependent variable.

All these differences warrant that the present study pursues, although close, but a different research question. Given the fragile role of many federal countries in reducing the CO2 emissions, an empirical investigation into the question of if the federal structure itself plays any positive or negative role at a cross-national global perspective remains of utmost importance. Therefore, the present study intends to fill the void of exiting scholarly efforts and offers contributions in the following areas: (1) it is the first of its kind to study the effect of federal structure at a cross-national perspective covering all of the countries in the world, (2) the study uses per capita CO2 emissions as its dependent variable to reflect governmental efforts for tackling the problem of climate change. Previous studies did not yet test federalism-environment relationship using the CO2 emissions as the dependent variable, and (3) the overall goal of the study is to improve upon much of the literature in terms of data coverage, model specification, and statistical techniques. The statistical analysis that examines this relationship is presented in chapter 4.

1.3.1 Introduction: Political Ideology and Climate Change

1.3.1 Introduction: Political Ideology and Climate Change

Do left-leaning governments respond differently to the problem of climate change than right-leaning governments? No doubt, politics comes as a driving force in the adoption of environmental policy, and partisan ideology plays a significant role in shaping climatic and environmental legislation, including strategies towards mitigation of carbon emissions. Studies that investigate the role of leftist versus rightist political ideology in climate policy produce mixed and contrary results. Some studies find an inverse relationship between left ideology and the level of carbon emissions (Garmann, 2014; R. F. King & Borchardt, 1994; Neumayer, 2003, 2004) while some studies find an opposite and uncertain results for the role of left-leaning ideology in environmentalism (Chang, Wen, Dong, & Hao, 2018; J. Wen, Hao, Feng, & Chang, 2016). Using multiple political ideology indices with some appropriate empirical methods, the present study investigates (1) the robustness of existing findings on the political ideology-environment relationship, and (2) if the results are consistent across different measures of political ideology at a cross-national level.

1.3.2 Theory

The existence of left-right political divide on environmental policy is strongly evident in the environmental politics literature (Costantini & Hanf, 1972; Dillman & Christenson, 1972; Tognacci, Weigel, Wideen, & Vernon, 1972). But the basis of party ideology and their environmental stances are not clear. Studies in environmental literature provide conflicting evidence on the effect of political ideology on climate change problems. Earlier studies in the 1970s provide no partisan differences on environmental concerns and environmental policy reform issues, especially in the U.S context (Buttel & Flinn,

1976a; Munton & Brady, 1970). However, studies since the 1990s show some mixed results for the role of partisan belief in the environment, with some studies providing evidence that left party ideology tends to be more supportive of the issue of environmental achievement.

Why the left political parties tend to exhibit a more substantial concern to environmental problems can be attributed to their political ideology and standpoint about the fundamental principles of state economic policy. In general, left ideology does not support a free flow of capital and the ideals of the market economy. They exert skepticism about the efficiency and equitability of the unregulated market and underscore the importance of government intervention in the market (Buttel & Flinn, 1976a; Neumayer, 2004). The widely held view is that an unregulated market, by design, leads to inequitable distribution of wealth. These discriminatory distributional concerns, coupled with skepticism towards any positive effects of the invisible hand, are traditionally regarded as major factors that divide the left-wing political parties from their right-wing counterparts.

Although both left-wing and right-wing ideologies do not deny the importance of economic growth for human welfare, the roots of their differences lie in the question of material production and distribution. Debates prevail between these two ideological tribes over if there should be a limit to the level of state intervention and the share of allocation of resources. Both of these ideological groups develop a pro-growth approach because, without a growth-friendly economic approach, the social and economic objectives of countries cannot be accomplished. Solesbury (1976) notes that the only other options beyond a pro-growth approach would probably be…the “unacceptable means” (p.28).

R. F. King and Borchardt (1994) observe that this perception was fundamental to the rise of the green movement that leads to the belief that independent political action was needed to promote an alternative conception of social progress. Feared by the probable consequences of industrial society on earth, they advance their belief in the early 1980s that "We are neither to the left nor the right, but out in front" (Pilat, 1980).

R. F. King and Borchardt (1994) suggest that probably being inspired with this environment-friendly stance, left political tribes incorporate environmental issues into their political agenda. Eventually, the left-wing parties demonstrate their dedication and action in advancing environmental causes not merely in symbolism, but also in party manifesto and policy stances. This involves left parties to assert stronger political will and greater policy capacity for environmental stewardship against environmental pollution and externalities of the market economy.

The partisan theory, as developed by Hibbs (1986) and the rational partisan theory as postulated by Alesina (1987) holds the view that left-wing parties are more inclined to frame expansionary economic policies to take care of the interest of the proletariat or the working class. By contrast, the right-wing parties tend to serve the interests of the wealthy, and they prefer to make the monetary policy in such a way that combats inflation and maintains the real wealth of capitalists. The differential preferences in line with partisan division may have different economic consequences leading to a different outcome for environmental achievement. This led to assume the present study's hypothesis that left-leaning governments may be more supportive of environmental issues in the spectrum of left-right ideological division.

1.3.3 Literature Review

Previous studies that examine the partisan relationship with environmentalism are split into different contrary findings. In comparison of environmental attitudes between liberals and conservatives, some studies find that liberals have always been more pro-environmental than conservatives (Costantini & Hanf, 1972; Dillman & Christenson, 1972; Dunlap, 1975; Tognacci et al., 1972). Some other studies, on the contrary, suggest no Republic-Democratic differences on environmental issues (Buttel & Flinn, 1976b; Munton & Brady, 1970). However, the studies that provide differences in party preferences on environmental questions provide evidence both for rightist and leftist ideologies to have equal concerns for environmental degradation. As mentioned above, the general thrust of interest of these studies is to examine whether and how the strength of a political party can influence the environmental quality. Among the studies that consider rightist political ideology to show more concerns for environmental problems, Dunlap (1975) and Buttel and Flinn (1976) are prominent.

Based on a questionnaire survey of 237 students that examined their pro-environmental attitude and behavior, Dunlap (1975) find significant differences in the approach in which the student respondents of different partisan identifications and political ideologies perceive the causes and solution of environmental problems. His study suggests that the Republican and Conservative students consistently showed lower rates of pro-environmental attitudes and actions than their Democratic and Liberal-Left counterparts. However, when Conservatives perceive an environmental catastrophe as a distinct possibility, pro-environmental belief lift up as high as of Liberals.

Buttel and Flinn (1976a) examine the effect of party identification and political ideology on aspects of mass environmental beliefs and awareness of ecological problems. His study suggests that neither party identification nor political ideology has a considerable effect on perception of environmental problems. In fact, to a different context, they indicate that the anti-laissez-faire political liberalism is positively correlated with support for environmental reform, particularly among the middle-class people.

Among several authors who find that left-leaning parties are more pro-environmental, Neumayer is notable among them, who, in his two papers, conclude that left-parties are more environment-friendly. His 2003 paper studies 21 OECD countries over the period of 1980 and 1990-1999, where he argues that parliamentary green/libertarian party and more environment-oriented parties in the parliament, including the traditional left-leaning parties. Later, in his 2004 paper, Neumayer studies the relationship between a party's position within the left-right political spectrum and its stance on environmental issues, as expressed in party manifestos. The study also examines the relationship between individuals' ideological orientation and environmental beliefs, attitudes, and self-reported behavior. In this paper, he suggests that left-leaning political parties, as well as individuals with left-orientation both, are more likely to support environmental issues than their right-wing counterparts (Neumayer, 2004).

J. Wen et al. (2016) compares the party's position on economic issues in relation to environmental issues, and his findings suggest that left-wing governments prefer environmental quality to economic performance. On the contrary, right-wing governments focus more on economic growth than environmental issues. Chang et al. (2018) find that the left-wing governments are associated with lower carbon dioxide

emissions among the least polluted countries, but it was not the case with the median and highly polluted nations.

The study of Garmann (2014), Change and Berdiev (2011), and R. F. King and Borchardt (1994) investigate the effect of government ideology on the environmental pollution on OECD countries. These studies indicate an inverse relationship between government ideology and pollution. The study of Garmann (2014), however, indicates a different finding where he shows that center governments are associated with more emissions abatement than left-wing governments, while the left-wing governments are associated with more emissions reduction compared to right-wing governments. Garmann (2014) concludes that climate change policy cannot be classified on a typical left-right scale of the political spectrum.

The following table shows the findings of major empirical research that studies the relationship between political ideology and the environment.

Table 5: Summary of Empirical Literature for the Study of Political Ideology and Climate Change

Author (s)	**Geographic/ temporal coverage**	**DV/IV**	**Controls**	**Empirical model**
Findings that support left-ideology is more environment-friendly				
Chang et al. (2018)	65 countries including 26 developed countries and 39 developing countries/1981-2012	DV (log) Total carbon dioxide emissions (in metric tons per capita) Source: World Bank (2011) IV Government ideology Source: Beck et al. (2001) Database of Political Institutions	Energy GDP GDP-squared Population Export Import Globalization Yrsoffc Democracy	Instrumental variable quantile regression technique *Statistical Significance* Yes
J. Wen et al. (2016)	85 countries/ 2002-2012	DV Environmental Performance Index (EPI) Environmental Health Index (EHI) Ecosystem Vitality Index (EVI) IV	Per capita GDP (GDP) Trade openness (Trade, calculated as the ratio of import and export volumes to GDP) Share of manufacturing production in GDP (Industry) Emissions of CO2 (CO2)	Least square dummy variable (LSDVC) (Bias corrected) *Statistical Significance*

		Political ideology Ideology1 Ideology2	Energy efficiency, estimated by energy-GDP ratio (Efficiency) Urbanization rate (Urbanization) Share of the working age population (Workpeople) Secondary education enrollment rate (Secondary) Whether a country signed the Kyoto Protocol (Kyoto) Level of democracy (Democracy) Level of bureaucracy (Bureaucracy) Political stability (Stability)	Yes
Garman (2014)	19 OECD countries/ 1992-2008	DV CO2-emissions per unit GDP Source: Marland et al. (2008) and Camarero et al., 2013. IV Political ideology Source: Woldendorp et al. (2000, 2011) and Database on political institutions (Beck et al., 2001).	Government ideology Number of parties Election Minority government Population growth Urban population growth GDP growth Change share aged Electric power Consumption growth Change in openness Change in tertiary sector Change in sec. sector KP ratification	Fixed effect model Dynamic panel data model *Statistical Significance* Yes
Neumayer (2004)	1. 25 countries/ National elections over the period 1945 to 1998	DV 1. The percentage of sentences in a manifesto devoted to a particular policy category e.g. "environmental protection" in party manifestos for national elections 2. World and European Values Surveys covering 32,296 and 89,906 individuals	Gender Marital status Number of children Age Religiosity Employment status, Social status Education status as well as size of settlement Developing country (dummy)	Logit and ordered-logit model
	2. Between 44 and 62 countries/ Survey conducted during 1981-1984, 1990-1993 and 1995-1997	IV 1. Environment priority over growth Confidence in Green/Ecology movement Choose products that are better for the environment Recycle or reuse Reduce water consumption Willing to pay higher taxes Willing to pay higher prices Active member of environmental organization Attended meeting or signed letter contributed to environmental organization		*Statistical Significance* Yes

		2. Self-identified political ideology variable		
Neumayer (2003)	21 OECD countries/ 1980 or 1990-1999	DV Air pollutant Source: EMEP (2002) Emissions data (http://www.emep.int) - United Nations Economic Commission for Europe, Geneva	GDP Vehicles Manufacture Fossil Efficiency Corporatism	Fixed and Random Effects Estimation
		IV		*Statistical Significance*
		Left-wing party strength Source: Comparative Parties Data set of Swank (2002)		Yes
R. F. King and Borchardt (1994)	17 OECD countries/1980 For IV: 1970-1980	DV *Air pollution:* Carbon oxides (CO) Hydrocarbons (HC) Particulate matter (Part) Sulfur oxides (SOx) Sum Source: Environmental Data Compendium (OECD, Paris), 1989 and 1991	Energy consumption per capita Proportion of energy inputs from oil and solid fuels Proportion of GDP outputs from industry	Multivariate OLS regression
		IV		*Statistical Significance*
		Left Political Party: (a) (InCab): the percentage of years that parties of the political left participated in the ruling government, either alone or in coalition, and thus held at least one of the cabinet portfolios (b) (CabShare): the average annual share of cabinet portfolios held by parties of the left (c) (DomCab): the percentage of years that parties of the left were a dominant force in the government, with 40% or more of the cabinet portfolios (d) (Seats): the average annual share of seats in parliament held by parties of the left (e) (Votes): the average annual share of votes in parliamentary elections garnered by parties of the left (f) (Union): An index of labor organization, reflecting both the percentage of the work force unionized and the centralization of unions into peak associations Source: Swank (1992)		Yes

Findings that support right-ideology is more environment-friendly				
Buttel and Flinn (1976)	A 1974 statewide Wisconsin survey conducted by the Wisconsin Survey Research Laboratory (548 respondents)	DV Awareness of environmental problems Support for environmental reform IV Republican party identification Democratic party identification Anti-Laissez-Faire liberalism	Education Age Place of residence	Multiple regression *Statistical Significance* Yes
Dunlap (1975)	Questionnaire survey of students from the University of Oregon (237 usable sample, response rate 79%)	DV "Great interest in environmental issues" "Strongly Approve" of the environmental movement' IV Political ideology (categorical) Democrat Republican Liberal left Moderate Conservative Awareness of Environmental Problems Support for Environmental IV Republican Party Identification Democratic Party Identification Anti-Laissez-Faire	Family socio-economic status Residence	Crosstabulation (contingency table) Gamma ratio *Statistical Significance* Yes

In the realm of environmental policymaking, Barrilleaux (1997) argues that policymaking for the issues of climate change and environmental performance is largely shaped by the political background of the government, including that of powerful parties. A conventional notion runs that right-wing parties attach more importance to economic development, and they focus less attention on environmental achievements. On the contrary, left-wing parties pay more attention to environmental improvement because they are more careful about public welfare (Benton, 1997) and the future of the planet. While a few studies empirically probe that left-wing parties perform better in reducing climate change problems, some studies find mixed and uncertain results. With this backdrop into consideration, the present study investigates the effect of political ideology on the problems of climate change as a way of a robustness check of the existing empirical findings.

The present study encounters two gaps in the existing empirical literature in its inquiry into the political ideology-climate change relationship. They are: (1) there is a need for testing the rigorousness of the current empirical results using multiple political ideology indices, and (2) employing various empirical strategies of the same model(s) with an advanced time-series cross-sectional design.

Therefore, the study intends to contribute to testing the political ideology-CO2 relationship using various measures of political ideology and examining if the results are consistent across those multiple measures. Most of the existing study explored partisanship question within OECD countries and only two studies covered a cross-national analysis with 65 countries (Chang et al., 2018) and 85 countries (J. Wen et al., 2016) respectively, the present study contributes to the existing literature with more geographic and temporal coverage with the updated version of the dataset. Overall, the goal of the study is to improve upon much of the literature in terms of model specification and statistical techniques.

Chapter 2: Empirical Model

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The empirical model of this dissertation employs carbon dioxide (CO2) emissions (metric tons per capita) as its main dependent variable. Specifically, the indicator measures how many metric tons of carbon dioxide a country *i* emits in a given year *t* in relation to its total population. In brief, the CO2 per capita is a measure of a country's emissions of carbon dioxide gas that accounts for its number of people. It divides the country's total carbon dioxide emissions (in metric tons) by its total population. Why did the study use CO2 emissions (metric tons per capita) as its dependent variable is explained in section 2.4.

The dissertation uses time-series cross-sectional (TSCS) design to analyze the effect of three political institutions, e.g., democracy vs. non-democracy (160 countries), federal form vs. unitary form (176 countries), and leftwing vs. rightwing political ideology (120 countries) on carbon dioxide emissions behavior of (a list of countries is appended in Appendix A) from the year 1990 to 2014. The temporal coverage of the study captures a series of important developments in international climate politics. Looking into the annals of climate change history, it appears that the warming effect of CO2 on earth's atmosphere got its initial attention during the 1960s. Guy Stewart Callendar, a British engineer, warned about doubling of CO2 in Earth's atmosphere for the first time. He predicted the global temperature could potentially reach to 2 degree Celsius (History.com Editors, 2017). Because of missing observations for many of the variables in the period prior to 1990, I analyze the time period of 1990 to 2014.

Most of the authors in climate politics consider the 1990s as a benchmark point for their data analysis. Because beginning in the 1990s, the issues of climate change, global

warming, or greenhouse gas emissions received increased attention in the news, media, and academic circle. Eventually, climate change issues enter the political agenda both in international forums and national-level politics across the world. Several international environmental agreements were reached among many nations around the decade of the 1990s. Some such significant attempts, among others, were establishing the *Intergovernmental Panel on Climate Change (IPCC)* in 1989 under the auspices of the United Nation and constituting the *United Nations Framework Convention on Climate Change (UNFCCC)* in 1992 including the subsequent *Kyoto Protocol (KP)* in 1997.

The Kyoto Protocol called for reducing the emissions of six greenhouse gases in 41 countries, including the European Union (mostly developed countries often called Annex I parties) to 5.2 percent below 1990 levels during the target period of 2008 to 2012. After that, the second commitment period of the Kyoto Protocol spans from 2013 to 2020. In this second commitment period of the Kyoto protocol, the Annex I nations are required to reduce their level of emissions by 18%. Its commitment period will come to an end in 2020, and from then on, the Paris Agreement on Climate Change 2015 will go into effect (Davenport, 2015; United Nations, 2015).

The unit of analysis for the study of three political institutions in the dissertation is the country-year, where each observation describes the per capita CO2 emissions level of a country in a given year, bringing the total number of observations to 3,678 for the study of political regimes, 3,985 for federalism study, and 2,233 for political ideology study after listwise deletion of missing observations for each variable of the empirical model. The geographical coverage of the dataset was kept as widely as possible to reduce the risk of drawing conclusions from correlations that are caused by country-specific regional

attributes rather than the attributes of political institutions. The major criterion for dropping a country from the data was missing observations for two or more independent variables across the temporal coverage in the study. A total of 38 countries/territories are dropped out of the dataset. A list of dropped countries/territories is available in Appendix B.

The major independent variables of the dissertation are three political institutions: political regime (democracy vs. non-democracy), federalism (federal vs. unitary form of government), and political ideology (left-leaning vs. right-leaning partisanship). A brief description of three political institutions is presented below.

2.1 Political Regime as Political Institution

Scholars have identified several regime types in the spectrum between the extreme form of authoritarianism to a relatively liberal form of democracy including liberal democracy, participatory democracy, deliberative democracy and egalitarian democracy. The dissertation conceptualizes political regimes in the spectrum of democracy vs. non-democracy or countries that lack in democracy scale. This does not indicate a dichotomous or binary variable. It refers to a form of popular notion of electoral democracy where various democracy indices rank countries based on a point scale system for the characteristics or virtues of democracy that a country achieves. Needless to say, that various democracy indices have their own operationalization scheme in defining democracy and identifying the point scale system for the notion of democracy. The dissertation uses five different measures of democracy that are putatively thought to represent the basic attributes that make a political regime as ‘democratic’ per se. The

study expects that these five measures cover some basic notion of democracy as postulated by scholars and exercised by world nations.

Table 6 summarizes five different measures of democracy that the study uses as independent variables for its major empirics.

Table 6: Definition of Democracy Variables		
Variable	*Definition*	*Source*
Electoral Democracy Index *(v2x_polyarchy)*	V-Dem's electoral democracy index is comprised of a host of attributes that typically embody a regime which can be characterized as democratic. They include the capacity to make rules for citizens achieved through electoral competition with universal suffrage, freedom of political and civil society organizations, free and unbiased elections, freedom of expression and an independent media which can run unbiased and without intervention between the two elections. The index is configured by taking average of, on the one hand, the weighted average of the indices measuring freedom of association, clean elections, freedom of expression, elected officials, and suffrage and, on the other, the five-way multiplicative interaction between those indices. The V-Dem's codebook further mentions that the aggregation of this electoral democracy is based on the level of Dahl's subcomponents with the one exception of the non-electoral component. This is an interval level variable ranges from low to high (0-1) (Coppedge, Carl Henrik and Lindberg, & osefine and von Römer, 2019).	Varieties of Democracy (V-Dem)
Polity2 Score	The policy2 score is a combined polity score of democracy (democ) and autocracy (autoc) as measured in Polity IV Project by Center for Systemic Peace. The score is computed by subtracting the *autoc* score from the *democ* score. This is a revised score of original polity measure where some fixes are introduced in this version of polity2. The polity2 scale ranges from +10 (strongly democratic) to -10 (strongly autocratic). However, their conceptualization of democracy is based on three elements as mentioned in the codebook; (1) the existence of institutions and procedures by which citizens can express effective preferences about alternative policies and leaders, (2) the presence of established restrictions on the exercise of power by the executive, (3) the guarantee of civil liberties and of political participation to all citizens. The Polity IV project considers that the some other features of plural democracy such as the rule of law, systems of checks and balances, freedom of the press are all inclusive of these three general principles (Marshall, 2019)[3].	The Polity IV Project
Democracy as a composite score of civil liberties and	The Freedom House data assigns two ratings to a country or territory – one for political rights and one for civil liberties based on its total scores for the political rights and civil liberties questions. They are measured on a one-to-seven scale, with one representing the highest degree of Freedom and seven the lowest[4]. For the statistical purpose of the research, the present study recoded both of the variables following an inverse direction with one	Freedom House Data (a Stata version of Freedom House Time-Series data, 1973-2018 is taken from Amanda B.

[3] For details of coding, refer to Polity IV Project: Dataset Users' Manual v2018, pp.14-15.
[4] For a detail explanation of the ratings and status characteristics of 'civil liberties' and 'political rights' variables, please refer to the website: https://freedomhouse.org/report/methodology-freedom-world-2019

political rights	representing the lowest and seven the highest. Both of the recoded civil liberties and political rights variables then summed up and then divided by two to extract a mean composite score for the empirical analysis of the study. According to Freedom House methodology, an electoral democracy designation requires a score of 7 or better in the electoral process subcategory, an overall political rights score of 20 or better, and also an overall civil liberties score of 30 or better. The methodology further mentions that Freedom House's designation to an "electoral democracy" should not be equated with "liberal democracy," a term that implies a more vigorous compliance of democratic ideals and a wider range of civil liberties (Freedom House, 2018).	Edgell, V-Dem Institute, University of Gothenburg from the website: https://acrowinghen.com/data/)
Democracy Index, the Economist Intelligence Unit (EIU)	The Economist Intelligence Unit's Democracy Index covers 167 countries in the world based on 60 indicators. Their model of democracy is based on five criteria. They are (1) electoral process and pluralism, (2) functioning of government, (3) political participation, (4) democratic political culture, and (5) civil liberties. However, the index is created on a scale of 0 to 10. These scores represent four categories of democracy. They are authoritarian regime (below 4), hybrid regime (4-5.9), flawed democracy (6-7.9), and full democracy (8-10) (Economist Intelligence Unit (EIU), 2018). Data of *Democracy Index* is extracted from *Gapminder* which converted the range of values from 0 to 100 to make it easier to communicate (Economist Intelligence Unit (EIU), 2018).	The Economist Intelligence Unit. Gapminder data is available at (https://docs.google.com/spreadsheets/d/1d0noZrwAWxNBTDSfDgG06_aLGWUz4R6fgDhRaUZbDzE/edit#gid=501532268)
Democracy Status Index, Bertelsmann's Transformation Index (BTI)	Bertelsmann's Transformation Index provides a *Democracy Status* index based on the five following criteria, (1) stateness, (2) political participation, (3) rule of law, (4) stability of democratic institutions, (5) political and social integration. These five criteria are further categorized into several indicators each scaled in a scale of 1 to 10 derived from assessments made in response to 18 questions which in aggregate provide the democracy status scores. Finally, the *Democracy Status* index ranks the countries according to the state of their democracy (Stiftung, 2018).	Bertelsmann's Transformation Index (BTI), Available at (https://www.bti-project.org/en/data/)

The five measures of democracy are taken from the Freedom House, the Polity IV, the V-Dem datasets, Democracy index of Economic Intelligence Unit (EIU) and Bertelsmannand's Transformation Index (BTI) for the statistical analysis as well as for a robustness check of the main findings.

The V-Dem Dataset for the democracy variable covers four different types of democracy e.g. (1) electoral democracy index (v2x_polyarchy) which is scaled from 0 to 1 (Teorell et al, 2016), (2) liberal democracy index (v2x_libdem) scaled 0 to 1 (Coppedge et al, 2015), (3) participatory democracy index (v2x_partipdem) scaled 0 to 1 (Coppedge et al, 2015), and (4) deliberative democracy index (v2x_delibdem) also scaled from 0 to 1 (Coppedge et al, 2015).

This dataset covers data from 1789 to 2017 for a total of 201 countries. The dissertation uses the measure of the electoral democracy index from the V-Dem dataset and uses this data for the main empirical findings. The V-Dem data provides several advantageous features including its vast temporal and geographical coverage, various desegregated indicators, and a more representative conceptualization of Dhalsian electoral democracy (Bernhard, Edgell, & Lindberg, 2016; Lührmann & Lindberg, 2018). The electoral democracy variable of V-Dem data measures how democratic a political system is in its de-facto condition which goes beyond capturing the mere de-jure existence of political institutions. In addition, as a continuous democracy index, it quantitatively captures the sensitivity from gradual and slow-moving autocratization processes (Lührmann & Lindberg, 2018). *Second*, the Freedom House ranks countries based on 'political rights' (PR) and 'civil liberties' (CL), and they are measured on a one-to-seven scale, with one representing the highest degree of Freedom and seven the lowest (Freedom House, 2018). Freedom House data for democracy is available from 1973 to 2018. *Third*, the Polity IV dataset contains several variables - the most suitable for the dissertation is Polity2, which is computed by subtracting the autocracy score from the democracy score of a country and customized for time-series data analysis. Most of the

political scientists use this variable for their empirical work related to political institutions. The unified polity scale in Policy2 ranges from +10 (strongly democratic) to -10 (strongly autocratic) (Marshall, 2019). *Fourth*, The Economist Intelligence Unit's Democracy Index covers 167 countries in the world based on 60 indicators. Their model of democracy is based on five criteria. They are (1) electoral process and pluralism, (2) functioning of government, (3) political participation, (4) democratic political culture, and (5) civil liberties. However, the index is created on a scale of 0 to 10. These scores represent four categories of democracy. They are authoritarian regime (below 4), hybrid regime (4-5.9), flawed democracy (6-7.9), and full democracy (8-10) (Economist Intelligence Unit (EIU), 2018), and *fifth*, Bertelsmann's transformation Index which provides a democracy status index based on the five following criteria, (1) stateness, (2) political participation, (3) rule of law, (4) stability of democratic institutions, (5) political and social integration. These five criteria are further categorized into several indicators each scaled in a rank from 1 to 10 which in aggregate provide the democracy status scores.

Data for democracy is taken from five different sources, as presented in Table 1. Except for the Freedom House data, all the data sources have a democracy variable by name. The Freedom House data does not have a democracy variable by its name. Scholars in the field of political science and other social sciences use their measure of 'civil liberties' and 'political rights' variable as a proxy for democracy from the Freedom House dataset. Most of the data sources have configured democracy as a complex blending of several characteristics that a typical democratic regime should ideally nurture. In general, these various characteristics, as explained in Table 1, have separate

scales, which in the aggregate, comprise a democracy variable. There is no gainsaying that what democracy means is one of the most debated questions in political science. The study does not render to provide a new or revised version of the definition of democracy. It is, in fact, beyond the scope of this study. Rather, the study uses the measure of democracy as operationalized by these data sources. There are, however, reasons to believe that the conceptualization of democracy as constructed by the five different data sources vary in degree and determinants. However, the characteristics that are common across all of the five measures are the quality of electoral systems, civil liberties and political participation. All of the measures represent a composite blending of various regime characteristics scaled and ranked based on a scoring system. The biggest difference is that the number of regime characteristics vary across democracy indices. For example, the Freedom House operationalizes its democracy measure with only 'political rights' and 'civil liberties' while V-Dem dataset includes about five regime characteristics to operationalize their 'electoral democracy' variable. The details of each measure is presented in Table 6.

The use of five different measures of democracy in a single study, however, is not very common. The dissertation considers the use of these multiple datasets as a contribution to the existing literature in climate policy and environmental politics. Most of the previous studies have used either two or three measures of democracy, typically one for the main empirical results and the others for a robustness check. Since earlier studies on the effect of democracy on climate policy demonstrate conflicting and mixed results, the present study takes a rigorous attempt with more datasets and sophisticated methodology to evaluate the effect of political regimes on CO2 emissions. Among these

five measures of democracy, three measures are very widely used by scholars in environmental politics. These are Varieties of Democracy (henceforth, V-Dem) data, the Polity IV data and Freedom House data. On the other hand, the two other datasets are relatively less used in scholarly endeavors. These are *Democracy index* of the Economic Intelligence Unit (henceforth, EIU) and *Democracy Status Index* of Bertelsmann's Transformation Index (henceforth, BTI). The study expects that these five different datasets would allow us to understand the consistency of the results for climate change problems.

2.2 Federalism as Political Institution

The idea of federalism holds several connotations in relation to governance and economic management of a country that follows a non-unitary form. Riker (1975) considers federalism to have many flavors that can be thought of along a continuum from minimal (loosely connected) to maximal (highly centralized) federalism. Various scholars have distinguished different forms of federalism. Notables among them are Daniel. J. Elazar (1987), Riker (1975), Lijphart (2012), Keman (2000), Crepaz (1995), and Benz (2000), etc. The dissertation does not apply any technical use of the term. Rather it applies Scruggsian conceptualization of federalism as 'geographical separation of power' that embodies the definitions of both Daniel. J. Elazar (1987) and Riker (1975), that is, a guaranteed division or distribution of power among multiple centers within a nation.

Table 7 summarizes three different federalism indices that the study uses as independent variables for its major empirics.

Table 7: Definition of Federalism Variables		
Variable	*Definition*	*Source*
Federalism	The study constructed a dummy federalism variable with 1 if a country is listed as federal by the Forum of Federations website and 0 otherwise. To distinguish a federal system to that of unitary counterparts, the website mainly focuses on the measure of political decentralization or formal federalism, not other forms of devolution.	Forum of Federations, http://www.forumfed.org/countries/
DPI's 'author' variable	The DPI dataset has several measures of federalism variable and the study has used 'author' variable for its robustness check with the main findings. The 'author' variable is constructed based on the question if a subnational government or federal unit have the authority over taxing, spending, or legislating. This variable is coded as binary with 1 if a subnational unit has authority over any of these three characteristics and 0 otherwise (See Appendix C for a list of federal (author) countries included in the database).	(Cruz, Keefer, & Scartascini, 2018)
Lijphart's index of federalism	Along with the basic idea of distribution or division of power among subnational units, Lijphart incorporates some secondary features in his definition of federalism including a strong bicameral legislature, a written constitution, a supreme court or special constitutional court etc. Lijphart's quantitative index of federalism spans only on thirty six democracies of the world from a scale of 5 to 1 where highest value represents intense federalism and the lowest value or 1 represents unitary or centralized form (Lijphart, 2012). (See Appendix D for Lijphart's index of federalism).	(Lijphart, 2012)

Data for federalism is taken from the Forum of Federations website (http://www.forumfed.org/countries/). The website listed 24 countries as federal countries (a list of all federal countries by the website is appended in Appendix E). According to the estimates of the website, federal countries represents about 40 per cent of the world's total population. In illustrating what does federalism mean the website describes federalism as a system of voluntary self-rule and shared rule (Kincaid, 2002), which are grounded in a constitutional organization that permits action by a shared government for certain common purposes (Watts, 2002). However, the study has constructed a binary federalism variable based on the information of the website with 1 if a country is listed as a federal country and 0 otherwise. Andonova, Hale, and Roger (2017) have used the same binary federalism measure for their study. The study has verified the list of federal

countries mentioned on the website with several other resources to confirm the appropriate counts of the countries with the federal system. They include studies of Potter (2018), D. J. Elazar (1996), Jensen and McGillivray (2005), Rodden (2004), Lijphart (2012), etc. Besides, to check the robustness of empirical findings, the study has used the federalism indices from the Database of Political Institutions (DPI 2017) and Lijphart's scale of federalism (Lijphart, 2012).

2.3 Political Ideology as Political Institution

Political ideology serves as an influential political institution and considered a powerful determinant of party choice as well as policy preferences (Hellwig, 2008). In typical parlance, scholars operationalized political ideology along a left-right continuum. Scholars provide strong evidence that ideological cleavages drive policy preferences, and when it comes to the question of climate policy, the left-right divide is often obvious. The dissertation uses three measures of political ideology for its empirical analysis. Table 8 below summarizes these measures.

Table 8: Definition of Political Ideology Variables

Variable	*Definition*	*Source*
Swank's partisanship variable	Swank's partisanship variable is created based on his comprehensive work '*Comparative Political Parties Dataset: Electoral, Legislative, and Government Strength of Political Parties by Ideological Group in 21 Capitalist Democracies, 1950-2015*'. The dataset contains a variety of variable related to party identification/orientation. He categorizes 'left' parties as communist; socialist, social democratic, and labor and other various left-wing parties (e.g., left-libertarian parties). The study has created Swank's partisanship variable bases on six different variables extracted from this dataset. These six variables are (1) LEFTC (left party cabinet portfolios as a percent of all cabinet portfolios), (2) LEFTGS (left governing party seats as a percent of all legislative seats), (3) LEFTS (left party legislative seats as a percent of all legislative seats), (4) LLC	Swank's 'Comparative Parties Data Set' from https://www.marquette.edu/political-science/directory/documents/swank-party-data-update.xls

	(percentage of cabinet portfolios in national government held by left libertarian ("new left") parties as defined by Herbert Kitschelt[5], (5) LLGS (left libertarian governing party seats as a percent of all legislative seats), (6) LLSEAT (percentage of seats (lower chamber) for left-libertarian parties and various miscellaneous works). The left-libertarian party strength was added to the typical left party strength because they share the same environmental concern and pursue similar objectives with respect to environmental policy. The study has recoded the variable for the purposes of statistical analysis by combing the three left-party strength variables (LEFTC+LEFTGS+LEFTS) and then taking out the mean of these three variables by dividing the combined estimate by 3. In the same way, the other three variables are also summed up (LLC+LLGS+LLSEAT) and then divided by 3 for get the mean of left-libertarian party strength. Finally, both of these scores are summed up to get the partisanship variables that are assumed to represent the overall strength of left-party ideology. Swank's data covers a total of 21 nations from the year 1950 to 2015. Swank's original source of reference is as under: Sources: (1) Francis Castles and Peter Mair, "Left-Right Political Scales: Some 'Expert' Judgments", European Journal of Political Research 12 (1984): 73-88. (2) Political Handbook of the World (New York: McGraw-Hill, selected years.) (3) Country specific sources (studies of national party systems, party manifestos, etc.)	
Comparative Political Dataset's partisanship variable	The dataset has three variables related to left political ideology. The first one is gov_left1 which denotes the cabinet posts of social democratic and other left parties in percentage of total cabinet posts. The second one is gov_left2 which represents a relative power position of social democratic and other left parties in government based on their seat share in parliament, measured in percentage of the total parliamentary seat share of all governing parties. The other one is gov_left3 which designates the parliamentary seat share of social democratic and other left parties in government. For the purpose of statistical analysis, the study has created a partisanship variable by summing up all of the above three variables to represent the overall strength of left pollical ideology. The dataset covers a total of 23 OECD countries from 1960 onwards and 36 OECD and EU countries from the year 1990 onwards to the year 2017. The original source of data is: Armingeon, Klaus, Virginia Wenger, Fiona Wiedemeier, Christian Isler, Laura Knöpfel, David Weisstanner and Sarah Engler. 2019.	Comparative Political Data Set, 1960-2017 available at: http://www.cpds-data.org/index.php/data#CPDS

[5] Kitschelt, H. (1994). *The Transformation of European Social Democracy*: Cambridge University Press.

	Comparative Political Data Set 1960-2017. Bern: Institute of Political Science, University of Berne.	
DPI dataset's EXECRLC variable	The DPI's execrlc variable has an ordinal scale with 'Right' as 1, 'Left' as 3, 'Center' as 2 and 0 carries no information. This coding is based on the party orientation with respect to economic policy as found on the description of the party in the sources. Right is defined as "for parties that are defined as conservative, Christian democratic, or right-wing." The left is defined as "for parties that are defined as communist, socialist, social democratic, or left-wing" and center is defined as "for parties that are defined as centrist or when party position can best be described as centrist." Furthermore, a party is coded as 0 when a party does not fit into the above-mentioned category (e.g., party's manifesto does not focus on economic issues, or there are competing wings), or no information. The study has recoded the variable by dropping 0 cases for its major analysis. Also, the study has recoded a second variable by creating a dummy variable of partisanship from this execrlc variable by dropping both '0' and '2' (Center) cases and transforming the 'right' or 1 cases as 0 and 'left' or 3 cases as 1. The original source of data is as under: (1) Political Parties of Africa and the Middle East, (2) Political Parties of Eastern Europe and the Successor States, both published by Longman Current Affairs series. Besides, the coding was further compared with Huber, John, and Ronald Inglehart. 1995. "Expert Interpretations of Party Space and Party Locations in 42 Societies." Party Politics 1(1): 73-111 for maintaining consistency of the variable definition.	Database of Political Institutions 2017, Inter-American Development Bank

Data for political ideology is taken from three different sources, as presented in the above Table 8. Except for the DPI data, the other data sources have multiple variables relevant to party ideology. The study has combined these various variables either by adding up or both adding up and deriving the mean of overall left-party strength. Typically, the left party variable has three distinct measures based on their party representation in the cabinet and the government and finally, in the parliament.

The DPI dataset, however, only has one variable related to party ideology with an ordinal scale where 1 represents the right-wing party, 2 represents the centrist party, and

3 represents the left-wing party strength. The party identity is measured based on their economic policy, as described in the party manifesto.

The statistical analysis with the DPI dataset was made with both in its original version as well as with a recoded dummy version. The partisanship variable with Swank data and CPD dataset, however, was created with some recoding of the existing variables available in both datasets. Following Neumayer (2003), the study has combined all the variables that represent the left party's relative status in the cabinet, government, and in the parliament from the CPD dataset. In addition, from the Swank dataset, the study has combined all these three measures both for the left party as well as for the left-libertarian party. This composite construction of the political ideology variable is assumed to represent the overall strength of left-political ideology for the country *i*.

2.4 The Dependent Variable: Measuring Climate Change Problems

The dependent variable of the dissertation is carbon dioxide emissions or CO2 emissions per capita. To test the hypotheses whether the political institutions have any effect in addressing climate change problem by reducing the level of CO2 emissions, the study uses data of carbon dioxide emissions (CO2) per capita from the World Bank's World Development Indicator dataset. Principally, this dependent variable is used as a proxy for 'climate change problems.' With this proxy dependent variable, it is expected that political institutions will create a sizable variation in lessening CO2 emissions compared to its opposite counterparts (democracy vs. non-democracy, federal form vs. unitary form, and left-wing vs. right-wing political ideology) at a cross-national level.

Like many other scholars in social sciences (Farzin & Bond, 2006; Thomakos & Alexopoulos, 2016; Winslow, 2005), the reason why CO2 emissions is used as a proxy for climate change problems is because CO2 gas is one of the major greenhouse gases (GHG) and considered the highest global warming potential (GWP) among other greenhouse gases (Gillis, 2017). The CO2 gas raises global temperatures by trapping solar energy in the atmosphere. It is released through human actions such as deforestation and burning fossil fuels, as well as natural processes such as respiration and volcanic eruptions, etc. This CO2 gas alters and shrinks water supplies and changes weather patterns. Furthermore, it also changes the growing season for agricultural production and endangers coastal communities with the increasing rise of sea levels (Cairoli, 2017; NASA, 2020). The consequences of the release of CO2 emissions in the atmosphere together, as a whole, pose a major threat to climate change. Any national efforts at reducing the level of CO2 emissions are essentially important contributory steps for addressing the problem of climate change. That is why, following the convention of many earlier scholars, the dissertation considers per capita CO2 emissions as its dependent variable as a proxy for national efforts of tackling the problem of climate change.

It is important to mention that choosing an appropriate indicator to measure the problem of climate change is not very simple. The idea of addressing climate change problems can be attributed to by both policy-level efforts as well as by the effectiveness of climate policy implementation. This exemplifies that the dependent variable could have been operationalized by both ‘policy outputs’ e.g. various environmental law, climate policy, and legislation, and environmental regulatory stringency etc. as well as by

'policy outcomes' e.g., by levels of various pollutants, harmful gases, deforestation or by the measure of environmental damage. Various scholars suggest that policy output data is better to measure climate change problems because it has likely a direct link to institutional factors than outcome data like CO2 emissions. Most likely, environmental outcome data is heavily dependent on various non-institutional factors like industrial production, enforcement of environmental regulatory framework and other economic activity. However, cross-country output analyses are rare because data is limited and a meaningful comparison may be difficult (Wälti, 2004).

With these shortcomings of policy output data, choosing an outcome data thus seems to be the reasonable (Scruggs, 2003; Wälti, 2004). In the realm of climate policy and environmental politics literature, however, there is one more challenge and that is there is no agreed upon outcome data that represents climate change problems. Contrary to economic policy, where GDP or GNP and unemployment rates appear to be commonly accepted measures of economic performance, climate policy presents no such agreed-upon measures.

Therefore, the dissertation selects CO2 emissions (metric tons per capita), a dependent variable that is common among a variety of options in the environment and climate policy literature that is assumed to represent the notion of climate change problems. How does the CO2 emissions appear to represent the problem of climate change? As discussed earlier, CO2 gas is one of the leading contributory greenhouse gases. It has the highest warming potential and considered a major cause of various climate change problems. Given its potential for dangerous effects, a national-level effort

at reducing the level of CO2 emissions is assumed a step towards tackling the issue of climate change.

How is the CO2 gas produced? The common source of the CO2 gas is that it enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement) (Environmental Protection Agency, 2018). In 2016 in the U.S., among different GHG emissions, 81 percent was carbon dioxide. Other gases were respectively methane (10%), nitrous oxide (6%), fluorinated gases (3%) (Environmental Protection Agency, 2018).

The data for CO2 emissions (metric tons per capita) emissions is available through the World Bank's World Development Indicator (WDI) database from 1960 to 2014. The database defined CO2 or carbon dioxide emissions as those "gases stemming from the burning of fossil fuels and the manufacture of cement. It also comprises carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring" (The World Bank, 2020). The original source of this data is from the Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States. Like many other researchers (Farzin & Bond, 2006; Thomakos & Alexopoulos, 2016; Winslow, 2005), the CO2 emissions in this dissertation is considered a proxy to climate change problems. Since major international environmental agreements including United Nations Framework Convention on Climate Change (1992), Kyoto protocol (1998) (de Chazournes, 1998) and Paris agreement (2015) (United Nations, 2015) urged countries to curb CO2 emissions from the atmosphere, any national

effort at reducing CO2 emissions is conceptualized as efforts towards battling the problem of climate change.

2.5 Control Variables

The empirical models used in the study introduce several control variables to hold constant in order to isolate the effect of political institutions on per capita CO2 emissions levels. These control variables are (1) GDP per capita, (2) trade openness, (3) population, (4) urbanization, (5) renewable energy consumption, (6) forest ratio, (7) Annex I status under the Kyoto Protocol, (8) Island dummy and (9) log of the latitude of the country. These control variables are expected to allow for fair comparisons between countries with varied democratic vs. non-democratic regimes, federal vs. unitary governments, and left-wing versus right-wing political ideologies that possess different socio-economic, geospatial, political, demographic as well as divergent climatic characteristics. Accounting for the effect of these variables is expected to provide evidence in favor of the research hypotheses that a systematic variation exists in per capita emissions levels comparable across countries based on regime typologies, political ideologies and federalism versus unitary governmental systems.

The choice of control variables used in the model is highly conventional and most of them are tested robustly in terms of their usage in multiple empirical studies. Overall, they cover three categories of factors believed to affect the main dependent variable. These categories are (1) economic and demographic factors, (2) environmental conservation factors, and (3) climatic or ecological factors.

Among the economic and demographic factors, the study has included GDP per capita, trade openness, population, urbanization, and Annex I status (Kyoto dummy) as controls. First, the GDP per capita in purchasing power parity is considered as one of the major indicators of a country's economic performance. It is assumed to exert a positive association with CO2 emissions levels; the higher GDP per capita is to correlate with higher per capita CO2 emissions as increased levels of production is believed to release higher levels of emissions.

From a contrary perspective, however, it is also argued in the literature that the higher GDP per capita may also indicate an economic transition to service sector and therefore lower levels of productivity, a shift to climate-friendly green technologies and a consequent lower levels of carbon emissions at certain points in economic development. From this perspective, the GDP per capita is also argued to correlate negatively with CO2 emissions when a country's income level reaches to a certain status.

In addition, a variety of other studies, however, find a mixed results with a curvilinear relationship between GDP per capita and CO2 per capita emissions (Apergis & Ozturk, 2015; Liddle, 2015; Özokcu & Özdemir, 2017; Shahbaz & Sinha, 2019). The dissertation also explores if there is any curvilinear relationship for this variable at the cross-national level and did not find any such traces. So, the it refrains to add a quadratic term in the model. However, the study uses GDP per capita as in its log-transformed version for its being rightly skewed and for a huge variation across countries.

Second, trade openness measured as the sum of exports and imports of goods and services as a share of GDP. The existing literature is divided on whether the trade effects are positive or negative. The reasons behind such uncertainty about the direction of trade

effects may be attributed to the (1) varied economic structure, (2) quantity and quality of industrial output, and (3) income level. Various researchers argue that it is difficult to isolate which of the three effects dominates or whether they impact each other (Antweiler, Copeland, & Taylor, 2001; Bättig & Bernauer, 2009).

The literature further suggests that trade may affect the environment in two distinct ways. *One*, the regulatory environment of domestic production, the methods of production, and the level of consumption may change under trade agreement if countries tend to follow their comparative advantages and demand for cleaner technologies for production. This is assumed to improve environmental quality of the trading destination countries and vice versa. This trend may also involve in bringing changes to the environmental regulation of the home country since many international environmental treaties and trade pact requires countries to follow certain regulatory standards in the production of goods and services. *Two*, on the contrary, trade may affect the environment by increasing economic growth, and therefore, changing people's consumption behaviors over time. While the effect of trade on the environment is ambiguous and often debated, it has been included in the model to comply with other studies in the environmental literature. (Li & Reuveny, 2006; Organization for Economic Co-operation and Development (OECD), 1994).

Third, both population and urbanization rate are believed to affect carbon emissions. More population means more use of energy, and obviously more reliance on fossil fuel. In fact, an increased number of population implies an intensified pressure on agricultural land for food, living and industry and, as a consequence, more environmental degradation

(Li & Reuveny, 2006). So, countries' population should have a positive association with CO2 emissions.

The rate of urbanization, on the other hand, is debated to have either positive or negative impact. On the one hand, countries' urbanization rate are expected to exert a positive relationship with national CO2 emissions due to the concentration of automobiles and industrial facilities in an urbanized city area (Arvin & Lew, 2011). As people flock to city areas for living and work, the consequent effect is often the burgeoning of slum areas and the fall of natural habitat leading to water and air pollution and more environmental degradation.

The other side of the argument, however, demonstrates that increased urbanization in the city area often involves an energy-efficient public transportation system, walking accessibility, and the emphasis on the use of solar panel and other clean energy technologies in the urban area which may relatively reduce the level of CO2 emissions (Lee, 2019; Makido, Dhakal, & Yamagata, 2012; Povitkina, 2018a; Shi et al., 2019).

Fourth, the Annex I is a binary variable that represents countries that had entered into the Kyoto Protocol during its first commitment period in the 1990s with a vision to cut down a targeted level of carbon emissions. A total of 41 countries have pledged to an emissions reduction target with their Annex I status under the Kyoto Protocol, and most of these countries are economically developed. Given the Annex I status would likely affect the emissions behavior, they are included in the model.

Apart from factors that are typically assumed to drive to increased carbon emissions, there are a few indicators that are likely to help reduce the level of CO2 emissions. The

two indicators of such kinds are renewable energy consumption and forest ratio. The more a country uses renewable energy, the less it adds carbon to the atmosphere and lowers the level of emissions. The variable in the model is defined as the consumption of renewable energy relative to total final energy consumption in a given year *t* for a country *i*.

Forested land, on the other hand, tends to promote environmental quality. The more a country is covered by forests, the better they bring good to the environment. In fact, forests work as a carbon sink and eliminate carbon pollution from the atmosphere. For example, the U.S. forests alone store 14 percent of all annual carbon dioxide (CO2) emissions from the national economy (A. a. Buis & Rasmussen, 2014; Friedel, 2017). The USDA calculates that forests in the United States absorb and store about 750 million metric tons of carbon dioxide each year, which is equivalent to 10% of the country's CO2 emissions (United States Department of Agriculture (USDA), 2010).

Finally, in order to obtain unbiased estimates of the effects of democracy on CO2 emissions at the cross-national levels, it is important to control for the effect of the varying atmospheric, topographical and ecological conditions across the cross-sectional units (G. M. Grossman & Krueger, 1991). In the regression models, the effect of varying climatic and ecological conditions was controlled by including two other variables in the model. These variables are (1) latitude of the country (used in logarithm) and (2) an island dummy variable. These two variables of the model which are included to account for any unobserved heterogeneity caused by biophysical or atmospheric and climatic characteristics like temperature, precipitation, winds and other weather conditions (Congdon Fors, 2007; Uusivuori, Lehto, & Palo, 2002; Wei, 2000).

Table 9: Definition of Dependent and Control Variables		
Variable	*Definition*	*Source*
CO2 (Carbon dioxide) emissions (metric tons per capita)	The level of total carbon dioxide emissions is divided by total population for a country in each year. The World Bank defines carbon dioxide emissions as those that are stemming from the burning of fossil fuels and the manufacture of cement including carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	World Development Indicators (WDI), The World Bank.
Ln GDP per capita	Natural log of GDP per capita based on purchasing power parity (PPP) (constant 2011 international $). The gross domestic product is converted to international dollars using purchasing power parity rates in constant 2011 international dollars.	World Development Indicators (WDI), The World Bank.
Trade Openness	Trade openness measured as percent of GDP. The World Bank defines trade as "the sum of exports and imports of goods and services measured as a share of gross domestic product."	World Development Indicators (WDI), The World Bank
Population	The World Bank considers a de facto definition of population which is based on the counts of all residents regardless of legal status or citizenship. The values in the data are midyear estimates.	World Development Indicators (WDI), The World Bank
Urbanization	Urban population (% of total population). The World Bank refers urban population as to "people living in urban areas as defined by national statistical offices." The data for total population are collected and smoothed by United Nations Population Division.	World Development Indicators (WDI), The World Bank
Renewable energy cons	The renewable energy consumption is the share of renewable energy used in total final energy consumption in a given year in a country.	World Development Indicators (WDI), The World Bank
Forest (% of land area)	The World Bank considers forest area as those land under natural or planted stands of trees of at least 5 meters in its natural condition, whether productive or not. It excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees grown in urban parks and gardens.	World Development Indicators (WDI), The World Bank
Annex I	The Annex I refers to a signatory status of a group of countries to the international climate regime. It is a binary variable coded 1 for the annex I parties -- the countries which gave pledge for a quantifiable emissions targets under Article 3 of the Kyoto Protocol, and 0 for non-annex parties/countries, which have only a political commitment to reduce global emissions over the first commitment period.	United Nations Framework Convention on Climate Change, United Nations, 1992 https://unfccc.int/resource/docs/convkp/conveng.pdf
Island dummy	A binary variable with 1 for countries with small island states and 0 otherwise.	Betz, Cook, & Hollenbach (2019)
Latitude	Log absolute latitude of the country.	Betz, Cook & Hollenback (2018)

Various studies suggest that island states typically emit less carbon due to low levels of industrialization and their limited potential for industrial production (Povitkina, 2018a). In the regression model, a small island dummy is operationalized if a subnational area of a country constitutes an island or is part of an island. This unit receives the value of 1, and 0 otherwise.

The latitude variable, on the other hand, accounts for variations in geographical locations and their associated climatic differences (Povitkina, 2018a). La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1999) consider this variable to be a "theoretically justified measure of geography." Quoting Landes (1999), he further justifies the inclusion of latitude variable in the model because latitude accounts for differences in the temperate zones. The variation in the temperate zones is more likely to affect the productive capacity of the agriculture and trigger divergent climatic conditions which may, in turn, affect the overall growth of economies, and consequently, the level of CO2 emissions.

Chapter 3: Estimation Methods

Chapter 3: Estimation Methods

The previous chapters of this study presented the theoretical background and empirical model about the causes of cross-national variation in CO2 emissions due to the effect of various political institutions. The arguments of the study are derived from theoretical literature in environmental politics and climate policy related to the role of political institutions in CO2 emissions behavior.

One of the major challenges of the empirical model is that some of the variables may have endogeneity problem. For example, GDP or economic strength of a country may be affected by natural resources of the country. Likewise, the level of urbanization of a country may be affected by the industrial growth of the country indicating a possibility of endogeneity problem in the model.

Other variables like forests may also generate a contradictory effect. While forest coverage works as a sync for ecological balance and, in turn, improves environmental quality. Countries with high forest coverage are more likely to have depletion of forest or forest-fires. These appear to have become a frequent phenomenon in recent years and may dampen environmental quality. The effect of trade on CO2 emissions can also be uncertain and mixed. On the one hand, trade openness seems to have an adverse impact on the environment because of increased production and unchecked industrial effluence. On the other hand, a growing trend in strict environmental regulation across countries and a host of climate-friendly international trade agreements at a bilateral and multilateral level would likely address the harmful effect of environmental damage.

Apart from these likely endogeneity issues, the empirical model of the study contains all the noises a time-series and cross-sectional data may encounter. Thus, simple correlations or OLS regressions, while an indispensable starting point, need to be complemented by several other sophisticated models that can address the problems of heterogeneity, autocorrelation and cross-sectional dependence, etc. and offer a reliable and unbiased estimate.

The study maintains the following empirical procedure. It starts to construct its empirical model by estimating a series of nested regressions, keeping with only the most reasonably exogenous variables, and then gradually including clusters of variables based on how they respond to the variable of interest, e.g., the CO2 emissions. Following Achen (2002), the study restricts its initial model with only three independent variables, which are exogenous. Achen provided an ART (A Rule of Three) approach for empirical architecture, where he claims that a model specification that includes more than three independent variables is meaningless (Achen, 2002, 2005). On the contrary, however, there is another point of view that suggests including all plausible variables in the model that might have an impact on the dependent variable to account for a possible omitted variable bias (Leamer, 1985). In some middle range, some scholars consider both of these standpoints as extremes since the use of three variables is too 'rigid' in a typical social science inquiry, and the inclusion of all the variables is neither possible nor practical (Jahn, 2016). Because it would likely end up with an impossible adventure – no one knows what more to include and what are still missing.

Keeping these two approaches in mind, the study partly applies both strategies. *First,* starting the empirical analysis with only three independent variables based on two

indicators: (a) to include three variables which are most common in climate policy literature, and (b) the three variables should come as exogenous to each other. The present study considers this first strategy as a parsimonious model, and, *second*, the study includes all the independent variables which are found to be mostly common in the empirical climate policy literature and which are not highly correlated to each other (see Appendix F through Appendix K for correlations matrix). The present study uses this strategy as its main model.

The empirical models explain climate change behavior[6] as a function of political institutions controlling for various economic, demographic, geographic, and climatic conditions. The robustness of the empirical results is assessed in a variety of ways. The study investigates the robustness of results by using alternative measures of all three political institutions as used by other scholars in the literature. Besides, the study also tests the robustness of results by adding a number of other control variables in the model and reassessing the original model. For both parsimonious and main models, the study applies multiple econometric estimations suitable for time-invariant or rarely changing independent variables. These estimations are also capable of addressing various diagnostic errors a TSCS data typically poses. Besides, the study further applies multilevel models to estimate, in specific, the between-effects of all the three political institutions to CO2 emissions behavior at a cross-national level.

[6] The dependent variable, CO2 emissions, is used in this study as a proxy for climate change mitigation or environmental damage. The use of CO2 emissions or other forms of carbon gases is widely used in environmental politics and climate policy literature and can be found, for example, in (Clulow, 2018; Farzin & Bond, 2006; Lægreid & Povitkina, 2018; Li & Reuveny, 2006; Mayer, 2017b; Midlarsky, 1998; Neumayer, 2002; Povitkina, 2018a; J. Wen et al., 2016; Winslow, 2005) and many more authors.

The empirical estimation, however, begins by setting up a pooled cross-sectional OLS regression. It then, following other scholars (Krieckhaus, 2006) gradually provides various TSCS estimates that can address different assumptions of time series data, including the problem of data having hierarchical structure in panel models.

First, in the pooled OLS model, the study intends to understand the relationship between a panel's mean outcome of CO2 emissions and the mean values of the panel's predictor variables. To make the OLS estimate reliable, several graphical investigations (Appendix L – Appendix Z) and the Breush-Pagan test were run, and the diagnostics suggest the presence of heteroskedasticity in the model. The problem would likely generate a wrong estimate of the standard errors for the coefficients and therefore their t-values. To deal with this problem, the study uses the heteroskedasticity-robust standard errors for its pooled OLS estimation. The results of pooled cross-sectional OLS is presented in Appendix AA.

Next, in order to model the effect of political institutions and other IVs on CO2 emissions behavior across countries and years, the study attempts to use several TSCS models. In general, TSCS models are prone to several forms of diagnostic errors. The study attempts to scan all of these regression diagnostics to culminate into a final model that can produce an unbiased estimate of the model.

3.1 Regression Diagnostics

Several diagnostic tests are presented in the following to determine the correct estimation strategies to investigate the causes of three rarely changing political institution variables for the continuous outcome of per capita CO2 emissions. Since the data

contains information of both time-series and cross-sections, it needs to satisfy several assumptions for an unbiased estimation. The diagnostics begin with some common model specification tests used in the empirical studies.

As far as the stationarity issue, the study tries several forms of unit root tests to check if the data is stationary. Since the data has gaps, Im-Pesaran-Shin test, Hadri's Lagrange Multiplier test, and Levin-Lin-Chiu test did not work because these tests require strongly balanced data. Furthermore, the Dickey-Fuller test for unit root also did not work. The test returns with some error code. However, the only unit root test that worked for the data was *Fisher-type unit-root test*, and in this test, the p-value was statistically significant both with and without demean and time trends, which suggest that the data is stationary. To further confirm the test, the study uses a residual analysis with xtfisher with no lags and two lags; in both cases, the results appear to be statistically significant suggesting that there is no issue of unit root bias in the variables of the model (Appendix AB – Appendix AD). In addition, the Phillips-Perron test of unit root appears to be significant at 0.01 level, which confirms the alternative hypothesis to be true that at least one panel is stationary. Since the data has serial correlation, to some statisticians, "pperron" option is better instead of dfuller in the sense that the Phillips-Perron test is robust to serial correlation (Andy, 2013; Cashin & McDermott, 2003).

Next, in a test of multicollinearity, the study does not find any problem of collinearity in both models (Appendix AE – Appendix AG).

To inquire about further diagnostics, the study tests if a time fixed is needed, the results of *testparn i.year* appear to be statistically significant (Appendix AH – Appendix AJ). So, a time fixed effect term is included in the model.

Next, the study applies some other tests to diagnose the fitness or specification of the model. In order to do so, the study runs Ramsey RESET test (Appendix AK – Appendix AM) and a specification error test (Appendix AN – Appendix AP). In both of these tests, the results appear to be statistically significant which exemplifies that the models might suffer from some functional form misspecification. However, when the study includes a time-fixed effect variable in the model, the statistical significance of both tests disappears.

Since the data contains panel structure, diagnostic tests from the first to fifth test in the following are typically applicable for TSCS data analysis.

First, it embarks with the Hausman test that suggest using fixed effect model for the study. The empirical models with TSCS data are likely show unobserved unit heterogeneity in the model which implies that country-specific effects are correlated with the right-hand side variables (Appendix AQ – Appendix AS). To deal with this problem, Greene (2012) suggests using a fixed effects model for correct estimation because a random effects model will be inconsistent with such unit heterogeneity. Some scholars provide other suggestions and rather advocate to use different forms of random effect model if the purpose of the study is to investigate the effect of time-invariant variables to investigate the cross-sectional variation of the variable of interest. Since the present study is interested in investigating the effect of three political institutions at the cross-national level, the between-effect is more appropriate which is attainable through random effect model.

With rarely changing explanatory variable in the model, the Hausman test suggested fixed effect model may not be appropriate. Troeger (2008) advised that in the field of

International Relations and International and Comparative Political Economy, many explanatory variables measure institutions which rarely change over time but might be influenced by country specific characteristics. This may lead to unreliable results of the Hausman-test and researchers may left with wrong guidance to which models to use (Troeger, 2008). Beck and Katz (2001) echoed the same in their critique of Green, Kim, and Yoon (2001) where they suggest to follow some estimation methods that allow for temporally and geographically dependent data to account for model heterogeneity because, to them, complete homogeneity of data across units and time is usually doubtful (Beck & Katz, 2001).

In their paper, Bell and Jones (2015) remarks that the Hausman test is not a test of Fixed Effect versus Random Effect model. It is actually a test of the similarity of within and between effects. They suggest that the Random Effect model that correctly specifies the within and between effects will provide identical results to Fixed Effect whatever the result of a Hausman test provides. Therefore, Bell and Jones (2015) suggests that the between effects, other higher-level variables and higher-level residuals should not be discarded; they sometimes carry important information, especially for important entities such as countries. For these reasons, according to them, the Random Effect models are the obvious choice (Bell & Jones, 2015).

More explanation is provided below on why random effect models are more appropriate than fixed effect for the present study. The study, however, reported statistical results of both fixed effect and different random effects models for a comparison and robustness check in the empirical results section.

Second, in a panel data with more than one observation per panel, it is likely that the observations in the dataset are not all independent. So, traits of panel which are not represented by other variables will more likely cause a 'within-panel correlations' leading to some biased standard errors. The Breusch and Pagan Lagrangian multiplier test for random effects for both models are found to be statistically significant (Appendix AT – Appendix AV). It indicates that there is a panel effect or there are variances across units or differences across countries which may bias the results.

Third, the study attempts to check if there is any problem of cross-sectional dependence in the dataset. The test for cross-sectional dependence or contemporaneous correlations with popular xttest2 returns some error codes for insufficient observation. So, the study further attempts with Pesaran test for weak cross-sectional dependence (2015) and test of cross-sectional independence with the command 'xtcdf' (Appendix AW – Appendix BA). Both of the tests confirm that the data are correlated across panel groups.

Fourth, the study attempts to check if there is any problem of first-order autocorrelations in the data. The residual analysis of the graph and the Woolridge test for both models appear to be statistically significant (Appendix BB – Appendix BG) which suggests that the data is afflicted with the problem of serial correlations.

Fifth, to test if there is any possible bias of groupwise heteroskedasticity in the model, the study runs the Modified Wald test for groupwise heteroskedasticity with xttest3 command including with and without robust option. In both of the tests for parsimonious and main model, the estimates are found to be statistically significant which suggests that

the models have the problem of groupwise heteroskedasticity (Appendix BH – Appendix BJ).

To deal with all such noises from first through fifth diagnostic tests, the study applies some estimation techniques which can address these problems. Two such commonly used estimation strategies are using an OLS estimate with panel-corrected standard errors (PCSE) method and the other is using a random effect model with Driskoll-Kraay standard error estimation. According to Beck and Katz (1995), the PCSE estimator is able to preserve the (Prais-Winsten) weighting of observations for autocorrelation but uses a sandwich estimator to include cross-sectional dependence when calculating standard errors. So, essentially PCSE can simultaneously address the problem of groupwise heteroskedasticity, autocorrelation, and cross-sectional dependence. No doubt that the PCSE estimator gains currency as a panel data estimator among quantitative social scientists. Moundigbaye, Rea, and Reed (2018) calculate that there is as many as over 2000 citations in Web of Science that uses PCSE estimator. It is, however, noteworthy as Beck and Katz (1995) warns that the finite-sample properties of the PCSE estimator does not perform well when the panel's cross-sectional dimension *N* is larger than temporal dimension *T*.

As a second strategy, the random effect model with Driskoll-Kraay standard error estimation, on the other hand is also able to address the above-mentioned problematics. This estimation procedure assumes its error structure to be heteroskedastic, autocorrelated up to certain lags, and presumably correlated between the groups in the panel structure. One basic feature of this nonparametric technique of estimating standard errors is that it accounts some general forms of unit-specific and temporal dependence

when the time dimension tends to be large. This procedure, however, does not put any constraints on truncating the number of panels. Therefore, unlike PCSE, it allows the number of panels to be larger than time dimensions (Driscoll & Kraay, 1998).

One other issue of the empirical model is that its main predictor variables, i.e., all the three IVs of political institutions, are 'time-invariant' or 'a rarely changing variable'. One of the major problems of fixed effects models, however, is that it is not suitable to investigate time-invariant causes of the dependent variables. Since a country's status of political regimes i.e., being democratic or non-democratic, federal versus unitary form, and leftist versus rightist ideology do not vary much, there is more likely a very limited variation to identify the parameters associated with "*X*." Essentially, fixed-effects models are designed to investigate the causes of changes within an entity. So, technically, a time-invariant characteristic of the unit cannot cause such a change, because it is constant for each unit; it is modeled to control all time-invariant differences between the entities (Kohler & Kreuter, 2012).

In their papers, Beck (2001) and Beck and Katz (2001) bring forth the example of a study in the discipline of International Relations (IR) literature about the effect of democracy variable on a binary variable if a dyad of the country is at war or peace. The study generated an intense debate on the use and pitfalls of using fixed-effect when the data has both time series and cross-section (Erikson, Pinto, & Rader, 2009; Green et al., 2001; G. King, 2001; Oneal & Russett, 2001). Bell and Jones (2015) summarizes this debate and suggests that most of those authors argue that the estimates obtained through fixed effect could not show any relationship between democracy and peace because it "filters out all the effects of unchanging, time-invariant peace, which has an effect on

time-variant democracy." The major arguments, in sum, is that a rarely changing variable or a time-invariant dummy may have an effect on time-varying variables which are virtually lost in the fixed effect estimation. The empirical model essentially removes those countries from the sample whose political regime and peace status remained unchanged. PÏumper and Troeger (2007) further note that this problem of sample erosion arises when a predictor variable is time-invariant or 'rarely-changing'. But a time-varying covariate can have such time-invariant 'between' effects, which may be different from time-varying effects of the same variable. However, these processes are not able to be evaluated in the fixed effect estimation. Bell and Jones (2015) thus suggest using the random effect model because only the random effect model allows these processes to be modeled for both for the 'within-effect' and 'between-effect.'

With those suggestions into consideration and as per empirical diagnostics of the study, the dissertation applies random effects GLS and Panel-corrected standard errors (PCSE) and random effect model with Driscoll-Kraay standard errors along with pooled cross-sectional OLS estimation. The choice of these various random effect models is robust to heteroskedasticity, groupwise heteroskedasticity, first-order autocorrelation and contemporaneous correlations or cross-sectional dependence across units. In addition to these models, the paper further investigates a multilevel model or 'within-between random effect' estimation (using MLwiN 3.04) as advocated by Mundlak (1978), Bell and Jones (2015), and Schmidt-Catran and Fairbrother (2016). The software package, MLwiN provides model equations with subscripts representing at which level the variables are assumed to be measured (Charlton, Rasbash, Browne, Healy, & Cameron, 2019; Leckie & Charlton, 2013; Schmidt-Catran & Fairbrother, 2016).

In their paper, they emphasize that the within-between model is most suitable to extract the variation between countries and changes within countries over time. The estimator is able to model the hierarchical structure of the data and provide separate estimates for the between-effect and within-effect in one model. Therefore, based on their work, the paper simultaneously models the cross-sectional as well as longitudinal relationships by including both a group mean and a de-meaned term in the model (Christmann, 2018). This generates the following within-between random effects (REWB) model:

$$y_{it=}\ \beta_0 + \beta_1(x_{it} - \bar{x}_i) + \beta_2\bar{x}_i + \beta_3 z_i + \beta_4\ year_i + (u_i + \ e_i\ )$$

In the equation above, *i* stands for country and *t* denotes year. *ß0* is an intercept term. *X* represents a vector of independent time-varying covariates and z is a vector of time-invariant covariates at the country level, such as (a) country being a democratic or non-democratic, (b) if a country enters into the Kyoto Protocol and (c) if country has some small islands within its periphery. *ß4* represents a time-fixed effect term to deal with any concurrent but unrelated time trends (Christmann, 2018; Fairbrother, 2014). Finally, u is an error term for the between part and e is an error term for the within-part of the equation.

For each empirical estimation of different models in the dissertation, the analysis begins with listwise deletion of all missing observations of the variables included in the model and next, the study explores if there is any outlier in the dataset. On residual analysis, Qatar commonly appears to be an outlaying country by the model check (see Appendix BK – Appendix BL for the graph). So, Qatar has been excluded from the data analysis. The final dataset thus covers 160 countries beginning from 1990. Furthermore,

the study uses robust clustered standard errors to account for the errors derived from the hierarchical structure of the data. It also includes a year fixed effect in TSCS and multilevel equation to account for any unobserved factors or global trends that may affect the economy or technology, which may consequently affect the national level of CO2 emissions.

Chapter 4: Empirical Results

Chapter 4: Empirical Results

4.1 Empirical Results of the Study of Political Regimes

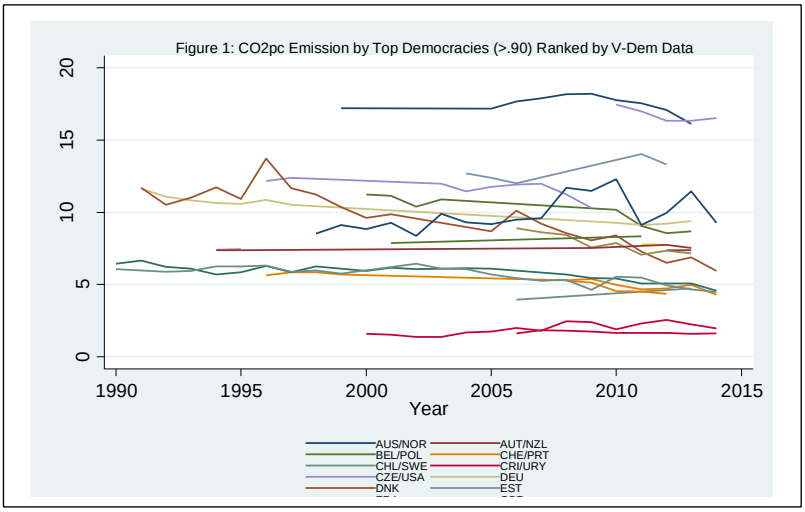
The first study of the dissertation is to evaluate the relationship between the per capita CO2 emissions and regime typologies between democracy and non-democracy. A descriptive statistic of the study is presented in table 10.

Table 10: Summary Statistics of the Study of Political Regimes (1990-2014)

Variable	*Observation*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Dependent variable					
CO2 emissions (metric tons per capita)	9718	4.421	7.500	-.020	101.052
Independent variables					
V-Dem's Electoral Democracy	24995	.263	.261	.007	.948
Polity2	17325	-.462	7.083	-10	10
Freedom House's democracy	8186	8.523	4.119	2	14
Economist Intelligence Unit (EIU)	2145	55.10	22.07	8.6	99.3
Bertelsmann's Transformation Index (BTI)	887	5.723	2.097	1.266	9.95
Control variables					
LnGDP per capita	5392	9.028	1.231	5.889	11.813
Trade openness	8424	78.087	52.648	0	860.8
Population	12438	2.46e+07	1.02e+08	3893	1.39e+09
Urbanization	12323	50.696	25.726	2.077	100
Renewable energy cons.	5296	31.247	31.128	0	98.343
Forest ratio	5507	32.279	24.458	0	98.910
Small island (dummy)	12826	.235	.424	0	1
Latitude	12606	2.793	1.120	-.693	4.277
Annex I	12885	.094	.292	0	1

The study begins its analysis by examining a national trend of per capita CO2 emissions by top democratic countries as measured by the V-Dem dataset. Figure 1 shows the patterns of per capita CO2 emissions at the national level by countries that are ranked top 10 percent in a democracy barometer from the 1990s to 2014. A closer look at the long right-hand side tails in the figure shows a gradual decline in per capita CO2

emissions by the majority of the high democratic countries. The graph, however, does not confirm that democracy itself is promoting to decrease the level of per capita CO2 emissions at the national level.



To establish a correlational relationship between the outcome of per capita CO2 emissions and the political regime variable, the study begins with the pooled cross-sectional OLS analysis which is a one of the frequently used quantitative approaches in the climate policy and environmental politics literature (see Appendix AA for OLS results). The study then progresses with time-series cross-sectional (TSCS) research designs to demonstrate the effects of regime typologies in the context of other potential explanations. Finally, the study presents a random effect within-between model believed one of the most appropriate estimation strategies for the research question of the present study. Table 11 summarizes the empirical results of the main TSCS models. The results of the parsimonious model, however, presented in Appendix BM – Appendix BO (Table 22-Table 30).

Table 11: Estimated Variable Impact on CO2 Emissions Per Capita with V-Dem Data (1990-2014)

Variables			
	Random effects, GLS (1)	*Panel-corrected standard errors (2)*	*Random-effects GLS with DK standard errors (3)*
Democracy	-0.108 (0.368)	-0.922*** (0.207)	-0.108 (0.238)
LnGDP per capita	1.585*** (0.37)	2.051*** (0.162)	2.678*** (0.201)
Trade (% of GDP)	-0.003 (0.003)	0.001 (0.001)	0.002 (0.002)
Population	0 0	0.000** 0	0.000** 0
Urbanization (% of total population)	0.049** (0.016)	0.036*** (0.008)	0.032*** (0.004)
Renewable energy cons	-0.023*** (0.006)	-0.021*** (0.003)	-0.002 (0.002)
Forest (% of land area)	-0.015 (0.011)	-0.024*** (0.005)	-0.017*** (0.002)
Annex I	1.188 (1.043)	0.954* (0.453)	2.046*** (0.261)
Island dummy	0.422 (0.91)	0.221 (0.453)	0.783*** (0.095)
Latitude	0.101 (0.246)	0.021 (0.171)	0.182*** (0.032)
Constant	-11.198*** (2.903)	-13.935*** (1.306)	-19.875*** (1.418)
R2		0.348	0.646
sigma_u	2.9505	-	-
sigma_e	0.8955	-	-
Observations	3,663	3,663	3,663
Year FE	Yes	Yes	Yes
#Country	160	160	160

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

The results of the random effects, GLS in Table 11, column 1, row 1, show a negative association (-0.108) between democracy and per capita CO2 emissions controlling for other covariates. The estimate, however, is not statistically significant at the conventional level. [7]

[7] The interpretation of the coefficients of random-effects GLS regression is somewhat delicate since it includes both the within-entity and between-entity effects. In this case, it represents the average effect of

To take a further step, next, the study applies a panel-corrected standard errors (PCSE) estimate[8]. Greene (2012) and Beck and Katz (2004) argue that the PCSE estimation is more efficient in dealing with the problems of groupwise heteroskedasticity and contemporaneous correlations in which the data under study is more likely to be afflicted with[9]. For this study, however, the PCSE estimate in column 2, row 1 shows an expected sign of negative association (-0.922) between per capita CO2 emissions and democracy holding other factors fixed, and the estimate is statistically significant at 0.01 level. The study, however, does not claim this estimate to be causal evidence of democracy's pro-climate policy stance since the estimate is not based on the basic panel model.

Next, the study further investigates the model with Driscoll–Kraay standard errors estimate, including 4 lag order of autocorrelation. While the earlier estimates of PCSE provides more accurate coefficients with reduced standard errors. Often time, the properties of the PCSE estimation in a finite sample are debated to produce poor results, especially when the cross-sectional unit is larger than the temporal unit (Zhang & Lin, 2012). Therefore, the study further uses a random effect GLS estimation with Driscoll-

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the outcome variable over predictor variable when the predictor variable changes across time and between countries by one unit (Torres-Reyna, 2007). Bell and Jones (2015), however, consider that the GLSE is identical to the 'within' effect which is as same as fixed effect estimator. To them, in this case, there is only one estimator. About the GLS estimate they lament that the whole literature is built on an 'imaginary difference' between the two estimators. They argue that this is an incorrect specification and it ignores the correlation for the between-effects and the explanatory variables (Bell & Jones, 2015).

[8] Like Bell and Jones (2015), Beck and Katz (1995) also criticizes Park's generalized least squares model and offers an alternative 'panel-corrected standard errors' (PCSE) model which they claim to be able to minimize the standard errors. In this model, when the data is TSCS, they propose to keep the OLS parameter estimates but replace the OLS standard errors with panel-corrected standard errors. Beck and Katz (1995) did a Monte Carlo analysis of this model and demonstrates that the sampling variability of this new estimates is more accurate, even in the presence of panel error structures.

[9] The study, however, was not able to confirm the problem of contemporaneous correlations or cross-sectional dependence with conventional code of xttest2 and Pasaran CD test. The Stata returns error code in the context of insufficient observation. It however, finds a problem of cross-sectional dependence with xtcdf command and Pesaran's test for weak cross-sectional dependence.

Kraay standard error. This procedure allows the standard error estimates to be robust to both cross-sectional and temporal dependence (Hoechle, 2007, 2018)[10].

Thus, compared to the previous two estimates, this is expected to provide a more accurate and robust estimate for the relationship between per capita CO2 emissions and political regimes of democracy vs. non-democracy controlling for other factors constant. However, the coefficient estimates of -.108 in table 11, column 3, row 1 brings forth the same results as the first estimate of random effect GLS, but it is not statistically significant.

Although all of the estimates demonstrate the expected direction of relationship, they do not attain statistical significance across all of the TSCS models. Based on the results of random effect, GLS with DK standard error model in table 11, column 3, row 1, on average, democratic regimes are associated with the reduction of 0.11 metric tons of per capita CO2 emissions holding other factors fixed. This magnitude of the effect is about 2.2 percent reduction of CO2 emissions (metric tons per capita) compared to the 2014 global average of 4.98 per capita CO2 emissions (The World Bank, 2020).

Importantly, however, if we look at the coefficient estimates of other control variables, they provide important information about the effect of different variables on per capita CO2 emissions. A brief discussion of the effect of control variables is presented in Appendix BP.

Next, the study wants to shift its focus to a random effect within-between estimate as a final model. To ensure that these findings are not artefacts of the models, the study

[10] In addition, Driscoll and Kraay (1998) confirm that the error structure in this estimate is assumed to be heteroskedastic, autocorrelated up to some lag, and correlated between the groups in the panel structure.

brings forth this model as a robustness check. However, one of the important advantages of this model is that it provides separate estimates for both within effect and between effect for the unit under study.

Table 12 below presents the results of the random effect within-between (REWB) estimate. This shows four different estimates beginning with a null model (with no predictor), followed by the fixed effect model, and then, random effect model (without accounting for heterogeneity bias), and finally within-between estimate with random effects (REWB)[11].

[11] Because of the structural nature of fixed effects estimate and the within-part of REWB estimate, the time-invariant variables or rarely changing variables - such as Annex I dummy, island dummy, and latitude variables are dropped out of the equation as shown in table 12, column 2 and column 4.

Table 12: Random Effect Within-Between Estimation with V-Dem Data (1990-2014)				
	Null	*FE*	*RE*	*REWB*
	(1)	*(2)*	*(3)*	*(4)*
Within-part				
Constant	4.313***	-	4.194***	1.777
	0.409		0.784	1.708
Democracy	-	0.026	-0.015	0.043
		0.254	0.251	0.2
LnGDP per capita	-	1.404***	1.437***	1.503***
		-0.133	-0.127	-0.105
Trade	-	-0.002*	-0.002^	-0.004***
(% of GDP)		-0.001	-0.001	-0.001
Population	-	-	0	0
			0	0
Urbanization	-	-	0.027**	0.048***
(% of total population)			-0.009	-0.007
Renewable energy cons	-	-	-0.017***	-0.024***
			-0.004	-0.003
Forest (% of land area)	-	-	-0.018^	-0.009
			-0.011	-0.008
Annex I	-	dropped	5.165***	dropped
			-1.005	
Island dummy	-	dropped	-0.317	dropped
			-1.375	
Latitude	-	dropped	-0.124	-1.307***
			0.436	3689263.516
Between-part				
Democracy	-	-	-	-3.471^
				1.808
LnGDP per capita	-	-	-	2.793***
				0.471
Trade	-	-	-	0.008
(% of GDP)				0.007
Population	-	-	-	0
				0
Urbanization	-	-	-	0.052*
(% of total population)				0.02
Renewable energy cons	-	-	-	0.013
				0.014
Forest (% of land area)	-	-	-	-0.024*
				0.012
Annex I	-	-	-	0.918
				1.81
Island dummy	-	-	-	0.356
				0.747
Latitude	-	-	-	0.265
				0.353
Level 2: Country				
sigma_u	-	49572.374	-	-
Level 1: Year				
sigma_e	-	.7347	-	-

Observations	3,663	1,540	1,540	3,663
R2	-	0.188	-	-
#countries	160	67	67	160
Year FE	No	Yes	Yes	Yes

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

The coefficients of democracy across different estimates in table 12 bring conflicting results. Except for random effect estimate in column 3, row 2, all results are positive. Although the random effect estimate shows an expected direction of relationship, the result is not statistically significant. However, the lower part of table 12 presents the results of democracy for the between-effects that present the variation of per capita CO2 emissions across countries. The result shows an expected sign that democratic regimes are negatively associated with per capita CO2 emissions controlling for other covariates, and it is statistically significant close to 0.05 level (p-value 0.055). The estimate suggests that keeping other factors constant, on average, democratic countries tend to emit about 3.5 metric tons less per capita carbon dioxide compared to non-democratic countries in a year. This is 1.51 lower per capita CO2 emissions than the global average of 4.98 CO2 emissions (metric tons per capita), according to the 2014 per capita CO2 data.

Most of the other covariates in the REWB model reveal expected sign, but not all of the estimates achieve statistical significance. A country's economy, population, and urbanization are associated with more per capita CO2 emissions holding all else constant. On the contrary, renewable energy, countries with a small island, and latitude show a negative association with CO2 emissions controlling for other factors.

4.2 Robustness Check for the Study of Political Regimes

The study performs multiple robustness checks to compare the empirical results of V-Dem data, as presented above, with other important quantitative measures of democracy in political science. The study uses four different measures of democracy used by scholars in empirical political science to perform the robustness check.

Among these four measures of democracy, the democracy variable from the Polity IV data and Freedom House data is frequently used by political scientists. However, the study adds two other measures of democracy from the Economic Intelligence Unit (EIU) and Bertelsmann's Transformation Index (BTI) data whose uses in political science literature are not as common as those of the other two. Given that the operationalization of democracy parameter varies across the different datasets, the empirical analysis of these four measures is expected to give some form of a robust understanding of how regime typologies as a political institution perform toward the goal of climate change protection.

To sum up the estimates of the robustness check, it follows that in the empirical analysis of these alternate measures of democracy in table 13, all the coefficients for the pooled OLS estimate appear to be statistically significant at 0.001 level. They are in hypothesized directions that with more democracy, there is a sign of reduction in per capita CO2 emissions level.

Table 13: Robustness Check with Other Measures of Democracy (1990-2014)

Democracy Measures	*Estimation Strategies*							
	Pooled OLS With robust	*Random effects, GLS*	*Panel-corrected standard errors*	*Random-effects GLS with DK standard errors*	*Fixed effect*	*Random effect*	*Within-part, REWB*	*Between-part, REWB*
	(1)	*(2)*			*(5)*	*(6)*	*(7)*	*(8)*

			(3)	*(4)*				
Main Model								
V-Dem	-5.066*** (0.324)	-0.108 (0.368)	-0.922*** (0.207)	-.108 (0.238)	0.026 (0.254)	-0.015 (0.251)	0.043 (0.2)	-3.471^ (1.808)
Robustness Check Models								
Polity IV	-0.150*** 0.013	0.002 (0.018)	-0.017* (0.008)	0.002 (0.012)	0.005 (0.008)	0.003 (0.008)	0.005 (0.008)	-0.074 (0.075)
Freedom House	-0.167*** (0.023)	0.010 (0.024)	-0.017 (0.000)	0.019 (0.022)	0.014 (0.017)	0.011 (0.017)	0.023 (0.017)	-0.192^ (0.116)
Democracy Index, EIU	-0.071*** (0.007)	-0.005 (0.007)	-0.046*** (0.009)	-0.005 (0.005)	0.002 (0.006)	-0.004 (0.005)	0.002 (0.006)	-0.078*** (0.016)
Transformation Index (BTI)	-0.560*** (0.077)	-0.076 (0.062)	-0.562*** (0.076)	-	-0.003 (0.062)	-0.071 (0.058)	-0.650*** (0.153)	-0.613*** (0.170)

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

The study fails to find any statistically significant results for the relationship between democracy and per capita CO2 emissions in fixed effect as well as in different random effect estimation across all the alternative measures of democracy. Some of them exert an expected negative sign while some did not show even an anticipated direction of relationship. However, the estimation of panel corrected standard errors shows an expected negative relationship between democracy and CO2 emissions, and for the EIU democracy index measures and BTI's democracy status measure, they show statistically significant results at 0.001 level.

In addition, however, the primary interest of table 13 is the coefficient estimates of democracy for the between-effect because they provide important information about the effect of democracy on per capita CO2 emissions in a cross-national comparison. It is interesting to note that for the between-effect, all the coefficients show an expected negative sign. Besides, except for the Polity IV measures, all of the other measures show

a statistically significant result. The Freedom House measure shows statistically significant results at 0.1 level, and all of the other alternative measures of democracy exert statistically significant results at a 0.001 level.

In sum, with all the estimates from the main model and the robustness check model, the study finds a moderate effect for democracy based on the between-effect model of REWB estimate, which accounts for hierarchical data structure. The main model with the V-Dem dataset does not provide any statistically significant results at a conventional 95% level of significance. However, among the robustness check models, out of four datasets, except for the Polity IV, all of the democracy indices provide differential effects with statistical significance. But their coefficient estimates appear to be trivial.

Continuing to test the robustness of findings apart from using these alternate measures of democracy, the study explores the differences between robust and normal standard errors as indications of model misspecification following a suggestion by G. King and Roberts (2015). The study chose to estimate robust standard errors. However, the differences are only minor and the coefficients for democracy do not lose their statistical significance (Appendix BQ – Appendix BV). Finally, to make a further test of robustness, the study has included a few other variables in the model. In most cases, the direction of the relationship did not change, and also it did not lose its statistical significance at a conventional level.

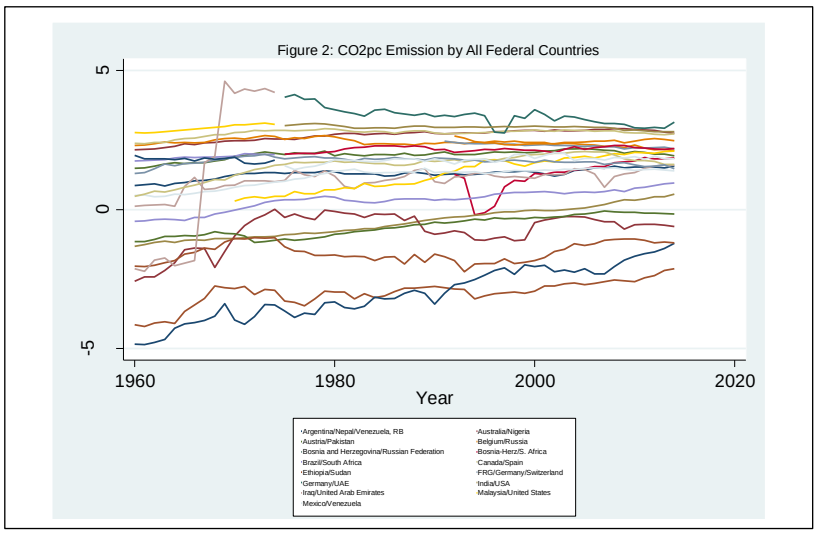
4.3 Empirical Results of the Study of Federalism

The second study of the dissertation is to examine the relationship between per capita CO2 emissions and federalism. A descriptive statistic of the study is presented in table 14.

Table 14: Summary Statistics of the Study of Federalism (1990-2014)

Variable	*Observation*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Dependent variable					
CO2 emissions (metric tons per capita)	9,665	4.419	7.518	-0.0201	101.1
Independent variables					
Federalism (Forum of Federation)	12,713	0.111	0.315	0	1
Federalism (Author) (DPI 2017)	2504	.4520767	.4977975	0	1
Lijphart's Index of Federalism	12,713	1.637	1.880	1	5
Control variables					
LnGDP per capita	5,348	9.026	1.235	5.889	11.81
Trade openness	8,391	77.99	52.65	0	860.8
Population	12,352	24,700,000	103,000,000	3,893	1,390,000,000
Urbanization	12,237	50.79	25.76	2.077	100
Renewable energy cons.	5,256	31.31	31.22	0	98.34
Forest ratio	5,453	32.19	24.52	0	98.91
Small island (dummy)	12,654	0.238	0.426	0	1
Latitude	12,434	2.790	1.123	-0.693	4.277
Annex I	12,713	0.0935	0.291	0	1

The study begins its analysis by examining a national trend of per capita CO2 emissions by all federal countries. Figure 2 shows that beginning in 1960, there is a gradual increase of per capita CO2 emissions by the countries of the federal system at the national level. A few federal countries, however, shows some drops in per capita CO2 emissions in the early 1990s, but the aggregate trend shows a gradual rise in national level CO2 emissions (metric tons per capita) among all federal countries over the years.



Like the previous study of political regimes, it also starts its empirical analysis with the pooled cross-sectional OLS analysis (see Appendix AA for OLS results) followed by time series cross sectional (TSCS) designs to examine the effects of federalism on per capita CO2 emissions. Table 14 summarizes the empirical results of main TSCS models. The results of the parsimonious model, however, presented in the Appendix BM – Appendix BO (Table 22-Table 30).

Table 15: Estimated Variable Impact on CO2 emissions per capita with Federalism Data (1990-2014)

	Random effects, generalized least-squares *(1)*	*Panel-corrected standard errors* *(2)*	*GLS random-effects with Driscoll-Kraay standard errors* *(3)*
Federalism	1.222 (0.947)	1.054* (0.434)	1.22 (0.421)
LnGDP per capita	1.582*** (0.362)	2.196*** (0.195)	1.58 *** (0.208)
Trade (% of GDP)	-0.004 (0.003)	0.000 (0.001)	-.004 * (0.002)
Population	-0.000 (0.000)	0.000 (0.000)	0.000* (0.000)
Urbanization (% of total population)	0.040** (0.014)	0.029** (0.009)	0.040*** (0.008)
Renewable energy cons	-0.027*** (0.006)	-0.023*** (0.003)	-0.027 (0.004)
Forest (% of land area)	-0.016	-0.020***	-0.0**

	(0.010)	(0.006)	(0.005)
Annex I	1.281	0.515	1.28
	(1.021)	(0.509)	(2.56)
Island dummy	0.358	-0.155	0.358
	(0.751)	(0.388)	(1.04)
Latitude	-0.026	-0.130	-0.026
	(0.249)	(0.169)	(0.473)
Constant	-10.237***	-14.773***	-10.23 ***
	(2.934)	(1.443)	(2.300)
R2	-	0.286	0.593
sigma_u	3.167	-	-
sigma_e	1.016	-	-
Observations	3,985	3,985	3,985
Year FE	Yes	Yes	Yes
#Country	176	176	176

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

The results of random effects, GLS in table 14, in column 1, row 1, show a positive association (1.22) between federalism and per capita CO2 emissions controlling for other covariates. In this estimate, it is not statistically significant. Next, the PCSE estimate also shows a positive association (1.05) between per capita CO2 emissions and federalism holding all other factors fixed, and the estimate is statistically significant at 0.05 level. Next, the study further investigates the model with Driscoll–Kraay standard errors estimate. The coefficient estimates of 1.22 of this model show a positive association between federalism and CO2 emissions, holding all else constant, but it is not statistically significant at the conventional level.

Although all of the estimates demonstrate the expected direction of relationship, except for the PCSE model, they do not attain statistical significance across all of the TSCS models.

With various TSCS models, the study argues that federalism and per capita CO2 emissions are positively correlated, but it fails to attain any statistically significant results. The focus now shifts to within-between estimate as a final model in Table 16 below.

Table 16: Random Effect Within-Between Estimation for the Relationship between CO2 emissions (metric tons per capita) and Federalism (1990-2014)				
	Null	*FE*	*RE*	*REWB*
Within-part				
Constant	4.426***	4.190***	4.121***	1.855
	(0.400)	(0.060)	(0.293)	(1.457)
Federalism		-	1.232	-
			(0.818)	
LnGDP per capita		1.437***	1.559***	1.438***
		(0.116)	(0.109)	(0.116)
Trade		-0.005***	-0.004***	-0.005***
(% of GDP)		(0.001)	(0.001)	(0.001)
Population		-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)
Urbanization		0.038***	0.039***	0.038***
(% of total population)		(0.007)	(0.006)	(0.007)
Renewable energy cons		-0.027***	-0.027***	-0.027***
		(0.004)	(0.003)	(0.004)
Forest (% of land area)		-0.010	-0.016*	-0.010
		(0.009)	(0.007)	(0.009)
Annex I		-	1.304^	-
			(0.785)	
Island dummy		-	0.370	-
			(0.674)	
Latitude		-	-0.016	-1.156**
			(0.328)	(3831956.58)
Between-part				
Federalism				0.975
				(0.798)
LnGDP per capita				3.237***
				(0.449)
Trade				0.012
(% of GDP)				(0.007)
Population				0.000
				(0.000)
Urbanization				0.019
(% of total population)				(0.019)
Renewable energy cons				0.010
				(0.014)
Forest (% of land area)				-0.026*
				(0.011)
Annex I				-0.505
				(1.671)
Island dummy				-0.218
				(0.664)
Latitude				0.025
				(0.335)
Level 2: Country				
sigma_u		3.609		
Level 1: Year				
sigma_e		1.016		
Observations	3,985	3,985	3,985	3,985
R2	-	0.110		

#countries	176	176	176	176
Year FE	No	Yes	Yes	Yes

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

The results show that the estimates of federalism in fixed effect and in the 'within-part' of REWB model are removed because of collinearity. In the same way, all other time-invariant independent variables are also wiped out by the Stata program for collinearity. The major point of interest in the table is the coefficient of federalism measure in the between-part of the estimate, and it shows a positive association with per capita CO2 emissions controlling for other covariates. But the results again are not statistically significant.

4.4 Robustness Check for the Study of Federalism

The study performs multiple robustness checks to confirm the empirical findings of the federalism study. First, to increase the robustness of analysis, the study uses two other measures of federalism, which are used by other researchers in empirical political science literature. The one is Lijphart's index of federalism, and the other is a federalism measure taken from the Database of Political Institutions (2017). Apart from Riker's and Elazar's delineation of federalism, which is mostly based on division/distribution of power[12], Lijphart incorporates some secondary features in his definition of federalism, including a strong bicameral legislature, a written constitution, a supreme court or special constitutional court, etc. (See Appendix D for Lijphart's index of federalism). Lijphart's

[12] For a detail explanation of the distinction between Riker's and Elazar's conceptualization of federalism, please refer to Lijphart (2012), pp. 186-188.

quantitative index of federalism spans only on thirty-six democracies of the world from a scale of 5 to 1 where the highest value represents intense federalism, and the lowest value or 1 represents unitary or centralized form (Lijphart, 2012). The second federalism measure is taken from the Database of Political Institutions 2017. The database maintains four measures of federalism, and among these four measures, the study finds the 'author' variable to be most appropriate for the research, which is based on the question if a subnational government or federal unit has the authority over taxing, spending, or legislating. This variable is coded as binary with 1 if a subnational unit has authority over any of these three characteristics and 0 otherwise (See Appendix C for a list of federal (author) countries included in the database).

In the empirical analysis of these alternate measures of federalism, coefficients of most of the appropriate major estimates appear to be congruent with the main analysis with the Lijphart's Index of Federalism and World Bank's DPI dataset with the 'author' federalism variable, and they do not show statistically significant results in any of the estimates (see Appendix BW, Table 31 and Table 32 for a full analysis).

Table 17: Robustness Check with other Measures of Federalism (1990-2014)

Federalism Measures	*Estimation Strategies*							
	Pooled OLS With robust	*Random effects, GLS*	*Panel-corrected standard errors*	*Random-effects GLS with DK standard errors*	*Fixed effect*	*Random effect*	*Within-part, REWB*	*Between-part, REWB*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Main Model								
Federalism	0.958*** (0.192)	1.222 (0.947)	1.054* (0.434)	1.22 (0.421)	-	1.232 (0.818)	-	0.975 (0.798)
Robustness Check Models								
Lijphart's Index of Federalism	0.199*** (0.037)	0.197 (0.163)	0.134^ (0.070)	0.193 (0.022)	-	0.198 (.148)	-	0.170 (0.151)
Federalism (author), DPI	0.125 (0.218)	0.338 (1.024)	0.120 (0.606)	0.136 (0.181)	-	0.349 (1.125)	-	-.371 (1.035)

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

In all of the TSCS models including the multilevel model with random effect estimation strategies, none of the results appear show any statistically significant results. Therefore, the study concludes that it does not get a conclusive evidence that federalism has a substantial effect either for the race to the bottom or for the race to the top.

4.5 Empirical Results of Political Ideology

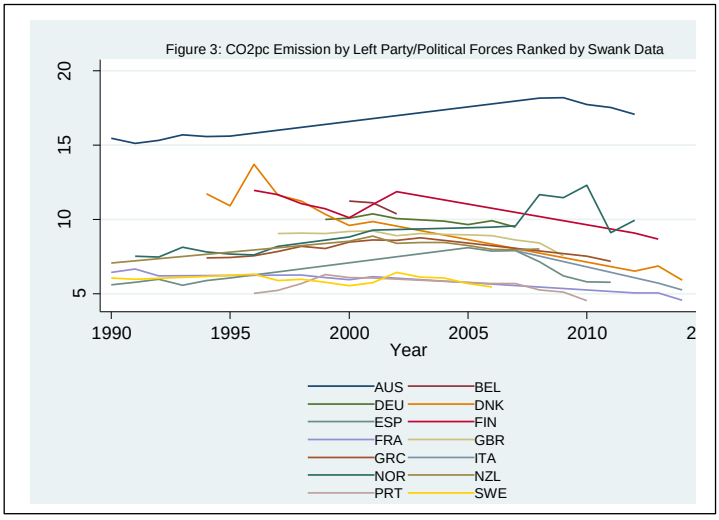
The final study of the dissertation is to examine the relationship between per capita CO2 emissions and political ideology. A descriptive statistic of the study is presented in table 17.

Table 18: Summary Statistics of the Study of Political Ideology (1990-2014)

Variables	*Observation*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Dependent variable					
CO2 emissions (metric tons per capita)	9718	4.421	7.500	-.020	101.051
Independent variables					
DPI's execrlc variable	7021	1.296	1.281	0	3
Swank's partisanship variable	1130	30.766	23.596	0	81
CPD's partisanship variable	1674	84.511	93.681	0	265.7
Controls					
LnGDP per capita	5392	9.028	1.231	5.889	11.812
Trade openness	8424	78.087	52.647	0	860.8
Population	12438	2.46e+0	1.02e+0	3893	1.39e+0
Urbanization	12323	50.696	25.725	2.077	100
Renewable energy cons.	5296	31.247	31.127	0	98.342
Forest ratio	5507	32.279	24.457	0	98.910
Small island (dummy)	12826	.234	.423	0	1
Latitude	12606	2.793	1.120	-.693	4.276
Annex I	12885	.094	.292	0	1

The study begins its analysis by examining a national trend of per capita CO2 emissions by top left-leaning countries. Figure 3 shows the patterns of per capita CO2

emissions at the national level from the 1990s to 2015 by countries that attained 50 percent and more left political strength in a composite score from the Swank political ideology dataset. A closer look at the long right-hand side tails shows a gradual decline in per capita CO2 emissions by the left-leaning countries. This, however, does not confirm that the ideology itself promoting this cut in per capita CO2 emissions.



To establish a correlational relationship between the per capita CO2 emissions and ideology variable, the study begins with the pooled cross-sectional OLS analysis presented in Appendix AA. The study, then progresses with time-series cross-sectional (TSCS) designs. Finally, the study presents a random effect within-between model to evaluate if there is any systematic variation in the per capita CO2 emissions level because of divergent political ideologies. Table 18 summarizes the empirical results of the main TSCS models. The results of the parsimonious model, however, presented in Appendix BM – Appendix BO (Table 22-Table 30).

Table 19: Estimated Variable Impact on CO2 emissions per capita with Political Ideology Data (1990-2014)

Variables	*Random effects, generalized least-squares* *(1)*	*Panel-corrected standard errors* *(2)*	*GLS random-effects with Driscoll-Kraay standard errors* *(3)*
Political ideology	-0.003 (0.002)	-0.002 (0.000)	-0.003 (0.002)
LnGDP per capita	3.124** (0.974)	4.807 (0.000)	3.140 (0.549)
Trade (% of GDP)	-0.011 (0.009)	-0.002 (0.000)	-0.011 (0.007)
Population	-0.000*** (0.000)	0.000 (0.000)	0.000*** (0.003)
Urbanization (% of total population)	0.001 (0.029)	0.057 (0.000)	0.000 (0.015)
Renewable energy cons	-0.168*** (0.036)	-0.074 (0.000)	-0.167*** (0.019)
Forest (% of land area)	0.027 (0.050)	-0.006 (0.000)	0.27 (0.028)
Annex I	-	-	-13.40 (16.87)
Island dummy	0.665 (2.785)	1.563 (0.000)	0.682 (1.43)
Latitude	-1.671 (6.750)	0.804 (0.000)	-1.63 (5.00)
Constant	-13.088 (26.797)		-0 (omitted)
R2		0.622	0.001
sigma_u	3.647		3.647
sigma_e	.575		0.575
Observations	514	514	514
Year FE	Yes	Yes	Yes
#Country	21	21	21

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

The estimate of the GLS random effect model in table 18, column 1, row 1 (-0.003) and the PCSE (-0.002) in table 18, column 2, row 1 and random effect GLS with DK standard errors (-0.003) all show expected negative sign, but they are not statistically significant at the conventional level. In all the TSCS models, the results provide a null effect.

For a further check of the results, however, the study wants to shift its focus to a random effect within-between estimate as a final model. Table 19 below presents the results of the within-between estimate.

The coefficients of political ideology across different estimates provide consistent results. All of the estimates show an expected negative sign for the within effect indicative of left party ideology to influence in reducing per capita CO2 emissions. The coefficients are statistically significant at the 95% level in the fixed effect, random effect, and in the within-part of the multilevel model. However, for the between effect, although the coefficient shows an expected sign, it is not statistically significant at the conventional level. Overall, the estimate suggests that keeping other factors constant, countries with left-party strength tend to emit about 0.03 metric tons of less per capita carbon dioxide within the country compared to right-wing ideology dominated countries.

Table 20: Random Effect Within-Between Estimation for the Relationship between CO2 emissions (metric tons per capita) and Political Ideology (1990-2014)

	FE	*RE*	*REWB*
Within-part			
Constant	9.185***	9.154***	1.988
	(0.105)	(1.104)	(19.901)
Political ideology	-0.003*	-0.003*	-0.003*
	(0.001)	(0.001)	(0.001)
LnGDP per capita	2.925***	3.037***	2.925***
	(0.504)	(0.502)	(0.504)
Trade	-0.010**	-0.011**	-0.010**
(% of GDP)	(0.004)	(0.004)	(0.004)
Population	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Urbanization	-0.005	-0.001	-0.005
(% of total population)	(0.014)	(0.014)	(0.014)
Renewable energy cons	-0.173***	-0.170***	-0.173***
	(0.013)	(0.013)	(0.013)
Forest (% of land area)	0.015	0.024	0.015
	(0.033)	(0.029)	(0.033)
Annex I	-		-
Island dummy	-	0.582	-
		(3.218)	
Latitude	-	-2.006	-1.813e+07
		(6.024)	(15632305.245)
Between-part			
Political ideology	-	-	-0.101
			(0.085)
LnGDP per capita	-	-	6.131
			(7.404)
Trade	-	-	-0.047
(% of GDP)			(0.084)
Population	-	-	-0.000
			(0.000)
Urbanization	-	-	0.076
(% of total population)			(0.150)
Renewable energy cons	-	-	0.093
			(0.107)
Forest (% of land area)	-	-	-0.049
			(0.062)
Annex I	-	-	
Island dummy	-	-	1.441
			(3.294)
Latitude	-	-	-2.251
			(7.841)
Level 2: Country			
sigma_u		-	-
Level 1: Year			
sigma_e		-	-
Observations	514	514	514
R2	0.634		-
#countries	21	21	21
Year FE	Yes	Yes	Yes

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

4.6 Robustness Check for the Study of Political Ideology

The study performs multiple robustness checks to compare the empirical results of Swank data as presented above, with other important quantitative measures of political ideology used in political science literature. To increase the robustness of analysis, the study uses two other measures of political ideology, which are used by scholars in empirical political science literature. Given the operationalization of the parameter of political ideology vary across the different dataset, the empirical analysis of these two measures are expected to give some form of robustness check for the findings of the main model.

To sum up the estimates of robustness check, it follows that in the empirical analysis of these alternate measures of political ideology in table 20, all the coefficients for the pooled OLS estimate appear to be statistically significant at the conventional level. Interestingly and perplexingly, however, while the data of CPD shows an expected negative sign in some estimation methods, the results of the DPI 2017 dataset show an opposite sign with statistical significance. This exemplifies that left-party ideology tends to increase the per capita CO2 emissions, which is contrary to our main empirical findings.

Table 21: Robustness Check with DPI 2017 and Comparative Political Dataset (1990-2014)

Political Ideology Measures	*Estimation Strategies*							
	Pooled OLS With robust (1)	*Random effects, GLS (2)*	*Panel-corrected standard errors (3)*	*Random-effects GLS with DK standard errors (4)*	*Fixed effect (5)*	*Random effect (6)*	*Within-part, REWB (7)*	*Between-part, REWB (8)*
Main Model								
Swank's Political ideology	-0.026*** (0.007)	-0.003 (0.002)	-0.002 (0.000)	-0.003 (0.002)	-0.003* (0.001)	-0.003* (0.001)	-0.003* (0.001)	-0.101 (0.085)
Robustness Check Models								
DPI data	0.269*** (0.058)	0.066* (0.031)	0.037 (0.000)	0.066** (0.023)	0.080** (0.027)	0.083** (0.027)	0.063** (0.019)	0.239 (0.331)
Comparative Political Dataset (CPD)	-0.002^ (0.001)	-	-	-0.003 (0.002)	-	-	-	-0.029^ (0.016)

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

On the other hand, the estimates of the CPD dataset demonstrate results similar to the Swank dataset. Some of the models with the CPD dataset, however, could not produce any results, perhaps because of data attrition and the consequent small sample size. But in the pooled OLS, and the between-part of the REWB model, the estimates show an expected negative sign with a statistical significance, which indicates that the left-political ideology may influence to reduce the level of per capita CO2 emissions compared to right-leaning political ideology.

Chapter 5: Discussion and Conclusion

Chapter 5: Discussion and Conclusion

Why some political institutions should systematically provide better responses to the problems of climate change is an important and debated question. The dissertation attempts to understand if regime variation between democracy and non-democracy, variation in governance structure between federal vs. unitary form, and variation in left-right political ideology provide some steady impact in the reduction of per capita CO2 emissions at the national level.

Theoretical arguments on all of these three questions provide contrary arguments for the effect of each political institution on climate change problems. For political regimes, some studies suggest that democracy renders better service to deal with climate change issues because of its inherent virtues like electoral accountability or freedom of speech and association. Some scholars also point to some attributes of democracy, like democracy's regard for the market economy and individual liberty to be detrimental for environmental performance.

Likewise, for the question of federalism, some scholars argue that the complexity in multilevel governance and subnational units' competition for businesses in a federal system brings harm to the environment. Some scholars, on the contrary, argue that subnational units compete with better and quality services for citizens and thus work as laboratories for climate policy success for other states.

Finally, for the political ideology question, scholars argue that right-wing political ideology does not necessarily bring harm to the environment; the rightist's pro-growth approach is necessary for the advancement of social progress. On the contrary, some

scholars express doubts about the efficiency and equitability of the unregulated market and believe this expansionary market economy is detrimental that may aggravate the problem of climate change.

These contrary arguments are not found in theories alone; the empirical investigations for the effect of all of these three political institutions on climate change problems also provide conflicting results. With that differing theoretical and empirical backdrop, the dissertation aims to provide a robustness check of the existing findings and improve upon much of the literature using some rigorous model specification, estimation techniques, alternative quantitative measures, and improved data coverage.

The use of alternative measures of main independent variables in the robustness check and various TSCS estimation techniques provide more robust evidence for the research findings of the study. The empirical results across different TSCS and multilevel models, overall, reveal some mixed findings between the per capita CO2 emissions and three political institutions: political regimes, federalism, and political ideology.

The study applies seven different estimation strategies to explore the relationship between political institutions and climate change problems at a cross-national level. These estimation methods are (1) pooled cross-sectional OLS with robust, (2) fixed effect, (3) random effect, (4) random effect GLS, (5) random-effects GLS with Driscoll-Kraay standard errors, (6) Panel-corrected standard errors, and finally, (7) multilevel model or random effect within-between (REWB) estimation. The purpose of using these several empirical methods is to test the robustness of results and to account for different biases and disturbances in the error term. As a rule of thumb, when the data has both cross-sections and time-series observations, the fixed effect or the random effect model

are considered to yield the most convincing results, which can allow some form of causal explanation. Partly, it also depends on the variables of interest, whether the variable is time-invariant or continuous or categorical, etc. Needless to say, however, that the stronger the model is when it is free from different biases and errors like omitted variable bias, endogeneity, heteroskedasticity, collinearity, serial correlations, time and unit-specific effect and cross-sectional dependence, etc. When a model can efficiently account for such noises, it can claim some form of causality and produce more robust and reliable estimates of the hypothesis of interest.

To navigate the relationship between the three political institutions and per capita CO2 emissions, the study has provided main empirical results that are backed up by several alternative measures in the robustness check. Based on the nature of research questions, empirical model specification, and diagnostic results, the study considers the results of random effect, GLS with DK standard error, and random effect within-between estimation techniques to be the most efficient estimation techniques for the present study.

While the existing literature provides inconsistent results across various studies for the effect of all the three political institutions that the present study investigates, the results of the current studies are near consistent both for main results and results of robustness checks with alternative measures. The lack of consistency in the existing studies may stem from a variety of sources. First, one such possible source is the use of various DVs in the estimation to identify the effect of political institutions.

It appears that researchers have used a range of DVs, including SO2, CO2, NOx, CFCs, suspended particulate matter (SPM), smoke, carbon intensity, actual emissions level, logged CO2, various climate indexes, water pollution, deforestation, and many

more. The estimation based on such divergent DVs may produce conflicting results. Most importantly, governmental responses to these various emissions-related problems may not be similar. For example, governments around the world may prioritize addressing the problem of air pollutants like Nitrogen dioxide (NO2) and Sulphur dioxide (SO2) more immediately and with greater concern than the pollution stemmed from carbon dioxide (CO2). Because air pollutants cause various public health risks and bring immediate air-borne diseases compared to other pollutants.

Second, empirical studies use different estimation strategies, which is possibly another source of inconsistency in various empirical papers that investigate the relationship between political institutions and climate policy. The choice of empirical models ranges from using multiple regression to various panel models, including quasi-experimental designs. The possible model misspecification and measurement errors in different studies may produce inconsistent results.

Third, some studies explore the effect of political institutions on environmental commitment (for example, policy adoption, the signatory of international environmental agreement etc.). Studies that investigate democracy's or federalism's relationship to environmental commitment is different from a question that asks their relationship to various pollutants. In brief, a political institution's effect on a policy output (commitment/policy adoption) would essentially be different than its effect on policy outcome (CO2 emissions). This output-outcome divergences in the operationalization of DV is possibly another source of inconsistency in the empirical results.

Fourth, spatial choice is not similar across various studies. Some studies use a cross-national global dataset covering most of the world countries while some studies focus on

European/OECD or Latin American countries. Some of the studies use a single study analysis. These different geographic regions may bring mixed results for the study.

Against these backdrop of various conflicting results, the present study determines CO2 emissions (metric tons per capita) as its DV which is a major indicator of climate change problem and uses a variety of democracy, federalism and political ideology indices to investigate the effect of political institutions to the problem of CO2 emissions. It appears that the statistical results from the main model and robustness check models are consistent in the estimation of multilevel modeling and random effect with DK standard error model. These two models are believed to produce unbiased results as they account for most of the noises that the study found in its diagnostic scan of TSCS dataset. While the results of these two preferred models provide expected direction of relationships between the variables of interest, but they did not attain statistical significance in all the models. Some of a few indices, however, provide contrary and statistically insignificant results.

In the study of political regimes, except for the Polity IV dataset, the estimate of multilevel model shows expected negative sign and statistically significant results. The results provide evidence that democracy is correlated with the reduction of CO2 emission across all of the democracy measures. As expected, however, the effect of results is strong enough. Given that both positive and negative effects of democratic regimes may be influencing in the levels of CO2 emissions as the literature suggests, the net effect of regimes appears trivial.

The study of federalism, in contrast, although shows expected positive coefficients, none of the estimates provide statistically significant results in any of the preferred

models. We conclude that federalism provides a null effect for the levels of CO2 emissions.

Finally, in the study of political ideology, the estimates of the random effect GLS with DK standard errors and the between-effect of multilevel model, which are considered the most appropriate models of the study provide statistically insignificant results. Interestingly, however, the results of fixed effect, random effect and within-part of REWB model show statistically significant results with expected sign.

The studies explore the probable association of three political institutions with climate change problem using multiple indicators and multiple estimation techniques. The studies provide rigorous robustness check of empirical findings in the question of the role of political regimes, federalism, and partisan ideology in climate change problems. This is the first of its kind to use a multilevel model to unearth cross-sectional variation in understanding the effect of political institutions in climate change problems. The studies provide a further understanding of why some previous findings were inconsistent and suggest the use of multiple indicators of IVs with robust estimators to cross-check the consistency of results.

While the study does not claim any causality for the effect of variables of interest, but it provides a moderate correlational relationship between the outcome and predictor variables for democracy and left-ideology variables. The study of federalism, however, provides a null effect. We did not find any substantial evidence in favor of or against federalism to have any impact on CO2 emissions.

It is noteworthy, however, that in assessing the impact of the three political institutions on climate policy, the study has debated two kinds of theories. One kind assumes that the specific political institution improves climatic conditions, while the other kind anticipates the opposite. The study does not deem to discard either set of theories based on theoretical arguments a priori. So, according to the theoretical arguments presented, both approaches may appear to be correct regarding the net effect of these three political institutions on per capita CO2 emissions. In addition, some political scientists like Krieckhaus (2006) argues that in the study of political institutions, regional or local political context matters. The regional political context, like populism as in Latin America, elitism as in East Asia, patrimonialism in Sub-Saharan Africa (Krieckhaus, 2006), clientelism in Africa (Vicente & Wantchekon, 2009; Wantchekon, 2003) affects the way political institutions operate within a political system. Accounting for these regional attributes are beyond the scope of this study. Since the study was not able to account for such variations, the net effect of political institutions under study may not be fully able to provide an appropriate effect for the climate change policy.

As noted above, the study finds that democracy has a moderate correlation with CO2 emissions. The possible explanation would be that both positive and negative forces of democracy, as the literature suggests, maybe affecting the levels of CO2 emissions, culminating into a moderate net effect of democracy.

Likewise, we did not find a differential effect of federalism because, in a federal system, a dual effect may affect the emissions level simultaneously. Some subnational units play a proactive role in dealing with climate change problems. In contrast, some other subnational units may remain less vigilant in addressing climate change issues or

may prioritize in maintaining economic incentives and thus not adopting a stringent regulatory environmental infrastructure. The consequent net national effect, therefore, may appear to be insignificant.

Finally, the study of political ideology provides an interesting finding. The results of the two preferred models did not provide any statistically significant results, which suggest that when compared between and among the countries, left ideology does not seem to make any meaningful effect. But the estimate of fixed effects, random effects, and within-part of REWB models produce statistically significant results. This finding is important and has a practical significance, which supports the theoretical arguments. These statistically significant results convey that when compared from a temporal perspective, countries tend to exhibit a relatively stronger effect of left ideology in the reduction of carbon emission. As it appears in the literature that since the 1990s when environmental issues receive more attention, left political parties tend to play a more vibrant role for environmental concerns. However, as expected, the effect of left ideology is trivial. We do not expect the effect of ideology as strong as a country's economy does in the levels of CO2 emissions.

The study attempts a model specification theoretically grounded with a robust survey of existing literature in the environmental politics. The study covers vectors of economic, political, demographic, geospatial and climatic characteristics. Accounting for the effect of these variables is expected to provide a relatively accurate results if a systematic variation exists in per capita CO2 emissions comparable across countries based on regime typologies, federalism, and political ideologies.

In the model, some variables drive to increase CO2 emissions while other some variables are assumed to cut down the levels of emissions. Among the variables that are assumed to be responsible for the increase of CO2 emissions are: GDP per capita, trade openness, population, urbanization, Annex I (Signatory countries of Kyoto protocol). The rest of the variables in the model are expected to have a moderating effect on the outcome variables including renewable energy consumption, forest ratio, island dummy, and latitude of the country.

Interestingly, one variable that appears to be always positive and statistically significant in both main model and robustness check models irrespective of whatever the indices of political regime, federalism, and political ideology have been used in the study is: GDP per capita. The results appear consistent with statistical significance in all the estimations leading us to conclude that economies always increase the levels of CO2 emissions. Next, urbanization and Annex I status of the country appear to show a positive correlation in almost all of the estimates. However, trade openness did not show a consistent direction of relationship. In some estimates, it shows positive while in some estimates it shows negative correlations. This ambivalent results border on the theoretical underpinnings as discussed earlier in Section 2.5 which explains because of differences in trade regulation and conditionalities, countries exert differences in levels of CO2 emissions.

On the contrary, the model includes a few other variables which are assumed to demonstrate a negative correlation with CO2 emissions. They are renewable energy consumption, forest ratio, latitude, and island dummy. In most of the models, renewable energy and forest ratio demonstrate an expected negative relation indicating that they

might restrain or influence a moderating role in the levels of CO2 emissions. Furthermore, latitude and island dummy also show negative correlations with CO2 emissions with some exceptions. These exceptions are mainly due to data loss and reduction in statistical power.

All these control variables in the model are expected to allow for fair comparisons between countries accounting for any unobserved heterogeneity caused by economic, geographic, political, demographic, and environmental conservation factors including atmospheric and climatic characteristics.

Overall, the dissertation examines the robustness of existing findings for the relationship between democratic institutions, federalism, and partisan ideology, and climate change at a cross-national perspective. The robustness of empirical results is tested through the use of multiple TSCS research designs and various measures of the same IV for the three political institutions. The research designs cover fixed effects, random effects, and multilevel model of random effects within-between estimators. Given the previous literature provide contradictory findings, the application of these rigorous models is assumed to provide a test of consistency of empirical findings across various indices and across different empirical models. One of the contributions of the dissertation is to remove the confusions emanated from previous contradictory results, which are often stemmed from questionable models and weak methodological approaches.

Using the World Bank data from 1990 to 2014, the study finds a moderate relationship for democracy, a less-than-moderate effect for left-political ideology, and a null effect of federalism in tackling climate change problems at a global scale. These

correlational relationships are statistically significant at the conventional level and consistent across most of the models and indices. The findings provide further insights and contribute to broadening our understanding that statistical models that do not account for various error components would produce biased results for the effect of political institutions as probably happened in various previous studies that used only OLS estimates without accounting for the unit-specific effects. Therefore, the need for the TSCS models examined through proper diagnostics is obvious for accurate and reliable estimates. The study further informs that a longitudinal single case study, even with appropriate models, also may not be externally valid because of the idiosyncrasies of other cross-sectional units. Finally, the findings of the study provide practical significance too. While the researchers are often tempted for ambitious regression estimates with robust statistical power, the present study came up with a moderate effect for democracy and even less-than moderate effect for political ideology variable. The study of federalism, in contrast, produces a null finding. We consider these low influential estimates to be akin to the real-world scenarios. The results contribute to further our understanding that the institutions that run under complex political system and are influenced by various actors and agents in the society would likely provide dual effect which exemplifies that democratic institutions, federalism and partisan ideology may provide both positive and negative effect to the problems of climate change as the literature suggests. Therefore, the net results appear moderate to trivial – an estimate which seems to more reliable and not exaggerated.

The study underscores that institutions and ideologies matter for a positive environmental outcome. They provide necessary impetus among various actors in the

society to create a conducive environment that promotes environmental quality while constrain opposing forces. These actors in a democratic milieu like media and civil society perform unfetteredly, create consciousness among citizens, provide pressure to policymakers to legislate and enforce policies that are climate-friendly. Likewise, in a left-ideology dominant political environment, policymakers receive a favorable environment to adopt policies of environmental sustainability. The study, therefore, gives us lessons that free flow of information through various media outlets and freedom of association with civil society activism should not confront any obstacle by the vested interest groups in a country. Political leaders, bureaucrats, non-state actors, and citizens alike have stakes and roles to play to keep these actors move forward to work for environmental sustenance.

Various democracies around the world, however, do not work diligently for the causes of environmental protection. Perhaps, the elements and attributes of these democracies did not flourish fully in those territories. Actos like media and civil society may not be responsive and effective because of the authoritarian-style governance by the political authority. Some scholars argue that democracies run the risk of "systemic failure" (Runciman, 2015, 2017) and less competent to deal with long-run threats (Dunn, 2014) like the problem of climate change. This feature of democratic failure, however, does not guarantee an alternative replacement with authoritarianism. Because the authoritarian form of the regime is more prone to short-term regime tenure (Congleton, 1992; Eaton & Kostka, 2014; Wallace, 2013; Wright, 2008) and embrace uncertain threats of being overthrown due to revolt or mass revolutions (Casper & Taylor, 1996; R. M. Desai, Olofsgård, & Yousef, 2009; Zunes, 1994).

The dissertation gives us the lesson that a democratic regime functions in environmental protection when it meaningfully becomes democratic with all its substances and attributes grown maturely. The countries that do not hold such substances, instead maintain a pseudo-democratic environment, media, civil society, and other non-state actors, should act proactively to sensitize environmental concerns among citizens and other forces in the society.

Anticipating the future climatic catastrophe and growing environmental degradation, some scholars emphasize the 'centralization of power' (Heilbroner, 1974), 'elite rule' (Ophuls, 1997) or "well-intentioned, well-informed tyranny" (Jonas, 1984) to be a viable solution to the problem of climate change. But the problem is that the modern-day electoral mechanism of a country or peaceful transfer of power through an electoral process in a state may find it difficult to appoint such a benevolent autocratic ruler. Besides, the rule by elites may turn to be despotic and guided by self-interest instead of public interest - eventually culminating into the proverbial reality that power tends to corrupt and absolute power corrupts absolutely as warned by the 19th-century British historian, Lord Acton (Dalberg-Acton, 1907).

Between this malfunctioned democracy and absolute despotism, one of the other ways widely pronounced nowadays is to embrace the characteristics of green authoritarianism by the political authority. The idea of "green authoritarianism" denotes a process where the state and non-state actors join forces to defend renewable energy sources and market-sponsored conservation processes (Finley-Brook & Thomas, 2011; Neumann, 1998; Peluso, 1992). As an example, the authors have provided the case of Western Panama's hydro development project, including the construction of both the

Chan 75 and Bonyic dams where the government expressed disregards to treaty rights of the local community by exercising carbon colonialism with military assistance (Finley-Brook & Thomas, 2011; Walker et al., 2019).

To some other authors, green authoritarianism also, at the same time, advocates to reduce local resource access and disempower indigenous people (Erlewein & Nüsser, 2011; Magnani, 2012). A recent study in the context of the Philippine postulates the catchphrase "green authoritarianism" to explain the link of environmental concerns to the Philippines' Duterte regime's consolidation of power in the government. Theriault illustrates how climatic adaptation policy, disaster management, and environmental enforcement turn into key promises and tenets in Duterte's politics and how he manipulated his commitments in ecopolitics to defuse his opposition and to strengthen his authoritarian regime (Maskovsky & Bjork-James, 2020; Theriault, 2020).

Another example of green authoritarianism is the garden city of Singapore that adopted a non-participatory stringent climate policymaking approach that reflects major postulations of green environmentalism in its environmental governance. In fact, Singapore's climate policy appears to become a model for other countries in terms of the expansion of green spaces and infrastructure, which has been achieved through a strict climate policy approach (Han, 2016). Besides, South Korea's Four Major Rivers Restoration Project (FMRRP), some scholars argue to have the manifestation of green authoritarianism because they followed previous path-dependent legacies of the authoritarian developmental state in terms of policy strictness and resilient environmental governance (Han, 2015).

The dissertation considers this approach of green authoritarianism as a viable option where democracies are fragile and democratic attributes are in question. In such cases, a strictness in policy measures and a stronghold in policy adoption may reap benefits to the quality of the environment and combat climate crises. But the long-term implications of green authoritarianism may still be unknown and should undergo trials to check how far it provides the ultimate benefits by enhancing public environmental goods. It is also essential to understand how citizens perceive green authoritarianism as a mode of governance in their territory and how far it retains to serve the public interest. The countries that embody green authoritarianism, as mentioned above, like Singapore, South Korea, Philippines, Panama, and others, may not serve as a model for diffusion for South and Southeast Asian and Latin American or African countries. While it appears to be a viable option in theory and abstraction, we should look cautiously into the long-term environmental outcome and other social welfare and public interest issues that are already exercising green authoritarianism in their regime. And perhaps, it still needs to undergo some trials and errors in practical applications in some other parts of the world to determine if it can be a prescriptive model.

The empirical results of the dissertation reveal a moderate and a less-than-moderate variation for the political regime and for the political ideology variables, respectively. The TSCS results of the study on political regimes did not find any systematic variation in the reduction of CO2 emissions within countries across the years. However, when compared at a cross-national level, the study found a statistically significant negative correlation between democracy and per capita CO2 emissions. The results showed that a unit increase in democracy, the index is associated with a 4.6 metric ton reduction in per

capita CO2 emissions which are close to the global mean of 4.9 metric ton per capita CO2 emissions – about 3.4 percent less CO2 emissions by democratic regimes compared to non-democracies. On the other hand, the estimate of political ideology variable suggests that keeping other factors constant, countries with left-party strength tend to emit about 0.003 metric tons of less per capita carbon dioxide emissions within a country compared to right-wing dominated countries and the results do not show systematic cross-sectional differences.

Given these moderate to trivial variations as an effect of governance of the country as per the study suggests, it triggers additional interest of what other institutional features or components of governance may provide further variations in the the outcome of per capita CO2 emissions. In addition, the results suggest that variables beyond the components of governance such as the effect of civil society activism and the role of electronic and print media may be the primary factors that explain variations in per capita CO2 emissions. Besides, the aggregate effect of governance (government effectiveness, regulatory quality, rule of law, and the control of corruption) as various authors (Helliwell, Huang, Grover, & Wang, 2018; Magelhaes, 2017) suggest may be important driving factors to explain variations in the outcome of per capita CO2 emissions.

The empirical model of the dissertation examines how regime typologies, federalism, and political ideology are correlated with per capita CO2 emissions controlling for vectors of economic, political, demographic, geospatial, and climatic characteristics. The model expects to extract the effect of politics on climate change holding constant those vectors. But what about other political institutions or elements of governance which may influence the levels of CO2 emissions. In other words, what are the possible future

directions of research examining the institutional design and climate change? The dissertation finds that democracy has a statistically significant negative correlation with per capita CO2 emissions. While it is interesting to learn that democracy may spell some influence to improve environmental quality – this study does not explain what aspect of democracy is more effective. Some future studies may investigate the role of media and civil society activism as important contributing components of democracy in combating the climate change problem. Both these variables represent democracy's hallmark virtue of freedom of information and freedom of association.

From a governance perspective, the role of bureaucracy may play an essential role in climate change, which is still underexplored in the environment politics literature. Besides, it would be worth pursuing to learn how elements of good governance fare in limiting CO2 emissions, in specific, the composite effect of government effectiveness, regulatory quality, the rule of law, and the control of corruption using the World Bank and the Quality of Government (QoG) Institute's governance dataset. One previous study has examined the moderating effect of control of corruption in a democratic regime (Povitkina, 2018a) in reducing climate change. But the studies on other aspects of governance or a combined effect of various elements of governance on climate change is still underappreciated. As a future research agenda, the dissertation expects that a thorough examination of these components of democracy and governance elements may provide a further understanding of the role of institutional design and climate change impact.

The study further considers that more research is needed to identify any causal implications. Some quasi-experimental designs may be applied to rule out alternative

explanations. Also, some micro-level questions may need to explore, e.g., how the political institutions affect within some regional geographic blocs or between some high-income or low-income economies or in the differing governance structure. Studies on various micro-level questions related to political institutions and governance structures and the causal mechanism of its effect on climate change are still underexplored. Furthermore, apart from empirical investigations, some qualitative methods, such as longitudinal case studies and process tracing, can also be adapted to obtain mechanism-based explanations in climate policy literature.

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List of Appendix

Appendix A

List of 160 Countries Used in the Empirical Analysis

Afghanistan
Albania
Algeria
Angola
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Central African Republic
Chad
Chile
China
Colombia
Comoros
Congo, Dem. Rep.
Congo, Rep.
Costa Rica
Cote d'Ivoire
Croatia
Cyprus
Czech Republic
Denmark
Dominican Republic
Ecuador
Egypt, Arab Rep.
El Salvador
Equatorial Guinea
Eritrea
Estonia
Eswatini
Ethiopia
Finland
France
Gabon
Gambia, The
Georgia
Germany
Ghana
Greece
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hungary
Iceland
India
Indonesia
Iran, Islamic Rep.
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Korea, Rep.
Kuwait
Kyrgyz Republic
Lao PDR
Latvia
Lebanon
Lesotho
Liberia
Libya
Lithuania
Luxembourg
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Moldova
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
North Macedonia
Norway
Oman
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Romania
Russian Federation
Rwanda
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovak Republic
Slovenia
Solomon Islands
South Africa
Spain
Sri Lanka
Suriname
Sweden
Switzerland
Tajikistan
Tanzania
Thailand
Timor-Leste
Togo
Tunisia
Turkey
Turkmenistan
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Uzbekistan
Vanuatu
Venezuela, RB
Vietnam
Zambia
Zimbabwe

Appendix B

List of Countries/Territories Dropped from the Dataset (38 Countries/Territories)

Turk Cyprus
Aruba
Andorra
American Samoa
Antigua and Barbuda
Bavaria
Bahamas
Brunei
Cuba
Djibouti
Fiji
Prussia
Grenada
Ivory Coast
Kosovo
Laos
Monaco
Modena
Marshall Islands
Nauru
Orange Free State
Palau
Papal States
Parma
Sardinia
Saxony
Saint Kitts and Nevis
Saint Lucia
San Marino
Somalia
Saint Vincent & Grenadines
Swaziland
Syria
Taiwan
Trinidad and Tobago
Tuscany
Wuerttemburg
Yemen

Appendix C

List of 'Author' Countries in DPI dataset (33 Countries)

UAE
Argentina
Australia
Austria
Belgium
Benin
Bosnia-Herz
Brazil
Botswana
Canada
Switzerland
Colombia
Comoro Island
Czech Republic
FRG/Germany
Spain
Ethiopia
Finland
Fiji
France
India
Italy
Mexico
Malaysia
Nepal
Philippines
Sudan
Senegal
Sweden
Trinidad-Tobago
USA
Venezuela
Yugoslavia

Note: 33 Countries are listed as 'author' including Yugoslavia
Source: Database of Political Institution 2017

Appendix D

Lijphart's Degrees of Federalism and decentralization in thirty-six democracies, 1945-96

Federal and decentralized [5.0]		
Australia	Switzerland	(Belgium after 1993)
Canada	United States	
Germany		
Federal and centralized [4.0]		
Venezuela		Austria [4.5]
		India [4.5]
Semi-federal [3.0]		
Israel	Papua New Guinea	Belgium [3.1]
Netherlands	Spain	(Belgium before 1993)
Unitary and decentralized [2.0]		
Denmark	Norway	
Finland	Sweden	
Japan		
Unitary and centralized [1.0]		
Bahamas	Jamaica	France [1.2]
Barbados	Luxembourg	Italy [1.3]
Botswana	Malta	Trinidad [1.2]
Colombia	Mauritius	
Costa Rica	New Zealand	
Greece	Portugal	
Iceland	United Kingdom	
Ireland		

Note: The indexes of federalism are in square brackets.

Source: Copies directly from Lijphart, A. (2012). Patterns of democracy: Government forms and performance in thirty-six countries: Yale University Press. p.189

Appendix E

List of Federal Country as mentioned in Forum of federation website (24 Countries)

Argentina
Australia
Austria
Belgium
Bosnia and Herzegovina
Brazil
Canada
Ethiopia
Germany
India
Iraq
Malaysia
Mexico
Nepal
Nigeria
Pakistan
Russia
South Africa
Spain
Sudan
Switzerland
United Arab Emirates
United States of America
Venezuela

Source: http://www.forumfed.org/countries/

Appendix F

Correlations Matrix for the Study of Political Regimes

Parsimonious Model

```
. pwcorr co2pc v2x_polyarchy lngdppc trade, star(0.05) sig
```

	co2pc	v2x_po~y	lngdppc	trade
co2pc	1.0000			
v2x_polyar~y	0.1333*	1.0000		
	0.0000			
lngdppc	0.7175*	0.4581*	1.0000	
	0.0000	0.0000		
trade	0.2117*	0.0131	0.2826*	1.0000
	0.0000	0.4266	0.0000	

Main Model

```
. pwcorr co2pc v2x_polyarchy lngdppc trade pop urban renew forest annexI island latitude, star(0.05) sig
```

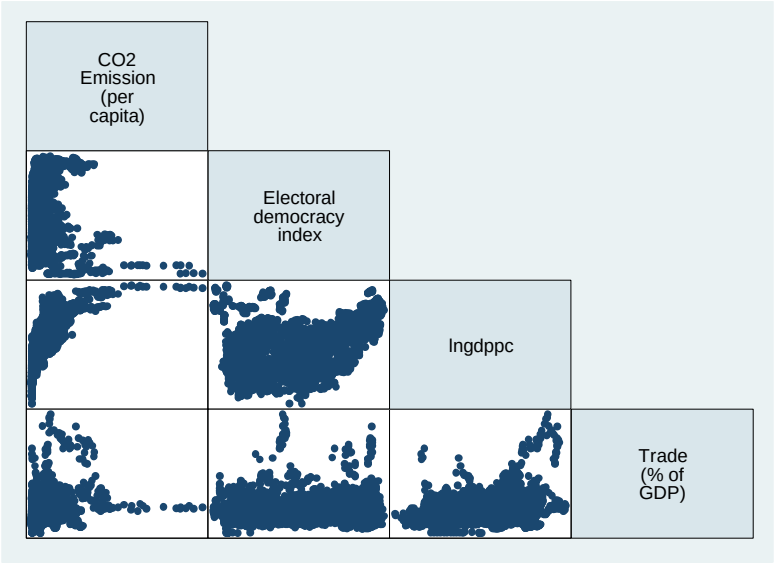
	co2pc	v2x_po~y	lngdppc	trade	pop	urban	renew
co2pc	1.0000						
v2x_polyar~y	0.1333*	1.0000					
	0.0000						
lngdppc	0.7175*	0.4581*	1.0000				
	0.0000	0.0000					
trade	0.2117*	0.0131	0.2826*	1.0000			
	0.0000	0.4266	0.0000				
pop	-0.0094	-0.0419*	-0.0364*	-0.1915*	1.0000		
	0.5689	0.0111	0.0272	0.0000			
urban	0.6214*	0.4189*	0.8273*	0.1964*	-0.0772*	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.0000		
renew	-0.5707*	-0.2851*	-0.7574*	-0.2792*	-0.0313	-0.6849*	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0577	0.0000	
forest	-0.1813*	0.1520*	-0.0541*	0.0344*	-0.0412*	-0.0742*	0.2511*
	0.0000	0.0000	0.0010	0.0369	0.0125	0.0000	0.0000
annexI	0.4036*	0.6099*	0.5923*	0.0936*	-0.0329*	0.4778*	-0.3863*
	0.0000	0.0000	0.0000	0.0000	0.0462	0.0000	0.0000
island	0.0802*	0.1430*	0.1062*	0.1993*	-0.0765*	0.0206	-0.0971*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.2112	0.0000
latitude	0.3502*	0.3425*	0.4418*	-0.0344*	0.0439*	0.3734*	-0.4933*
	0.0000	0.0000	0.0000	0.0370	0.0078	0.0000	0.0000

	forest	annexI	island	latitude
forest	1.0000			
annexI	0.0356*	1.0000		
	0.0308			
island	-0.0666*	0.0753*	1.0000	
	0.0001	0.0000		
latitude	-0.3223*	0.5328*	-0.0876*	1.0000
	0.0000	0.0000	0.0000	

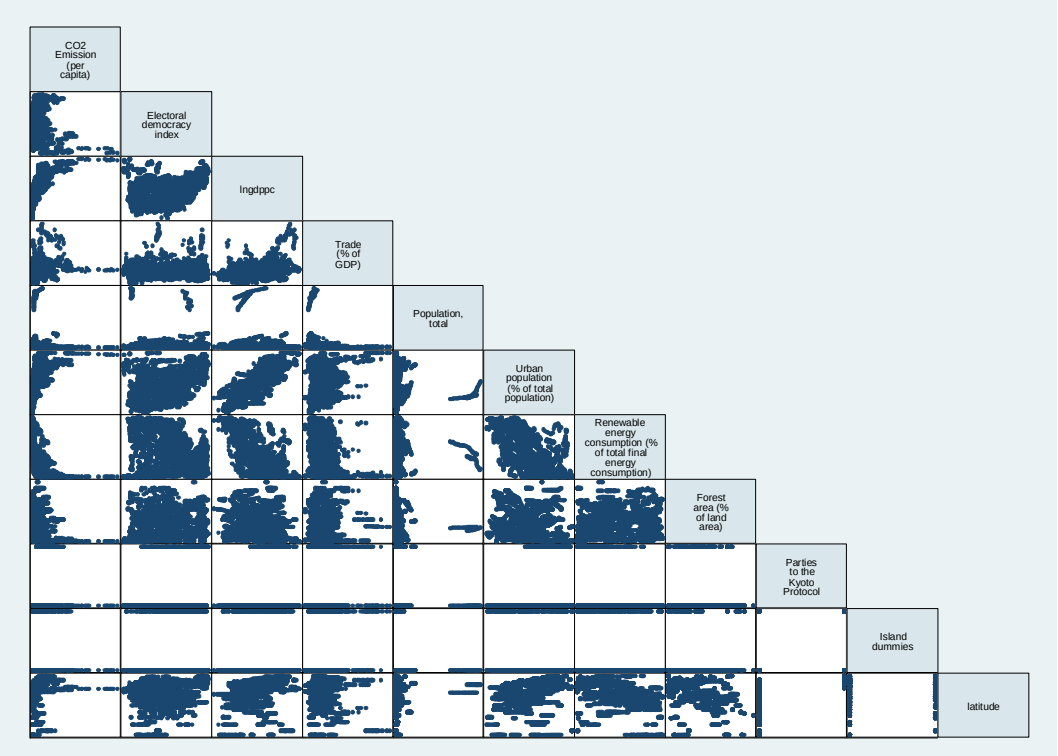
Appendix G

Graph Correlation Matrix for the Study of Political Regimes

Parsimonious Model



Main Model



Appendix H

Correlations Matrix for the Study of Federalism

Parsimonious Model

```
. pwcorr co2pc fedfof lngdppc trade, star(0.05) sig
```

	co2pc	fedfof	lngdppc	trade
co2pc	1.0000			
fedfof	0.1229*	1.0000		
	0.0000			
lngdppc	0.7014*	0.1509*	1.0000	
	0.0000	0.0000		
trade	0.2463*	-0.1924*	0.3329*	1.0000
	0.0000	0.0000	0.0000	

Main Model

```
. pwcorr co2pc fedfof lngdppc trade pop urban renew forest annexI island latitude, star(0.05) sig
```

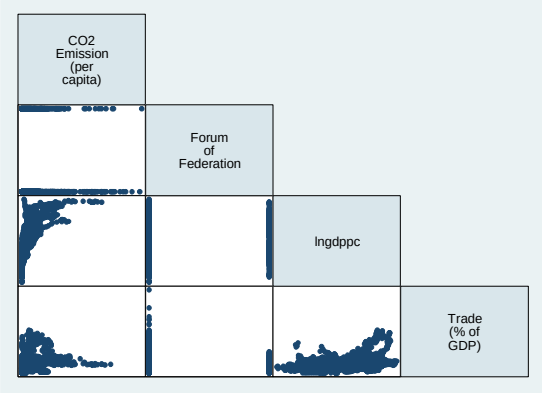
	co2pc	fedfof	lngdppc	trade	pop	urban	renew
co2pc	1.0000						
fedfof	0.1229*	1.0000					
	0.0000						
lngdppc	0.7014*	0.1509*	1.0000				
	0.0000	0.0000					
trade	0.2463*	-0.1924*	0.3329*	1.0000			
	0.0000	0.0000	0.0000				
pop	-0.0222*	0.2225*	-0.0398*	-0.1886*	1.0000		
	0.0288	0.0000	0.0036	0.0000			
urban	0.5070*	0.1114*	0.7868*	0.2953*	-0.0553*	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.0000		
renew	-0.5185*	-0.0370*	-0.7233*	-0.3107*	0.0179	-0.6185*	1.0000
	0.0000	0.0073	0.0000	0.0000	0.1935	0.0000	
forest	-0.1546*	-0.0426*	-0.0267	0.0802*	-0.0473*	-0.0236	0.1544*
	0.0000	0.0017	0.0638	0.0000	0.0005	0.0829	0.0000
annexI	0.1905*	0.1104*	0.5018*	0.1243*	0.0168	0.2849*	-0.2484*
	0.0000	0.0000	0.0000	0.0000	0.0613	0.0000	0.0000
island	0.0497*	-0.1635*	0.1208*	0.2602*	-0.1070*	0.0608*	-0.2477*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
latitude	0.2329*	0.1332*	0.3895*	-0.0751*	0.0679*	0.2586*	-0.2999*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

	forest	annexI	island	latitude
forest	1.0000			
annexI	0.0147	1.0000		
	0.2779			
island	0.0995*	-0.0507*	1.0000	
	0.0000	0.0000		
latitude	-0.2772*	0.3112*	-0.0482*	1.0000
	0.0000	0.0000	0.0000	

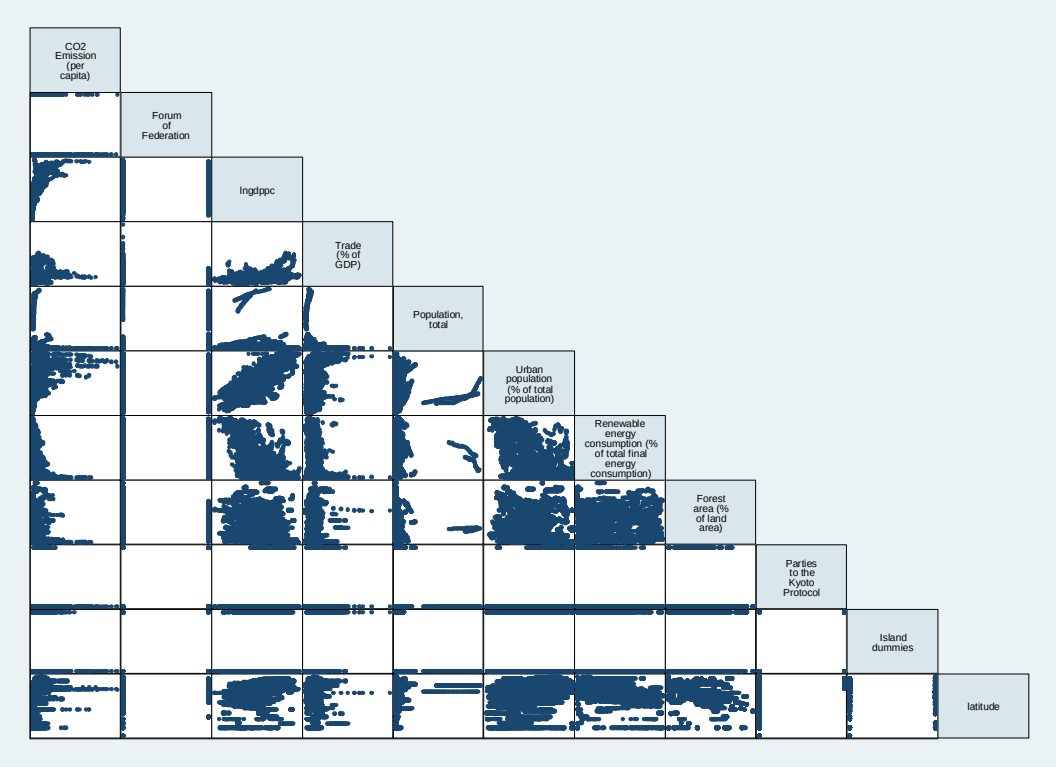
Appendix I

Graph Correlation Matrix for the Study of Federalism

Parsimonious Model



Main Model



Appendix J

Correlation Matrix for the Study of Political Ideology

Parsimonious Model

```
. pwcorr co2pc swank_left lngdppc trade, star(0.05) sig
```

	co2pc	swank_~t	lngdppc	trade
co2pc	1.0000			
swank_left	-0.3120*	1.0000		
	0.0000			
lngdppc	0.2260*	-0.0853	1.0000	
	0.0000	0.0532		
trade	-0.1973*	0.0163	0.3529*	1.0000
	0.0000	0.7130	0.0000	

Main Model

```
. pwcorr co2pc swank_left lngdppc trade pop urban renew forest annexI island latitude, star(0.05) sig
```

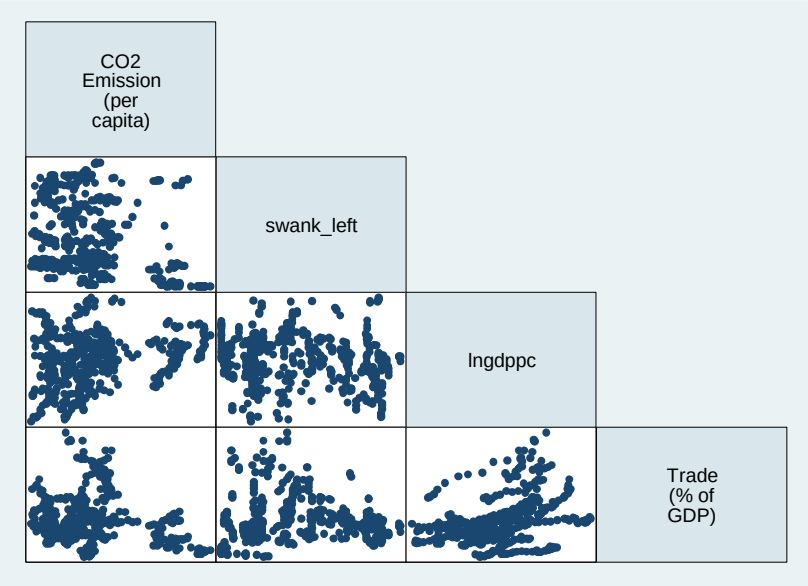
	co2pc	swank_~t	lngdppc	trade	pop	urban	renew
co2pc	1.0000						
swank_left	-0.3120*	1.0000					
	0.0000						
lngdppc	0.2260*	-0.0853	1.0000				
	0.0000	0.0532					
trade	-0.1973*	0.0163	0.3529*	1.0000			
	0.0000	0.7130	0.0000				
pop	0.4848*	-0.3536*	0.1333*	-0.4931*	1.0000		
	0.0000	0.0000	0.0025	0.0000			
urban	0.2895*	0.0036	0.2204*	-0.1006*	0.1048*	1.0000	
	0.0000	0.9356	0.0000	0.0225	0.0175		
renew	-0.2392*	0.2080*	0.2704*	0.0410	-0.3651*	-0.0050	1.0000
	0.0000	0.0000	0.0000	0.3534	0.0000	0.9100	
forest	-0.1384*	-0.0249	-0.0742	-0.3159*	0.0891*	0.1158*	0.4640*
	0.0017	0.5731	0.0930	0.0000	0.0434	0.0086	0.0000
annexI	.	.	.	.	.	.	.
	.	.	.	.	.	.	.
island	0.2257*	-0.0824	-0.0922*	-0.1323*	0.0009	0.3455*	-0.1782*
	0.0000	0.0620	0.0367	0.0026	0.9839	0.0000	0.0000
latitude	-0.1767*	0.0940*	0.3208*	0.4648*	-0.3250*	0.0561	0.4270*
	0.0001	0.0332	0.0000	0.0000	0.0000	0.2045	0.0000

	forest	annexI	island	latitude
forest	1.0000			
annexI	.	.		
	.			
island	-0.0058	.	1.0000	
	0.8960	.		
latitude	0.1405*	.	-0.4848*	1.0000
	0.0014	.	0.0000	

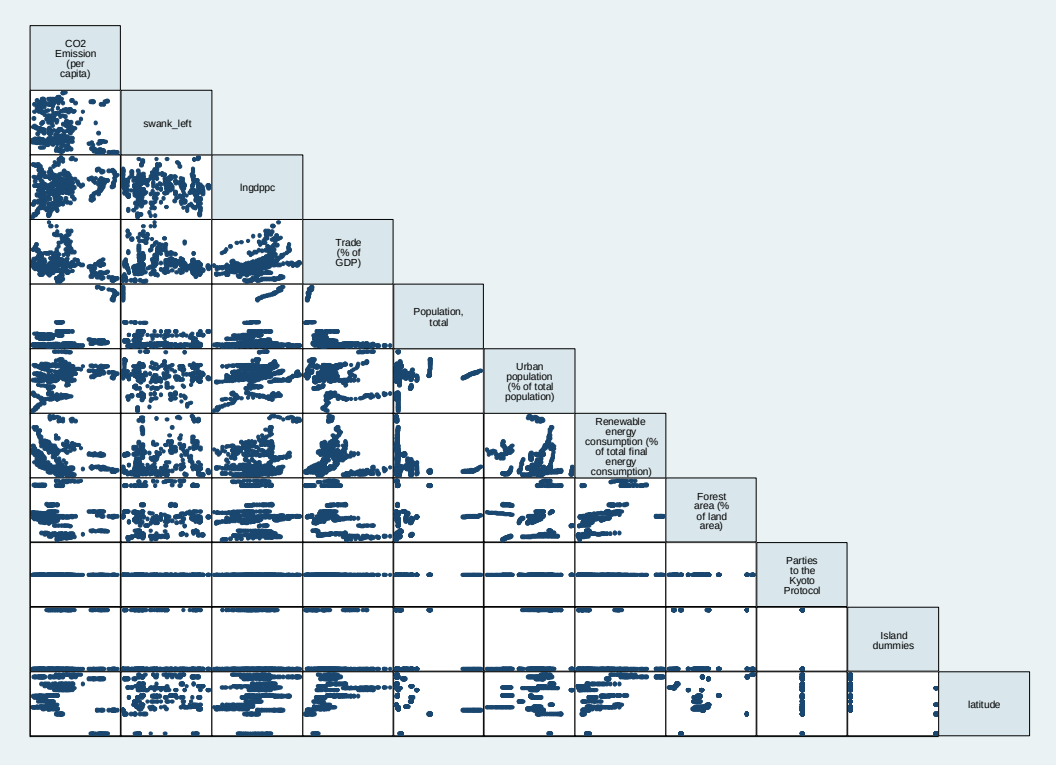
Appendix K

Graph Correlations Matrix for the Study of Political Ideology

Parsimonious Model

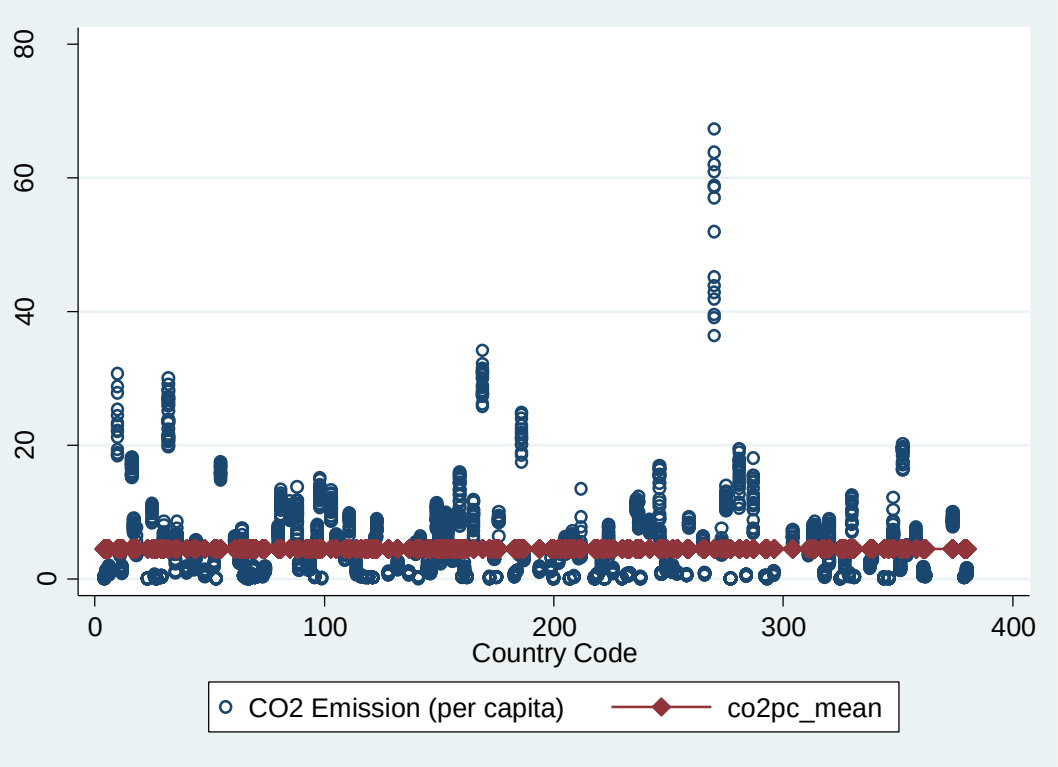


Main Model



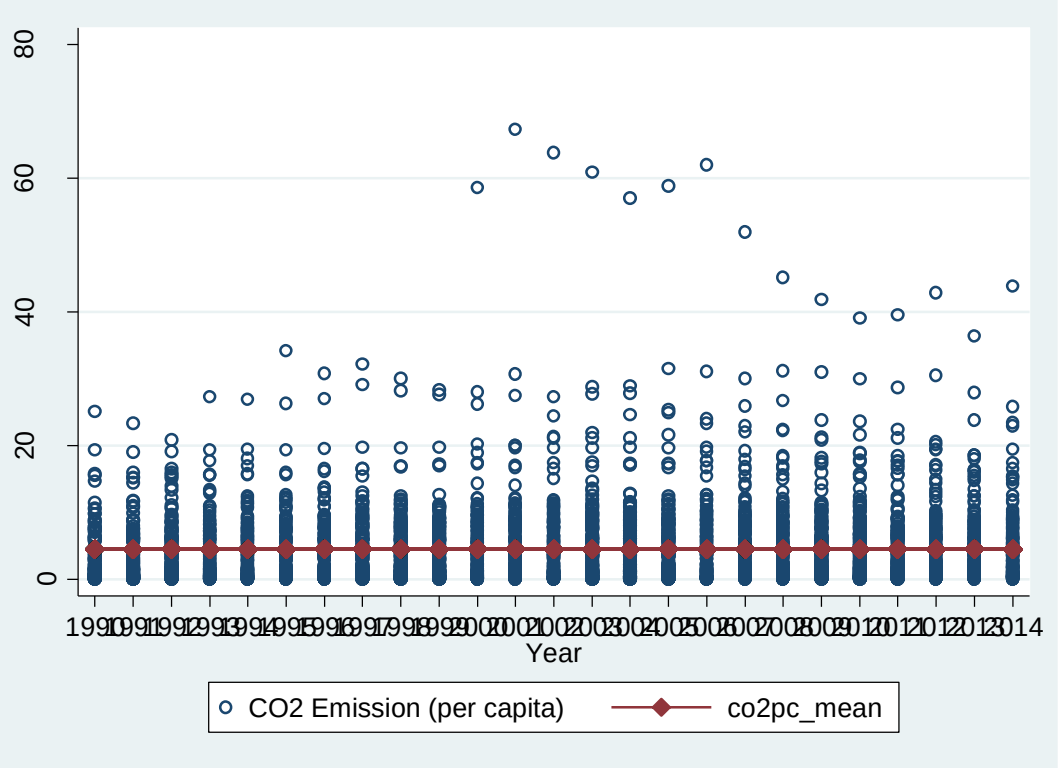
Appendix L

Checking for Heterogeneity across countries for the Study of Political Regimes



Appendix M

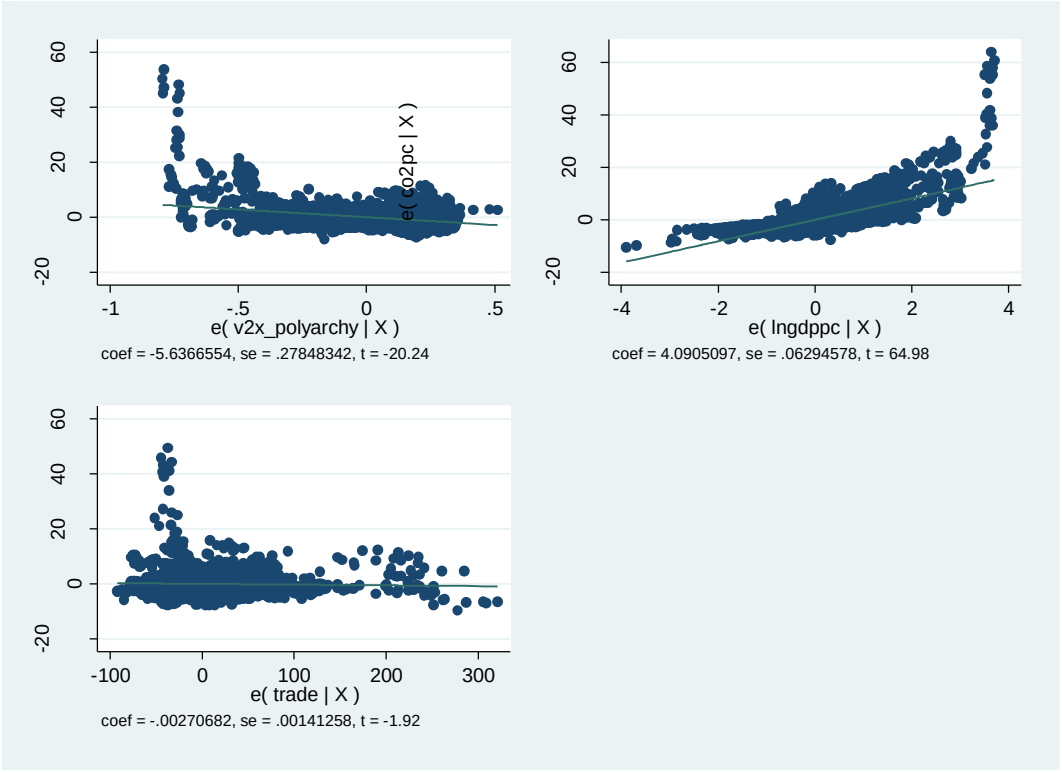
Checking for Heterogeneity across year for the Study of Political Regimes



Appendix N

Heteroskedasticity test for the Study of Political Regimes

Parsimonious Model

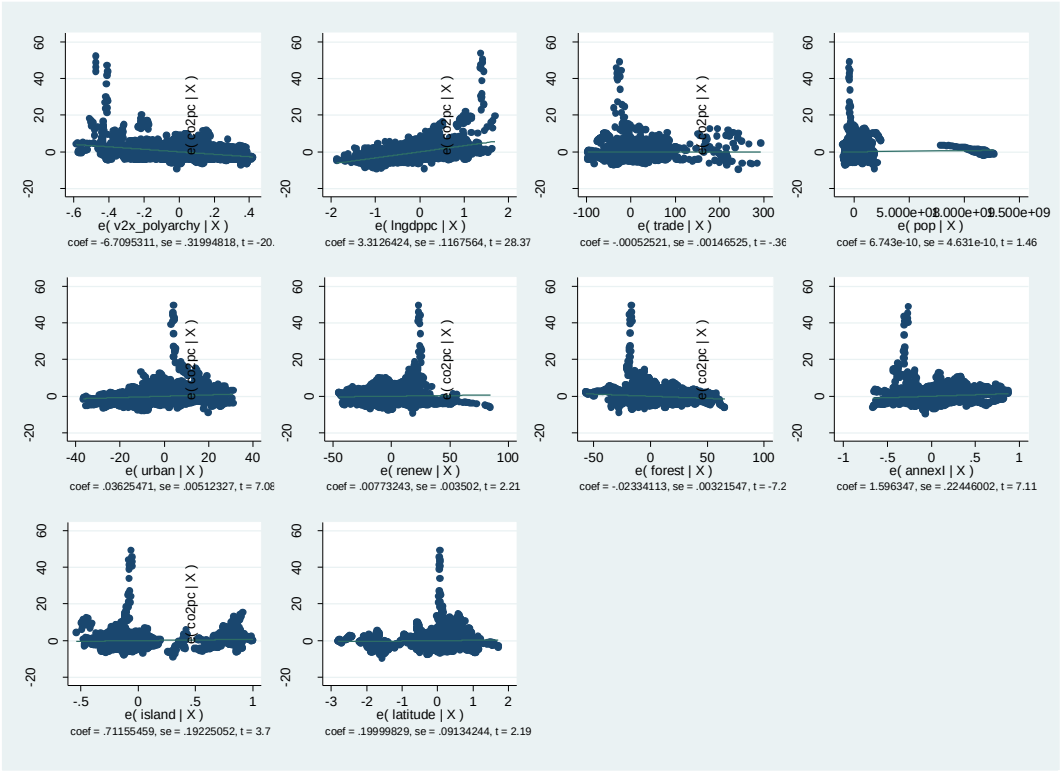



```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of co2pc

         chi2(1)      =  4028.35
         Prob > chi2  =   0.0000

.
. hettest, rhs fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: v2x_polyarchy lngdppc trade

         F(3 , 3674)  =   126.33
         Prob > F     =   0.0000
```

Appendix O

Heteroskedasticity test for the Study of Political Regimes

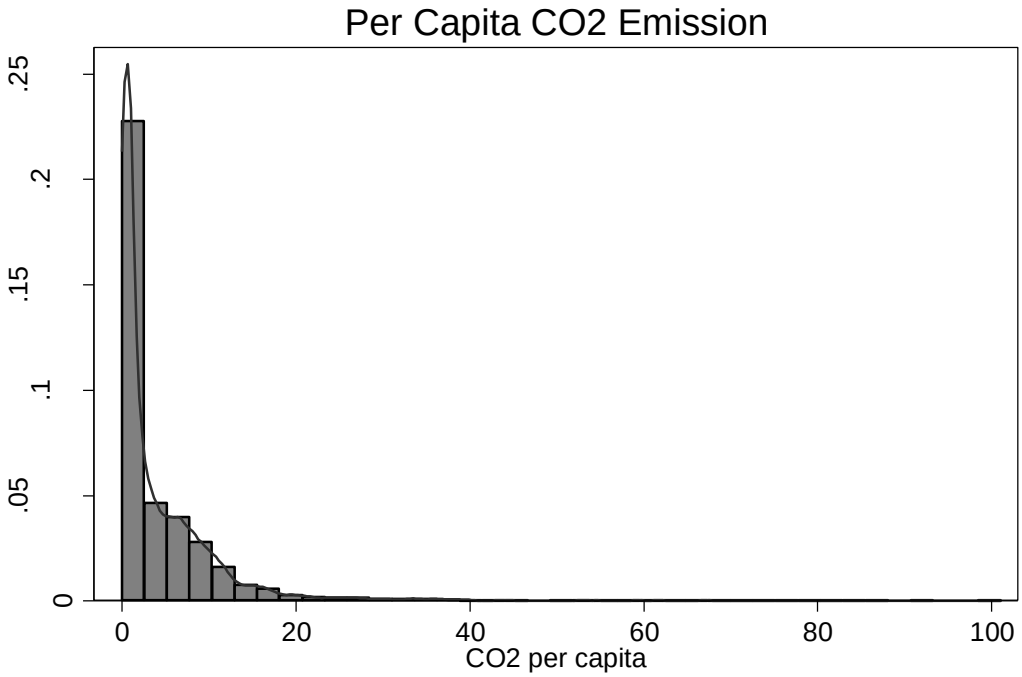
Main Model




```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of co2pc

         chi2(1)      =  4436.28
         Prob > chi2  =   0.0000

.
. hettest, rhs fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: v2x_polyarchy lngdppc trade pop urban renew forest annexI island latitude

         F(10 , 3667) =    45.18
         Prob > F     =   0.0000
```

Appendix P

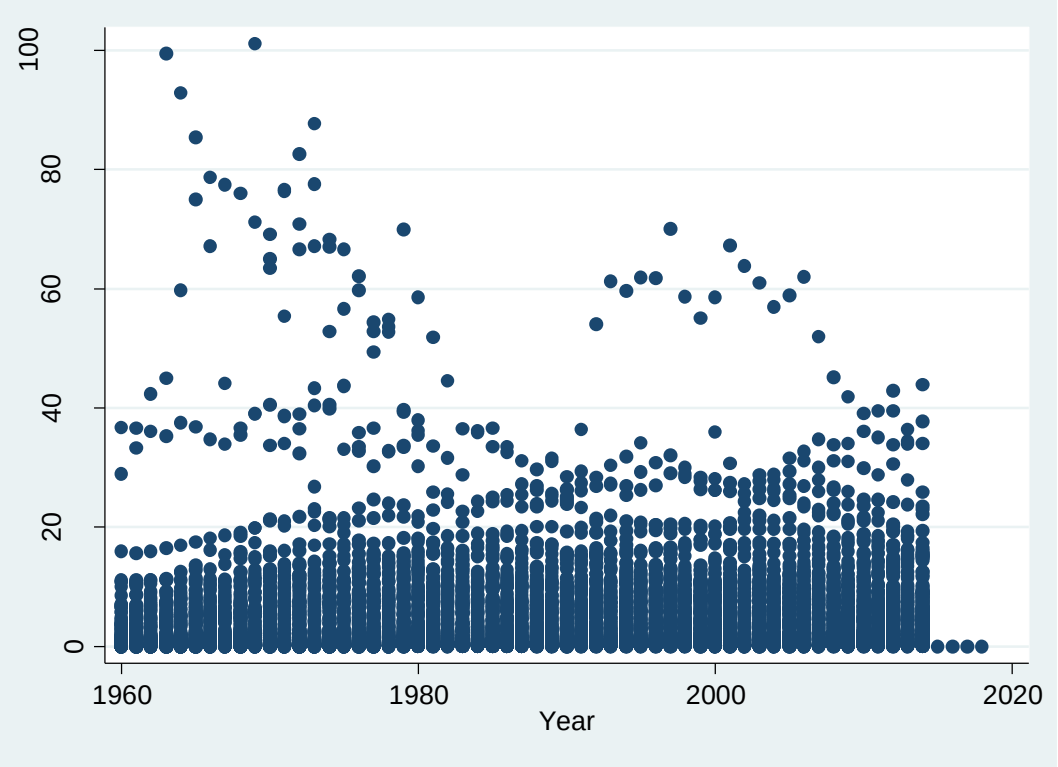
Histogram of the Dependent Variable (CO2 per capita) for the Study of Federalism



Source: World Bank

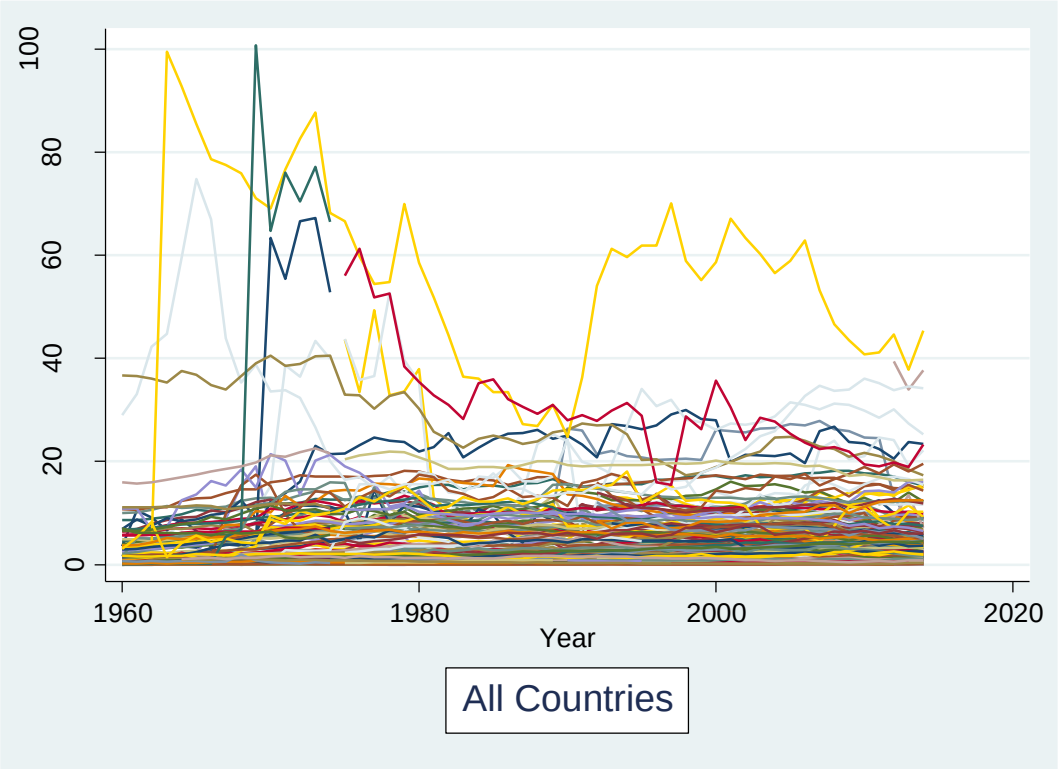
Appendix Q

Scatterplot between CO2 per capita and Year for the Study of Federalism



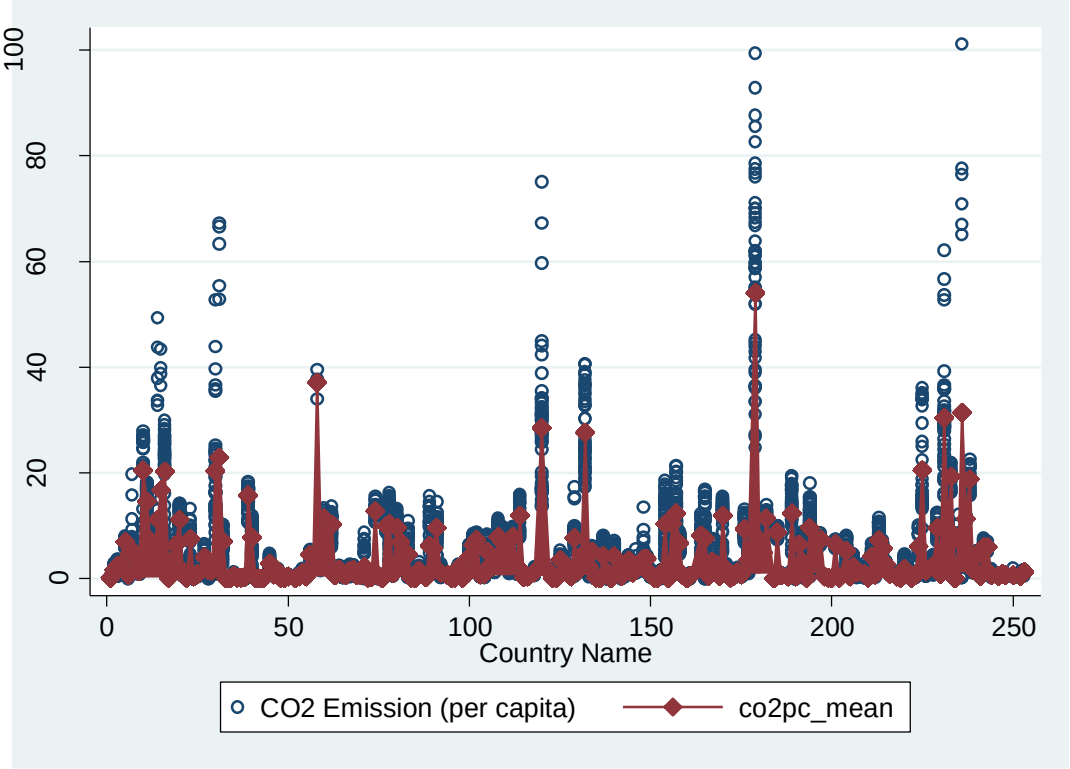
Appendix R

Status of CO2 emission per capita by all countries (xtline, overlay) for the Study of Federalism



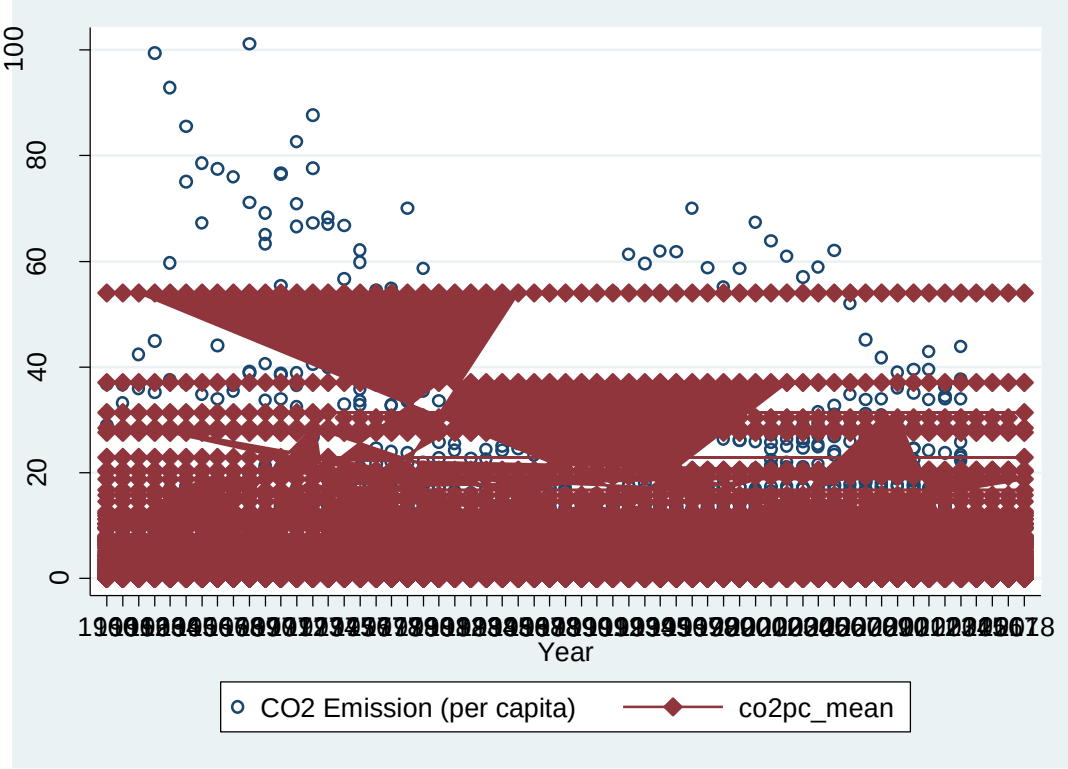
Appendix S

Checking for Heterogeneity across countries for the Study of Federalism



Appendix T

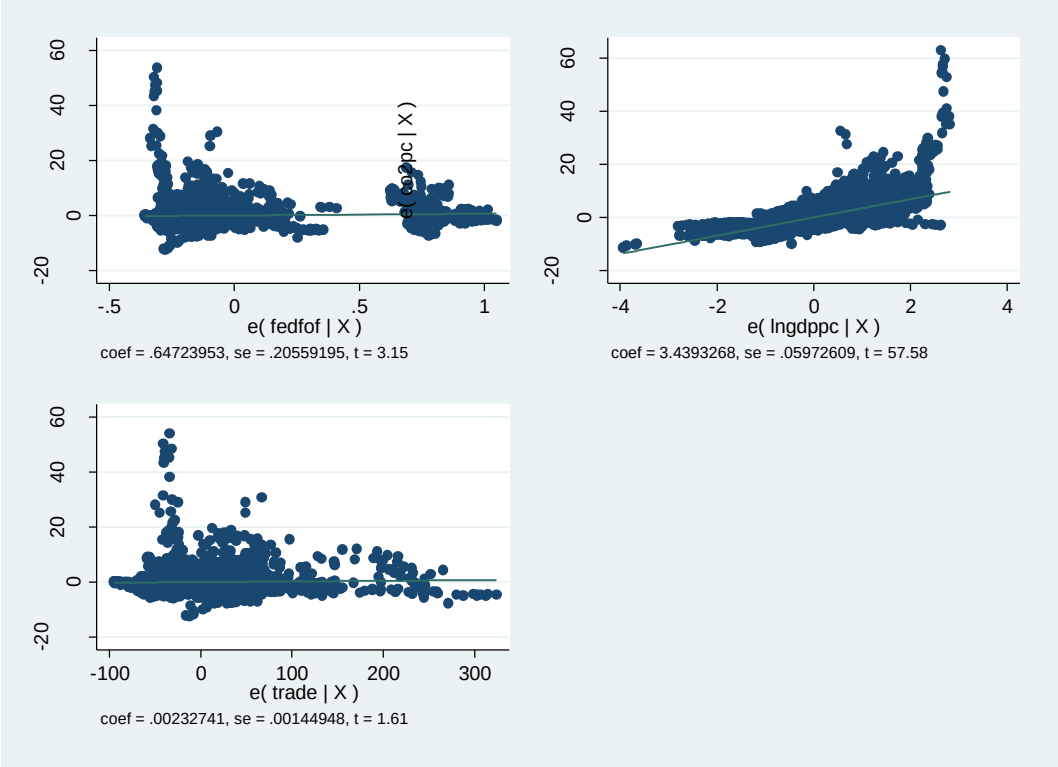
Checking for Heterogeneity across years for the Study of Federalism



Appendix U

Heteroskedasticity test for the Study of Federalism

Parsimonious Model

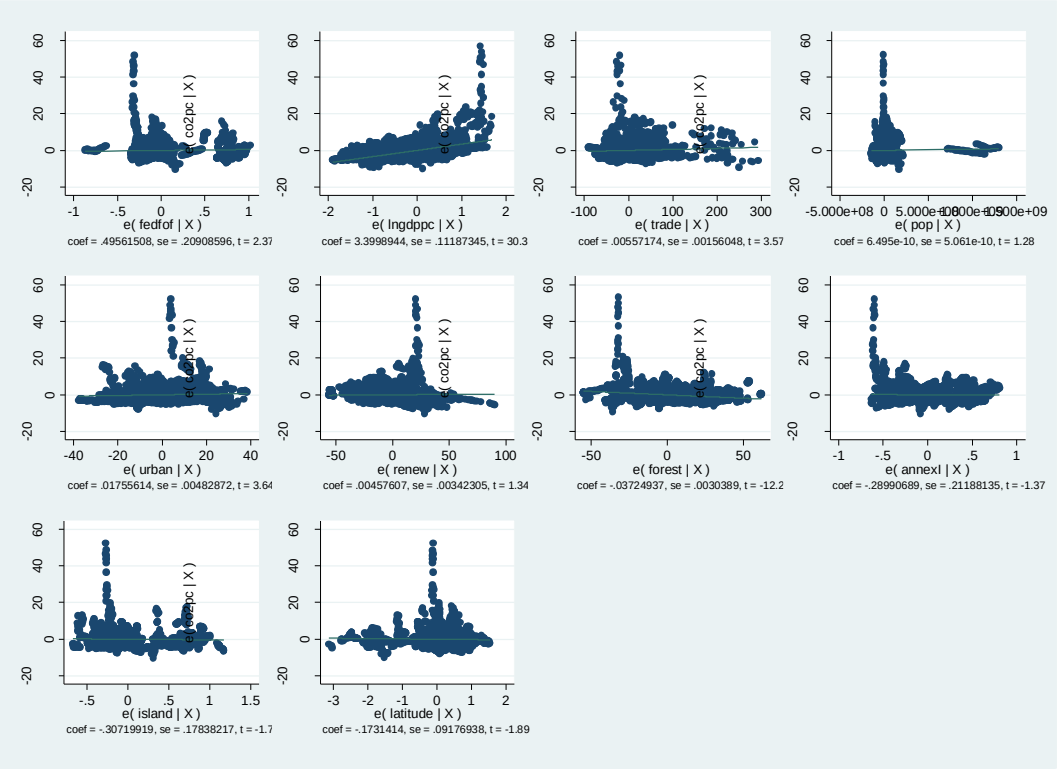



```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of co2pc

         chi2(1)      =  3145.86
         Prob > chi2  =   0.0000

. hettest, rhs fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fedfof lngdppc trade

         F(3 , 4130)  =    69.44
         Prob > F     =   0.0000
```

Appendix V

Heteroskedasticity Test for the Study of Federalism

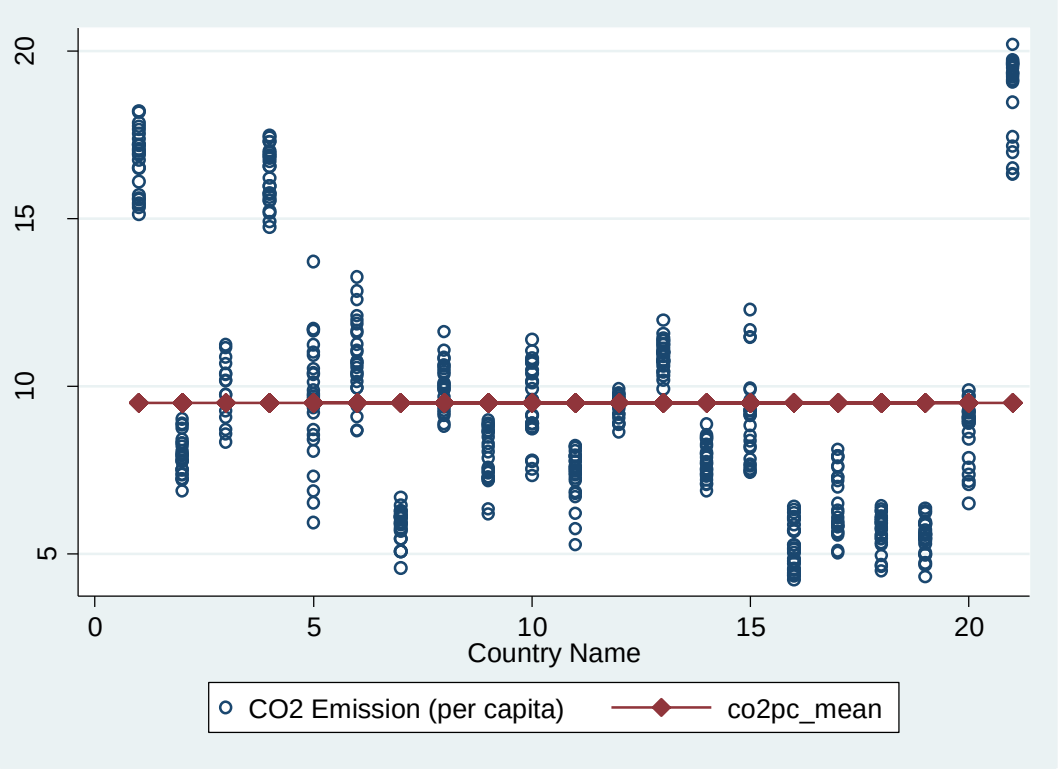
Parsimonious Model




```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of co2pc

         chi2(1)      =  3555.44
         Prob > chi2  =   0.0000



. hettest, rhs fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fedfof lngdppc trade pop urban renew forest annexI island latitude

         F(10 , 3989) =    40.32
         Prob > F     =   0.0000
```

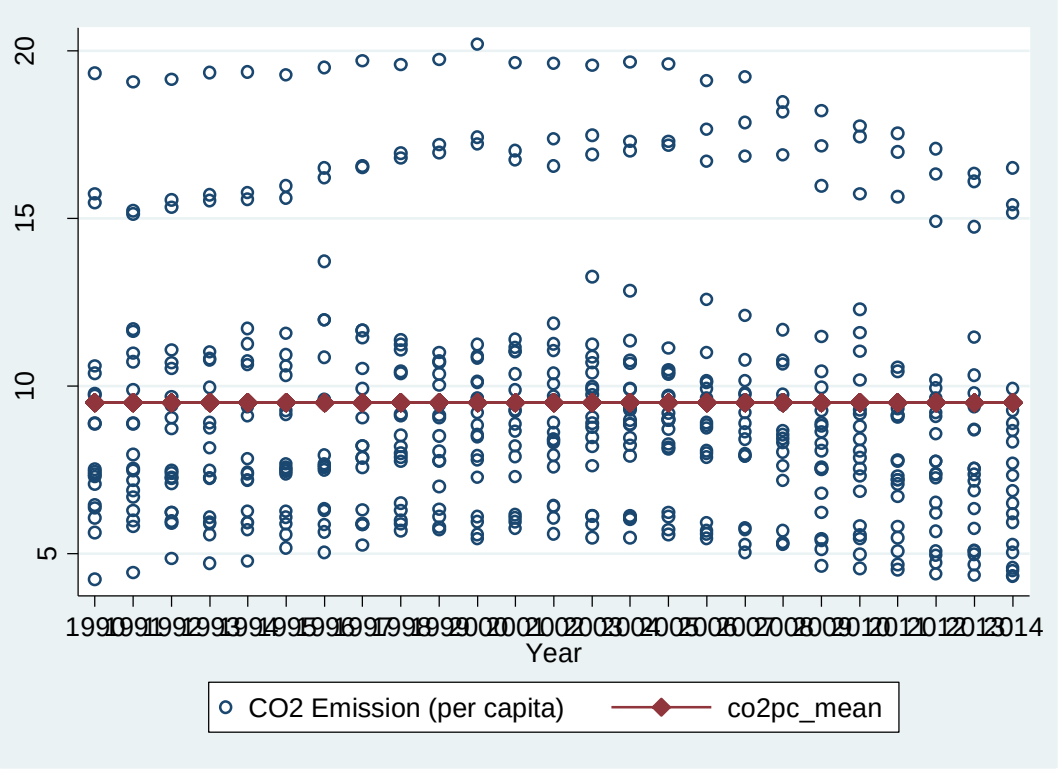
Appendix W

Checking for Heterogeneity across countries for the Study of Political Ideology



Appendix X

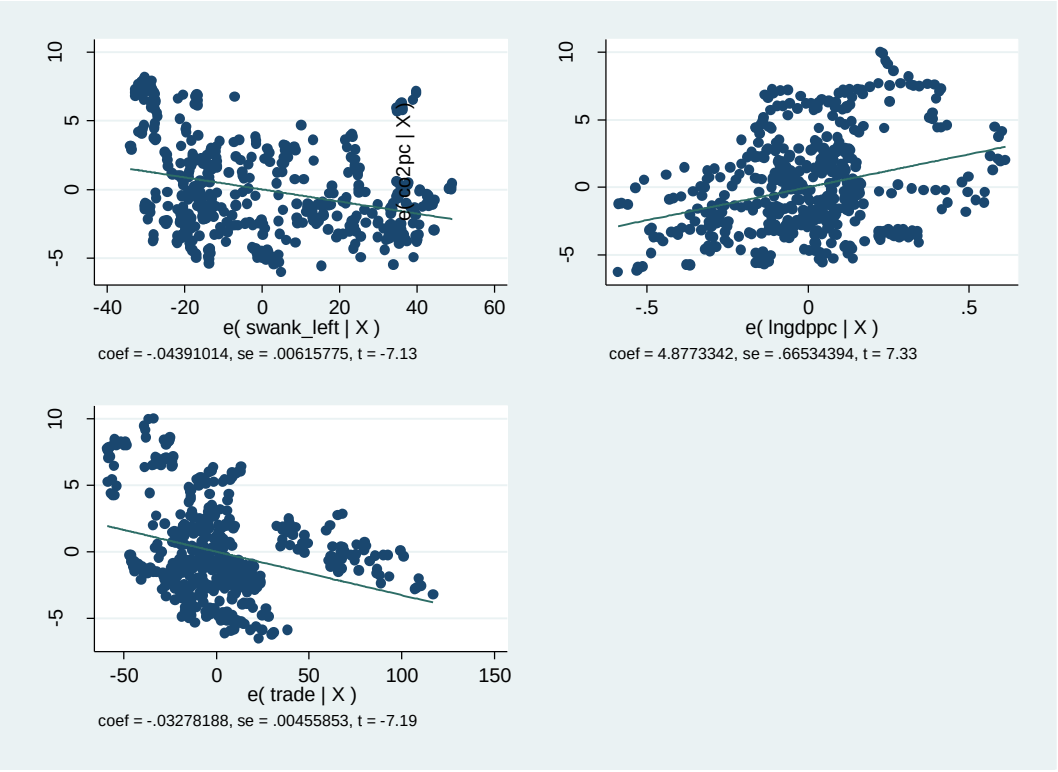
Checking for Heterogeneity across year for the Study of Political Ideology



Appendix Y

Heteroskedasticity test for the Study of Political Ideology

Parsimonious Model

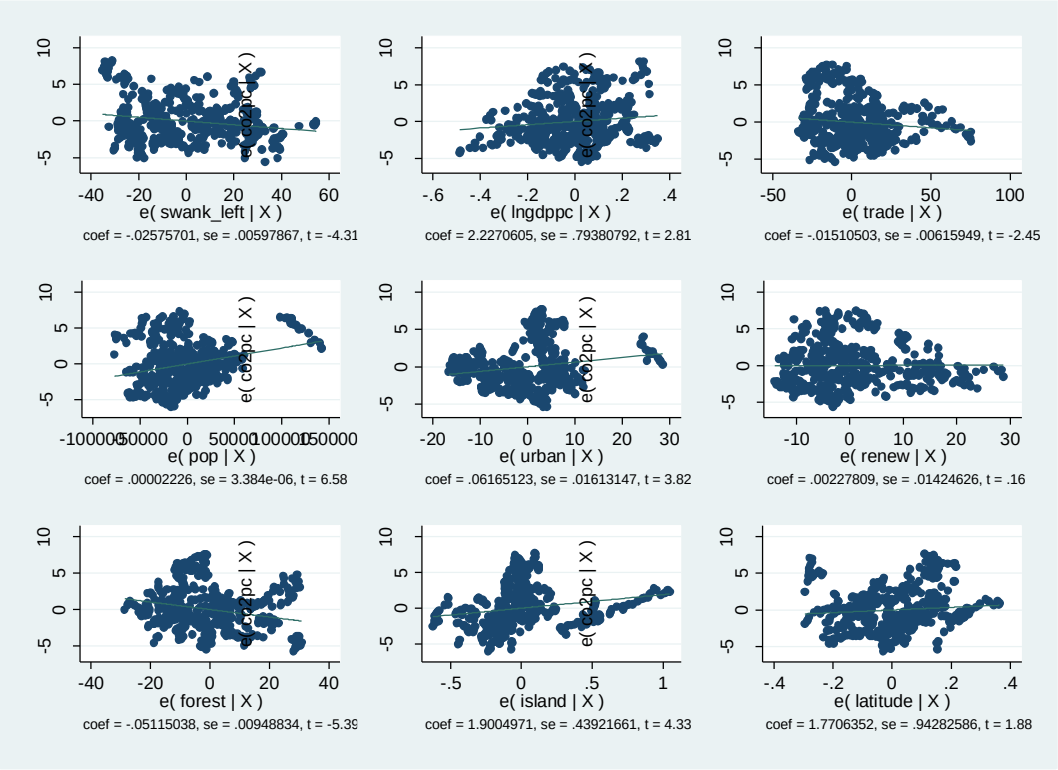



```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of co2pc

         chi2(1)      =    59.51
         Prob > chi2  =   0.0000

.
. hettest, rhs fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: swank_left lngdppc trade

         F(3 , 510)   =    31.20
         Prob > F     =   0.0000
```

Appendix Z

Heteroskedasticity test for the Study of Political Ideology

Main Model




```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of co2pc

         chi2(1)      =    16.97
         Prob > chi2  =   0.0000

.
. hettest, rhs fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: swank_left lngdppc trade pop urban renew forest o.annexI island latitude

         F(9 , 504)   =    15.05
         Prob > F     =   0.0000
```

Appendix AA

Pooled OLS Cross-Sectional Results for the Main Models

Variables					
	Pooled OLS With robust		*Pooled OLS With robust*		*Pooled OLS With robust*
Democracy	**-5.066*** (-0.324)**	***Federalism***	**0.958*** (0.192)**	***Political ideology***	**-0.026*** (0.007)**
LnGDP per capita	2.605*** -0.125		2.792*** (0.133)		2.227** (0.772)
Trade (% of GDP)	0.002 (-0.002)		0.007*** (0.002)		-0.015** (0.005)
Population	0.000*** 0		0.000** (0.000)		0.000*** (0.000)
Urbanization (% of total population)	0.032*** (-0.004)		0.014** (0.004)		0.062*** (0.010)
Renewable energy cons	-0.003 (-0.003)		-0.004 (0.003)		0.002 (0.011)
Forest (% of land area)	-0.017*** (-0.002)		-0.027*** (0.003)		-0.051*** (0.009)
Annex I	2.138*** (-0.195)		0.621** (0.234)		-
Island dummy	0.806*** (-0.18)		-0.026 (0.166)		1.900*** (0.281)
Latitude	0.183** (-0.059)		-0.137* (0.062)		1.771^ (1.071)
Constant	-18.770*** (-1.064)		- 20.949*** (1.062)		-23.138*** (6.749)
R2	0.643		0.589		0.400
sigma_u	-		-		
sigma_e	-		-		
Observations	3,663		3,985		514
Year FE	No		No		No
#Country	-		-		-

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Appendix AB

Fisher-type unit-root test for the Study of Political Regime: DV: co2pc

Without demean and time trend

```
Fisher-type unit-root test for co2pc
Based on augmented Dickey-Fuller tests
------------------------------------------------------------------------------
Ho: All panels contain unit roots           Number of panels       =    161
Ha: At least one panel is stationary        Avg. number of periods =  22.84

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(322)  P       341.0807       0.2225
 Inverse normal            Z         5.0220       1.0000
 Inverse logit t(799)      L*        4.2092       1.0000
 Modified inv. chi-squared Pm        0.7519       0.2261
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

With demean and time trend

```
Fisher-type unit-root test for co2pc
Based on augmented Dickey-Fuller tests
------------------------------------------------------------------------------
Ho: All panels contain unit roots           Number of panels       =    161
Ha: At least one panel is stationary        Avg. number of periods =  22.84

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included                      Cross-sectional means removed
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(322)  P       381.0971       0.0130
 Inverse normal            Z         4.9294       1.0000
 Inverse logit t(799)      L*        3.3143       0.9995
 Modified inv. chi-squared Pm        2.3288       0.0099
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

With demean and time trend including pperrron option

```
Fisher-type unit-root test for co2pc
Based on Phillips-Perron tests
------------------------------------------------------------------------------
Ho: All panels contain unit roots           Number of panels       =    161
Ha: At least one panel is stationary        Avg. number of periods =  22.84

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included                   Cross-sectional means removed
Newey-West lags: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(322)  P       429.1953       0.0001
 Inverse normal            Z         1.5524       0.9397
 Inverse logit t(799)      L*        0.7599       0.7762
 Modified inv. chi-squared Pm        4.2241       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix AC

Fisher-type unit-root test for the Stud of Federalism: DV: co2pc

Without demean and time trend

```
Fisher-type unit-root test for co2pc
Based on augmented Dickey-Fuller tests
------------------------------------------
Ho: All panels contain unit roots           Number of panels       =    227
Ha: At least one panel is stationary        Avg. number of periods =  42.58

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(450)  P       514.9831       0.0182
 Inverse normal            Z         2.2956       0.9892
 Inverse logit t(1109)     L*        2.2307       0.9870
 Modified inv. chi-squared Pm        2.1661       0.0152
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

With demean and time trend

```
Fisher-type unit-root test for co2pc
Based on augmented Dickey-Fuller tests
------------------------------------------
Ho: All panels contain unit roots           Number of panels       =    227
Ha: At least one panel is stationary        Avg. number of periods =  42.58

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included                      Cross-sectional means removed
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(450)  P       666.4133       0.0000
 Inverse normal            Z        -5.2595       0.0000
 Inverse logit t(1124)     L*       -5.5869       0.0000
 Modified inv. chi-squared Pm        7.2138       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

With demean and time trend including pperrron option

```
Fisher-type unit-root test for co2pc
Based on Phillips-Perron tests
------------------------------------------
Ho: All panels contain unit roots           Number of panels       =    227
Ha: At least one panel is stationary        Avg. number of periods =  42.58

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included                   Cross-sectional means removed
Newey-West lags: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(454)  P       782.0031       0.0000
 Inverse normal            Z        -7.6427       0.0000
 Inverse logit t(1119)     L*       -8.6083       0.0000
 Modified inv. chi-squared Pm       10.8852       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix AD

Fisher-type unit-root test for the Study of Political Ideology: DV: co2pc

Without demean and time trend

```
Fisher-type unit-root test for co2pc
Based on augmented Dickey-Fuller tests
------------------------------------
Ho: All panels contain unit roots           Number of panels       =     21
Ha: At least one panel is stationary        Avg. number of periods =  24.48

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                     Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(42)   P         18.1138       0.9995
 Inverse normal            Z          4.1038       1.0000
 Inverse logit t(109)      L*         4.2163       1.0000
 Modified inv. chi-squared Pm        -2.6062       0.9954
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

With demean and time trend

```
Fisher-type unit-root test for co2pc
Based on augmented Dickey-Fuller tests
------------------------------------
Ho: All panels contain unit roots           Number of panels       =     21
Ha: At least one panel is stationary        Avg. number of periods =  24.48

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included                      Cross-sectional means removed
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                     Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(42)   P         30.7349       0.9007
 Inverse normal            Z          2.2811       0.9887
 Inverse logit t(109)      L*         2.3154       0.9888
 Modified inv. chi-squared Pm        -1.2291       0.8905
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

With demean and time trend including pperrron option

```
Fisher-type unit-root test for co2pc
Based on Phillips-Perron tests
------------------------------------
Ho: All panels contain unit roots           Number of panels       =     21
Ha: At least one panel is stationary        Avg. number of periods =  24.48

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included                   Cross-sectional means removed
Newey-West lags: 1 lag
------------------------------------------------------------------------------
                                     Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(42)   P         48.0642       0.2406
 Inverse normal            Z          0.0737       0.5294
 Inverse logit t(109)      L*        -0.0538       0.4786
 Modified inv. chi-squared Pm         0.6617       0.2541
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix AE

Multicollinearity Test for the Study of Political Regimes

Parsimonious Model

```
. estat vif
```

Variable	VIF	1/VIF
lngdppc	1.45	0.691272
v2x_polyar~y	1.33	0.751455
trade	1.11	0.900411
Mean VIF	1.30	

Main Model

```
. estat vif
```

Variable	VIF	1/VIF
lngdppc	5.14	0.194572
urban	3.40	0.293998
renew	3.04	0.328630
annexI	2.37	0.421952
latitude	2.00	0.500945
v2x_polyar~y	1.81	0.551860
forest	1.34	0.748980
trade	1.26	0.793546
island	1.15	0.869620
pop	1.07	0.933160
Mean VIF	2.26	

Appendix AF

Multicollinearity Test for the Study of Federalism

Parsimonious Model

```
. estat vif
```

Variable	VIF	1/VIF
trade	1.19	0.839952
lngdppc	1.19	0.840255
fedfof	1.10	0.908755
Mean VIF	1.16	

Main Model

```
. estat vif
```

Variable	VIF	1/VIF
lngdppc	4.35	0.229957
urban	2.88	0.347274
renew	2.72	0.367899
latitude	1.88	0.533189
annexI	1.87	0.534335
trade	1.28	0.784110
island	1.24	0.807782
forest	1.20	0.834936
fedfof	1.18	0.849589
pop	1.11	0.898061
Mean VIF	1.97	

Appendix AG

Multicollinearity Test for the Study of Political Ideology

Parsimonious Model

```
. estat vif
```

Variable	VIF	1/VIF
lngdppc	1.15	0.867159
trade	1.15	0.873289
swank_left	1.01	0.990260
Mean VIF	1.10	

Main Model

```
. estat vif
```

Variable	VIF	1/VIF
pop	2.81	0.355974
trade	2.70	0.370627
renew	2.58	0.387112
latitude	2.42	0.412577
lngdppc	2.12	0.472041
island	1.81	0.553189
forest	1.74	0.574669
urban	1.45	0.690385
swank_left	1.23	0.813961
Mean VIF	2.10	

Appendix AH

Testing for time-fixed effect for the Study of Political Regimes

Parsimonious Model

```
. testparm i.year

 ( 1)  1991.year = 0
 ( 2)  1992.year = 0
 ( 3)  1993.year = 0
 ( 4)  1994.year = 0
 ( 5)  1995.year = 0
 ( 6)  1996.year = 0
 ( 7)  1997.year = 0
 ( 8)  1998.year = 0
 ( 9)  1999.year = 0
 (10)  2000.year = 0
 (11)  2001.year = 0
 (12)  2002.year = 0
 (13)  2003.year = 0
 (14)  2004.year = 0
 (15)  2005.year = 0
 (16)  2006.year = 0
 (17)  2007.year = 0
 (18)  2008.year = 0
 (19)  2009.year = 0
 (20)  2010.year = 0
 (21)  2011.year = 0
 (22)  2012.year = 0
 (23)  2013.year = 0
 (24)  2014.year = 0

       F( 24,  3490) =    3.94
            Prob > F =    0.0000
```

Main Model

```
. testparm i.year

 ( 1)  1991.year = 0
 ( 2)  1992.year = 0
 ( 3)  1993.year = 0
 ( 4)  1994.year = 0
 ( 5)  1995.year = 0
 ( 6)  1996.year = 0
 ( 7)  1997.year = 0
 ( 8)  1998.year = 0
 ( 9)  1999.year = 0
 (10)  2000.year = 0
 (11)  2001.year = 0
 (12)  2002.year = 0
 (13)  2003.year = 0
 (14)  2004.year = 0
 (15)  2005.year = 0
 (16)  2006.year = 0
 (17)  2007.year = 0
 (18)  2008.year = 0
 (19)  2009.year = 0
 (20)  2010.year = 0
 (21)  2011.year = 0
 (22)  2012.year = 0
 (23)  2013.year = 0
 (24)  2014.year = 0

       F( 24,  3486) =    5.38
            Prob > F =    0.0000
```

Appendix AI

Testing for time-fixed effect for the Study of Federalism

Parsimonious Model

```
. testparm i.year

 ( 1)  1991.year = 0
 ( 2)  1992.year = 0
 ( 3)  1993.year = 0
 ( 4)  1994.year = 0
 ( 5)  1995.year = 0
 ( 6)  1996.year = 0
 ( 7)  1997.year = 0
 ( 8)  1998.year = 0
 ( 9)  1999.year = 0
 (10)  2000.year = 0
 (11)  2001.year = 0
 (12)  2002.year = 0
 (13)  2003.year = 0
 (14)  2004.year = 0
 (15)  2005.year = 0
 (16)  2006.year = 0
 (17)  2007.year = 0
 (18)  2008.year = 0
 (19)  2009.year = 0
 (20)  2010.year = 0
 (21)  2011.year = 0
 (22)  2012.year = 0
 (23)  2013.year = 0
 (24)  2014.year = 0
 (25)  2015.year = 0
 (26)  2016.year = 0
 (27)  2017.year = 0

       F( 27,  3922) =    2.54
            Prob > F =    0.0000
```

Main Model

```
. testparm i.year

 ( 1)  1991.year = 0
 ( 2)  1992.year = 0
 ( 3)  1993.year = 0
 ( 4)  1994.year = 0
 ( 5)  1995.year = 0
 ( 6)  1996.year = 0
 ( 7)  1997.year = 0
 ( 8)  1998.year = 0
 ( 9)  1999.year = 0
 (10)  2000.year = 0
 (11)  2001.year = 0
 (12)  2002.year = 0
 (13)  2003.year = 0
 (14)  2004.year = 0
 (15)  2005.year = 0
 (16)  2006.year = 0
 (17)  2007.year = 0
 (18)  2008.year = 0
 (19)  2009.year = 0
 (20)  2010.year = 0
 (21)  2011.year = 0
 (22)  2012.year = 0
 (23)  2013.year = 0
 (24)  2014.year = 0

       F( 24,  3793) =    3.82
            Prob > F =    0.0000
```

Appendix AJ

Testing for time-fixed effect for the Study of Political Ideology

Parsimonious Model

```
. testparm i.year

 ( 1)  1991.year = 0
 ( 2)  1992.year = 0
 ( 3)  1993.year = 0
 ( 4)  1994.year = 0
 ( 5)  1995.year = 0
 ( 6)  1996.year = 0
 ( 7)  1997.year = 0
 ( 8)  1998.year = 0
 ( 9)  1999.year = 0
 (10)  2000.year = 0
 (11)  2001.year = 0
 (12)  2002.year = 0
 (13)  2003.year = 0
 (14)  2004.year = 0
 (15)  2005.year = 0
 (16)  2006.year = 0
 (17)  2007.year = 0
 (18)  2008.year = 0
 (19)  2009.year = 0
 (20)  2010.year = 0
 (21)  2011.year = 0
 (22)  2012.year = 0
 (23)  2013.year = 0
 (24)  2014.year = 0

       F( 24,   466) =   10.84
            Prob > F =    0.0000
```

Main Model

```
. testparm i.year

 ( 1)  1991.year = 0
 ( 2)  1992.year = 0
 ( 3)  1993.year = 0
 ( 4)  1994.year = 0
 ( 5)  1995.year = 0
 ( 6)  1996.year = 0
 ( 7)  1997.year = 0
 ( 8)  1998.year = 0
 ( 9)  1999.year = 0
 (10)  2000.year = 0
 (11)  2001.year = 0
 (12)  2002.year = 0
 (13)  2003.year = 0
 (14)  2004.year = 0
 (15)  2005.year = 0
 (16)  2006.year = 0
 (17)  2007.year = 0
 (18)  2008.year = 0
 (19)  2009.year = 0
 (20)  2010.year = 0
 (21)  2011.year = 0
 (22)  2012.year = 0
 (23)  2013.year = 0
 (24)  2014.year = 0

       F( 24,   462) =    2.22
            Prob > F =    0.0009
```

Appendix AK

Ramsey RESET test for the Study of Political Regimes

Parsimonious Model

```
Ramsey RESET test using powers of the fitted values of co2pc
       Ho:  model has no omitted variables
                 F(3, 3656) =    668.22
                   Prob > F =      0.0000
```

Main Model

```
Ramsey RESET test using powers of the fitted values of co2pc
       Ho:  model has no omitted variables
                 F(3, 3649) =    970.59
                   Prob > F =      0.0000
```

Appendix AL

Ramsey RESET test for the Study of Federalism

Parsimonious Model

```
. ovtest

Ramsey RESET test using powers of the fitted values of co2pc
       Ho:  model has no omitted variables
                 F(3, 4127) =    551.22
                   Prob > F =      0.0000
```

Main Model

```
Ramsey RESET test using powers of the fitted values of co2pc
       Ho:  model has no omitted variables
                 F(3, 3986) =   1150.39
                   Prob > F =      0.0000
```

Appendix AM

Ramsey RESET test for the Study of Political Ideology

Parsimonious Model

```
. ovtest

Ramsey RESET test using powers of the fitted values of co2pc
       Ho:  model has no omitted variables
                 F(3, 507) =     25.92
                  Prob > F =      0.0000
```

Main Model

```
. ovtest

Ramsey RESET test using powers of the fitted values of co2pc
       Ho:  model has no omitted variables
                 F(3, 501) =     31.73
                  Prob > F =      0.0000
```

Appendix AN

Specification Error Test for the Study of Political Regimes

Parsimonious Model

```
. linktest
```

Source	SS	df	MS		
Model	70145.9716	2	35072.9858	Number of obs	= 3663
Residual	25677.9153	3660	7.01582385	F(2, 3660)	= 4999.13
				Prob > F	= 0.0000
Total	95823.8869	3662	26.1670909	R-squared	= 0.7320
				Adj R-squared	= 0.7319
				Root MSE	= 2.6487

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
_hat	.1764925	.0227408	7.76	0.000	.1319067	.2210783
_hatsq	.09892	.0023918	41.36	0.000	.0942306	.1036094
_cons	.1426017	.0642206	2.22	0.026	.01669	.2685134

Main Model

```
. linktest
```

Source	SS	df	MS		
Model	71348.6028	2	35674.3014	Number of obs	= 3663
Residual	24475.2841	3660	6.6872361	F(2, 3660)	= 5334.69
				Prob > F	= 0.0000
Total	95823.8869	3662	26.1670909	R-squared	= 0.7446
				Adj R-squared	= 0.7444
				Root MSE	= 2.586

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
_hat	.1765767	.02394	7.38	0.000	.1296395	.2235138
_hatsq	.0920998	.0024107	38.20	0.000	.0873733	.0968264
_cons	.2881348	.0621258	4.64	0.000	.1663302	.4099394

Appendix AO

Specification Error Test for the Study of Federalism

Parsimonious Model

```
. linktest
```

Source	SS	df	MS	Number of obs =	4134
				F(2, 4131) =	3306.31
Model	94792.1198	2	47396.0599	Prob > F =	0.0000
Residual	59218.0562	4131	14.3350414	R-squared =	0.6155
				Adj R-squared =	0.6153
Total	154010.176	4133	37.2635316	Root MSE =	3.7862

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
_hat	.0612895	.0297776	2.06	0.040	.0029094	.1196695
_hatsq	.1076374	.0030336	35.48	0.000	.10169	.1135848
_cons	.0445468	.0856549	0.52	0.603	-.123383	.2124766

Main Model

```
. linktest
```

Source	SS	df	MS	Number of obs =	4000
				F(2, 3997) =	4158.12
Model	98392.6036	2	49196.3018	Prob > F =	0.0000
Residual	47290.0831	3997	11.8313943	R-squared =	0.6754
				Adj R-squared =	0.6752
Total	145682.687	3999	36.4297791	Root MSE =	3.4397

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
_hat	.080131	.0253497	3.16	0.002	.0304314	.1298305
_hatsq	.1013947	.0024423	41.52	0.000	.0966064	.1061829
_cons	.1091035	.0779571	1.40	0.162	-.0437359	.2619429

Appendix AP

Specification Error Test for the Study of Political Ideology

Parsimonious Model

```
. linktest
```

Source	SS	df	MS		
Model	2205.04315	2	1102.52158		
Residual	5018.7343	511	9.82139784		
Total	7223.77745	513	14.0814375		

Number of obs	=	514			
F(2, 511)	=	112.26			
Prob > F	=	0.0000			
R-squared	=	0.3052			
Adj R-squared	=	0.3025			
Root MSE	=	3.1339			

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
_hat	-4.707614	.712192	-6.61	0.000	-6.106798	-3.308429
_hatsq	.2910835	.036096	8.06	0.000	.2201687	.3619984
_cons	27.06364	3.441965	7.86	0.000	20.3015	33.82579

Main Model

```
. linktest
```

Source	SS	df	MS		
Model	3075.10201	2	1537.551		
Residual	4148.67544	511	8.11873863		
Total	7223.77745	513	14.0814375		

Number of obs	=	514			
F(2, 511)	=	189.38			
Prob > F	=	0.0000			
R-squared	=	0.4257			
Adj R-squared	=	0.4234			
Root MSE	=	2.8493			

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
_hat	-.3579115	.2905516	-1.23	0.219	-.9287342	.2129113
_hatsq	.0642941	.0135263	4.75	0.000	.0377201	.090868
_cons	6.734875	1.508762	4.46	0.000	3.770735	9.699015

Appendix AQ

Hausman Test for the Study of Political Regimes

Parsimonious Model

```
. hausman fixed random, sigmamore

                 ---- Coefficients ----
                |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
                |     fixed        random       Difference          S.E.
----------------+----------------------------------------------------------------
v2x_polyar~y    |     .1274019    -.0608187        .1882206        .0411463
     lngdppc    |     1.216113     1.474783       -.2586696        .0270977
       trade    |    -.0046163    -.0047587        .0001424        .0001614
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      110.08
                Prob>chi2 =      0.0000
```

Main Model

```
. hausman fixed random, sigmamore

Note: the rank of the differenced variance matrix (6) does not equal the number of coefficients being tested (7); be sure
        this is what you expect, or there may be problems computing the test.  Examine the output of your estimators for
        anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.

                 ---- Coefficients ----
                |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
                |     fixed        random       Difference          S.E.
----------------+----------------------------------------------------------------
v2x_polyar~y    |    -.1740849    -.5048443        .3307594        .0454451
     lngdppc    |     .9228693     1.043467       -.1205973        .0220484
       trade    |    -.0046171     -.004667        .0000499         .000162
         pop    |     1.07e-10    -9.67e-10        1.07e-09        8.55e-10
       urban    |     .0102197     .0184661       -.0082464        .0023924
       renew    |    -.0304051    -.0309368        .0005317        .0010227
      forest    |     .0086582    -.0047112        .0133694        .0055204
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       70.06
                Prob>chi2 =      0.0000
```

Appendix AR

Hausman Test for the Study of Federalism

Parsimonious Model

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |    fixed        random       Difference          S.E.
-------------+------------------------------------------------------------
     lngdppc |   1.213059     1.425819       -.2127608        .0226675
       trade |  -.0054767    -.0055429        .0000662              .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       76.01
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Main Model

```
. hausman fixed random

Note: the rank of the differenced variance matrix (5) does not equal the number of
        coefficients being tested (6); be sure this is what you expect, or there may be
        problems computing the test.  Examine the output of your estimators for anything
        unexpected and possibly consider scaling your variables so that the coefficients are
        on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |    fixed        random       Difference          S.E.
-------------+------------------------------------------------------------
     lngdppc |   .9801703     1.110904       -.1307334        .0212115
       trade |  -.0053986    -.0054583        .0000597        .0001024
         pop |  -2.61e-10    -1.49e-09        1.23e-09        8.76e-10
       urban |   .0097232     .0154508       -.0057276        .0023223
       renew |  -.0311529    -.0315167        .0003638        .0009947
      forest |   .0041498    -.0078106        .0119604        .0060349
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       52.78
                Prob>chi2 =      0.0000
```

Appendix AS

Hausman Test for the Study of Political Ideology

Parsimonious Model

```
. hausman fixed random, sigmamore

                ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |    fixed        random       Difference          S.E.
-------------+------------------------------------------------------------
  swank_left |  -.0003216   -.0005232        .0002016        .0000803
     lngdppc |   2.742919     2.74586       -.002941        .0681863
       trade |  -.0415175   -.0410743       -.0004433        .0010216
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        8.21
                Prob>chi2 =      0.0418
```

Main Model

```
 Test:  Ho:  difference in coefficients not systematic

               chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                       =    -4.59    chi2<0 ==> model fitted on these
                                     data fails to meet the asymptotic
                                     assumptions of the Hausman test;
                                     see suest for a generalized test
```

Appendix AT

Breusch and Pagan Lagrangian multiplier test for random effects for the Study of Political Regimes

Parsimonious Model

```
Breusch and Pagan Lagrangian multiplier test for random effects

        co2pc[c_code,t] = Xb + u[c_code] + e[c_code,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+------------------------------
                   co2pc |    35.45581       5.954478
                       e |    1.284033       1.133152
                       u |    16.70404       4.087058

        Test:   Var(u) = 0
                             chibar2(01) = 23349.94
                           Prob > chibar2 =   0.0000
```

Main Model

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        co2pc[c_code,t] = Xb + u[c_code] + e[c_code,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+------------------------------
                   co2pc |    35.45581       5.954478
                       e |    1.260946       1.122919
                       u |    16.34526       4.042927

        Test:   Var(u) = 0
                             chibar2(01) = 22910.03
                           Prob > chibar2 =   0.0000
```

Appendix AU

Breusch and Pagan Lagrangian multiplier test for random effects for the Study of Federalism

Parsimonious Model

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        co2pc[country,t] = Xb + u[country] + e[country,t]

        Estimated results:
                     |       Var     sd = sqrt(Var)
             ---------+------------------------------
              co2pc  |    37.26353       6.104386
                  e  |    1.484085        1.21823
                  u  |      23.664       4.864566

        Test:   Var(u) = 0
                             chibar2(01) = 26577.07
                          Prob > chibar2 =   0.0000
```

Main Model

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        co2pc[country,t] = Xb + u[country] + e[country,t]

        Estimated results:
                     |       Var     sd = sqrt(Var)
             ---------+------------------------------
              co2pc  |    36.42978       6.035709
                  e  |    1.448705       1.203622
                  u  |    18.92912       4.350761

        Test:   Var(u) = 0
                            chibar2(01) = 26199.89
                         Prob > chibar2 =   0.0000
```

Appendix AV

Breusch and Pagan Lagrangian multiplier test for random effects for the Study of Political Ideology

Parsimonious Model

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        co2pc[c_code,t] = Xb + u[c_code] + e[c_code,t]

        Estimated results:
                     |       Var     sd = sqrt(Var)
             ---------+------------------------------
                co2pc |    14.08144       3.752524
                    e |    .7344485       .8569997
                    u |    9.832529       3.135686

        Test:   Var(u) = 0
                              chibar2(01) =  4495.39
                            Prob > chibar2 =   0.0000
```

Main Model

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        co2pc[c_code,t] = Xb + u[c_code] + e[c_code,t]

        Estimated results:
                     |       Var     sd = sqrt(Var)
             ---------+------------------------------
                co2pc |    14.08144       3.752524
                    e |    .3516779       .5930244
                    u |    11.51054       3.392719

        Test:   Var(u) = 0
                              chibar2(01) =  4576.82
                            Prob > chibar2 =   0.0000
```

Appendix AW

Pesaran (2015) test for weak cross-sectional dependence for the Study of Political Regimes

```
. xtcd2
Pesaran (2015) test for weak cross-sectional dependence.
Residuals calculated using  predict, e from xtreg.
Unbalanced panel detected, test adjusted.
Please install xtset2 from xtdcce2 package.
Panel information might be incorrect.
```

Variable	Obs	Mean	Std. Dev.	Min	Max
__000000	3678	80.69467	46.60021	1	161

Variable	Obs	Mean	Std. Dev.	Min	Max
__000001	3678	13.60005	7.061189	1	25

```
H0: errors are weakly cross-sectional dependent.
        CD = 11.250
   p-value = 0.000
```

Appendix AX

Test of Cross-sectional Independence with the command ‘xtcdf’ for the Study of Political Regimes

```
xtcd test on variables co2pc v2x_polyarchy lngdppc trade pop urban renew forest annexI island latitude
Panelvar: c_code
Timevar: year
```

Variable	CD-test	p-value	average joint T	mean Ï□	mean abs(Ï□)	
co2pc	41.227	0.000	21.06	0.08	0.49	9 combinations of panel units ignored (insufficient joint observations).
v2x_polyarchy	56.105	0.000	21.06	0.10	0.39	9 combinations of panel units ignored (insufficient joint observations).
lngdppc	297.65	0.000	21.06	0.57	0.73	9 combinations of panel units ignored (insufficient joint observations).
trade	100.121	0.000	21.06	0.19	0.45	9 combinations of panel units ignored (insufficient joint observations).
pop	301.969	0.000	21.06	0.58	0.93	9 combinations of panel units ignored (insufficient joint observations).
urban	251.527	0.000	21.06	0.48	0.86	9 combinations of panel units ignored (insufficient joint observations).
renew	14.141	0.000	21.06	0.03	0.50	9 combinations of panel units ignored (insufficient joint observations).
forest	-1.616	0.106	21.06	0.00	0.70	9 combinations of panel units ignored (insufficient joint observations).
annexI	0	1.000	21.06	0.00	0.00	9 combinations of panel units ignored (insufficient joint observations).
island	0	1.000	21.06	0.00	0.00	9 combinations of panel units ignored (insufficient joint observations).
latitude	5.192	0.000	21.06	0.01	0.46	9 combinations of panel units ignored (insufficient joint observations).

```
Notes: Under the null hypothesis of cross-section independence, CD ~ N(0,1)
       P-values close to zero indicate data are correlated across panel groups.
```

Appendix AY

Pesaran's test of cross-sectional independence for the Study of Political Ideology

Parsimonious Model

```
. xtcsd, pesaran abs

Pesaran's test of cross sectional independence =    22.729, Pr = 0.0000
Average absolute value of the off-diagonal elements =     0.414
```

Main Model

```
. xtcsd, pesaran abs

Pesaran's test of cross sectional independence =     1.284, Pr = 0.1991
Average absolute value of the off-diagonal elements =     0.348
```

Appendix AZ

Pesaran (2015) test for weak cross-sectional dependence for the Study of Political Ideology

Parsimonious Model

```
. xtcd2
Pesaran (2015) test for weak cross-sectional dependence.
Residuals calculated using  predict, e from xtreg.
Unbalanced panel detected, test adjusted.
Please install xtset2 from xtdcce2 package.
Panel information might be incorrect.
```

Variable	Obs	Mean	Std. Dev.	Min	Max
__000000	514	11.16537	6.016699	1	21

Variable	Obs	Mean	Std. Dev.	Min	Max
__000001	514	13.16926	7.18677	1	25

```
H0: errors are weakly cross-sectional dependent.
        CD = -2.448
   p-value = 0.014
```

Main Model

```
. xtcd2
Pesaran (2015) test for weak cross-sectional dependence.
Residuals calculated using  predict, e from xtreg.
Unbalanced panel detected, test adjusted.
Please install xtset2 from xtdcce2 package.
Panel information might be incorrect.
```

Variable	Obs	Mean	Std. Dev.	Min	Max
__000000	514	11.16537	6.016699	1	21

Variable	Obs	Mean	Std. Dev.	Min	Max
__000001	514	13.16926	7.18677	1	25

```
H0: errors are weakly cross-sectional dependent.
        CD = -2.622
   p-value = 0.009
```

Appendix BA

Test of Cross-sectional Independence with the command 'xtcdf' for the Study of Political Ideology

Parsimonious Model

```
. xtcdf co2pc swank_left lngdppc trade

xtcd test on variables co2pc swank_left lngdppc trade
Panelvar: c_code
Timevar: year
```

Variable	CD-test	p-value	average joint T	mean Ï□	mean abs(Ï□)
co2pc	30.697	0.000	23.96	0.44	0.53
swank_left	.02	0.984	23.96	0.00	0.30
lngdppc	64.982	0.000	23.96	0.92	0.92
trade	46.574	0.000	23.96	0.66	0.67

Notes: Under the null hypothesis of cross-section independence, CD ~ N(0,1)
P-values close to zero indicate data are correlated across panel groups.

Main Model

```
xtcd test on variables co2pc swank_left lngdppc trade pop urban renew forest annexI island latitude
Panelvar: c_code
Timevar: year
```

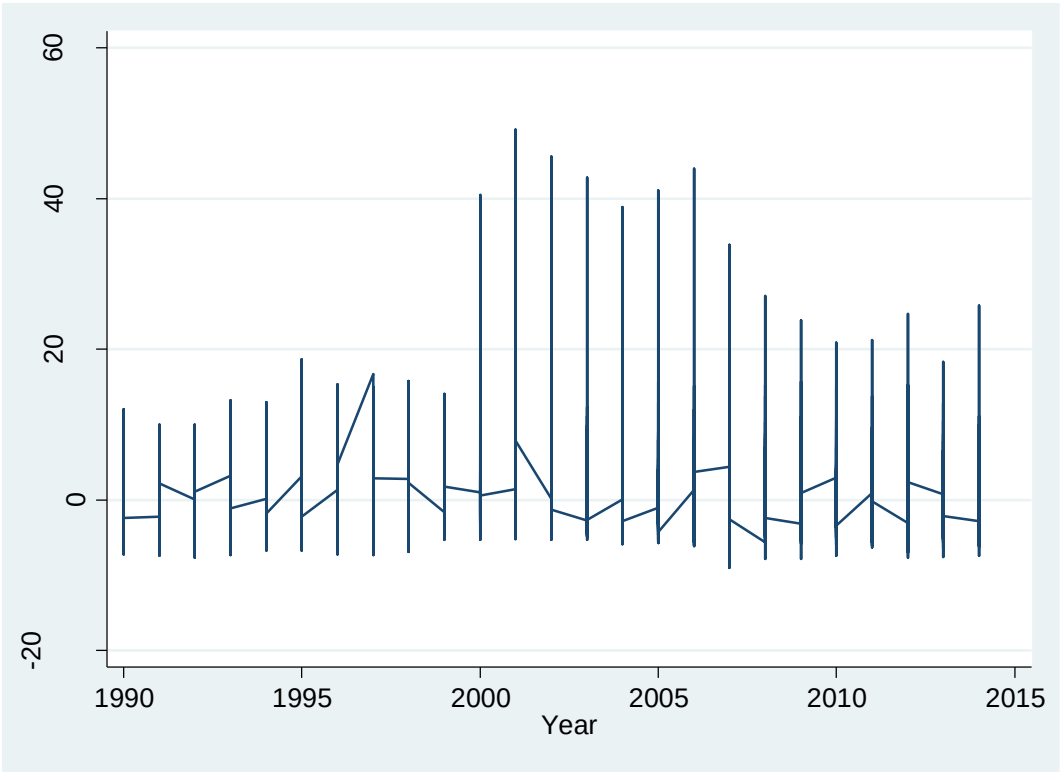
Variable	CD-test	p-value	average joint T	mean Ï□	mean abs(Ï□)
co2pc	30.697	0.000	23.96	0.44	0.53
swank_left	.02	0.984	23.96	0.00	0.30
lngdppc	64.982	0.000	23.96	0.92	0.92
trade	46.574	0.000	23.96	0.66	0.67
pop	58.198	0.000	23.96	0.82	0.88
urban	42.936	0.000	23.96	0.61	0.83
renew	41.507	0.000	23.96	0.59	0.68
forest	18.783	0.000	23.96	0.27	0.79
annexI	0	1.000	23.96	0.00	0.00
island	0	1.000	23.96	0.00	0.00
latitude	-1.677	0.093	23.96	-0.02	0.72

Notes: Under the null hypothesis of cross-section independence, CD ~ N(0,1)
P-values close to zero indicate data are correlated across panel groups.

Appendix BB

Autocorrelation or serial correlation for the Study of Political Regimes

Parsimonious Model

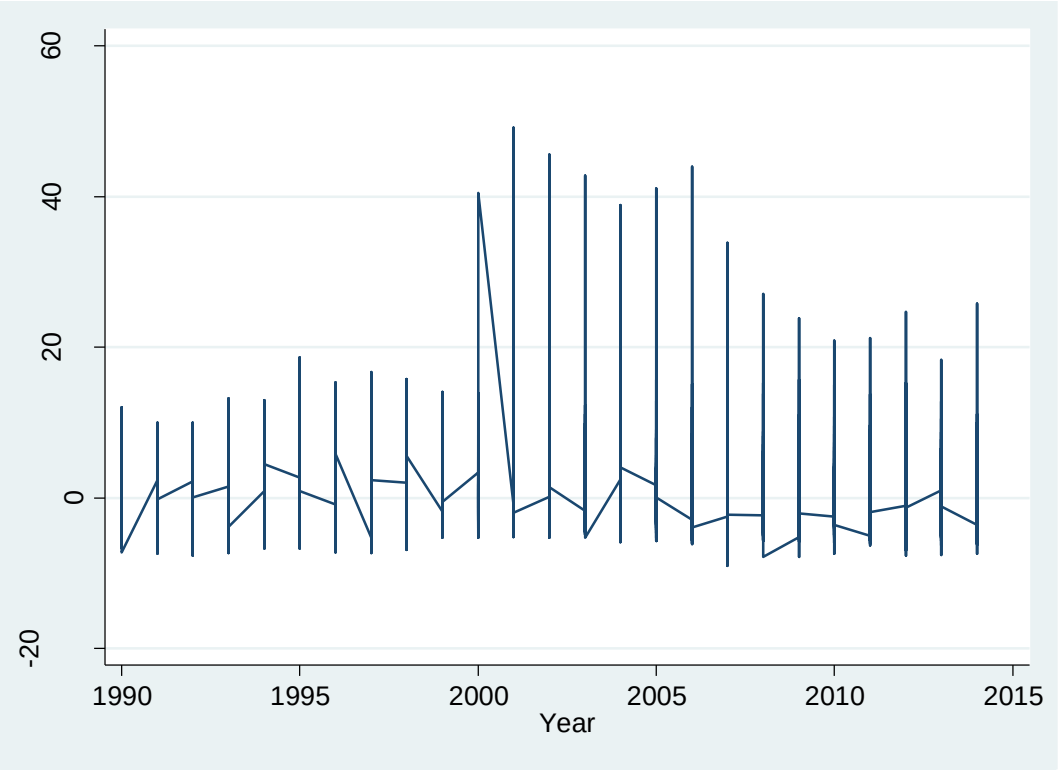



```
. xtserial co2pc v2x_polyarchy lngdppc trade

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,     160) =    132.914
           Prob > F =      0.0000
```

Appendix BC

Autocorrelation or serial correlation for the Study of Political Regimes

Main Model

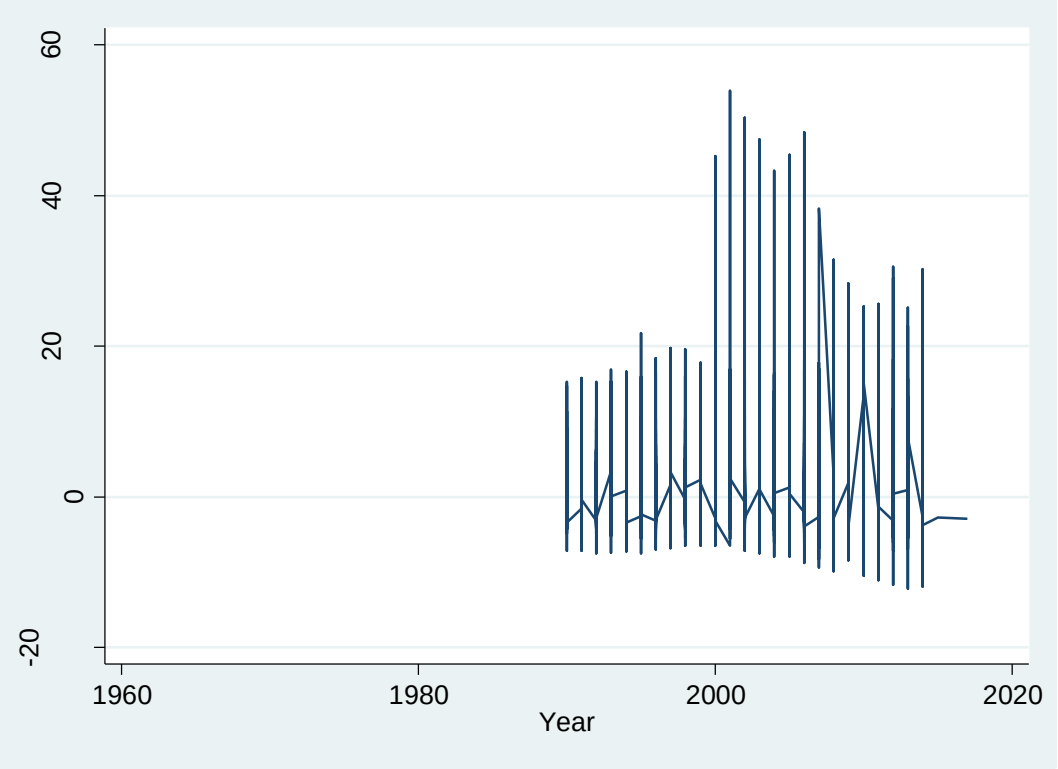



```
. xtserial co2pc v2x_polyarchy lngdppc trade pop urban renew forest annexI island latitude

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,     160) =    129.769
           Prob > F =      0.0000
```

Appendix BD

Autocorrelation or serial correlation for the Study of Federalism

Parsimonious Model

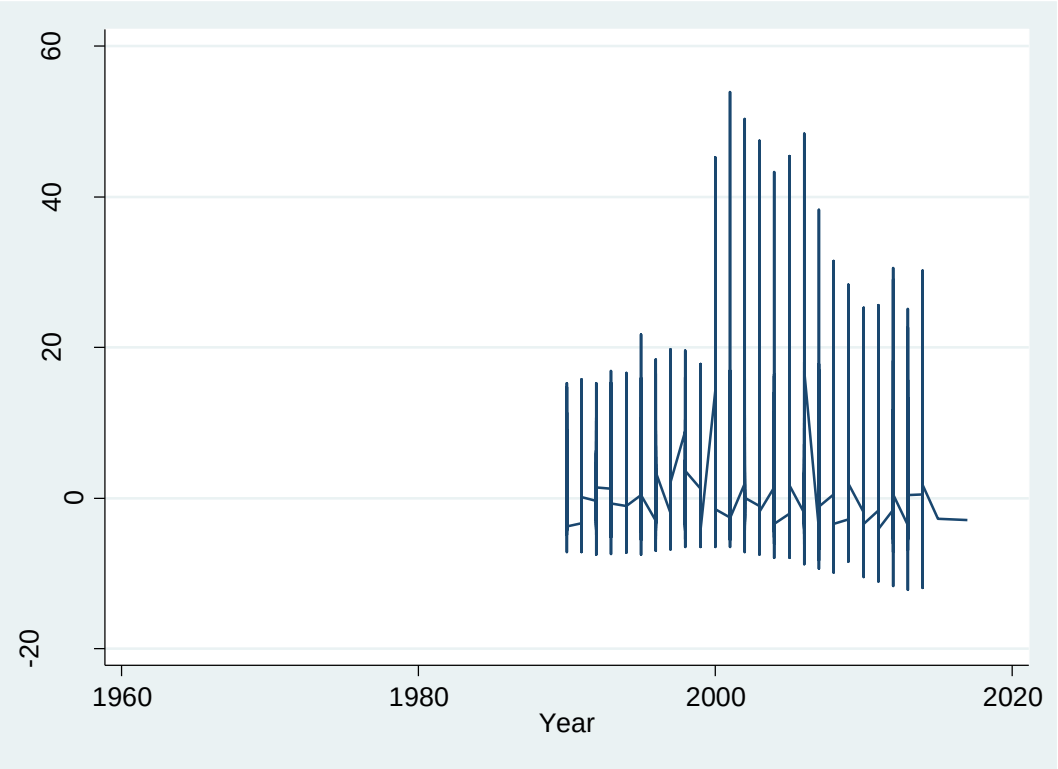



```
. xtserial co2pc fedfof lngdppc trade

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,     182) =     78.761
           Prob > F =      0.0000
```

Appendix BE

Autocorrelation or serial correlation for the Study of Federalism

Main Model

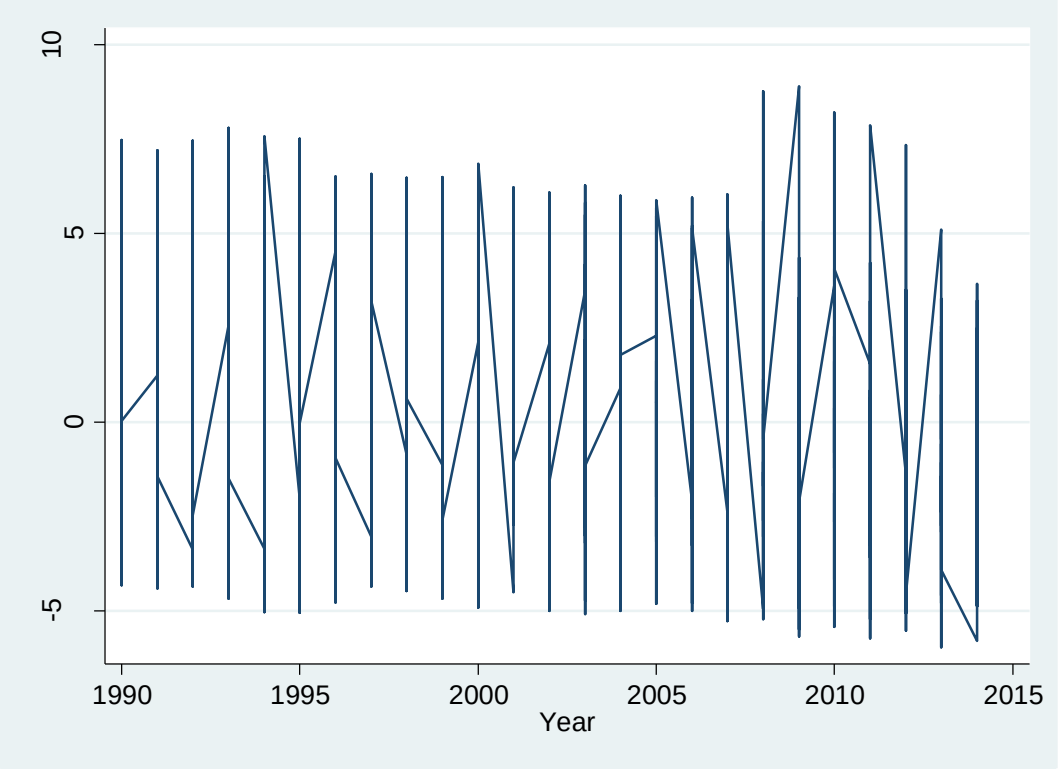



```
. xtserial co2pc fedfof lngdppc trade pop urban renew forest annexI island latitude

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,     176) =     82.784
           Prob > F =      0.0000
```

Appendix BF

Autocorrelation or serial correlation for the Study of Political Ideology

Parsimonious Model

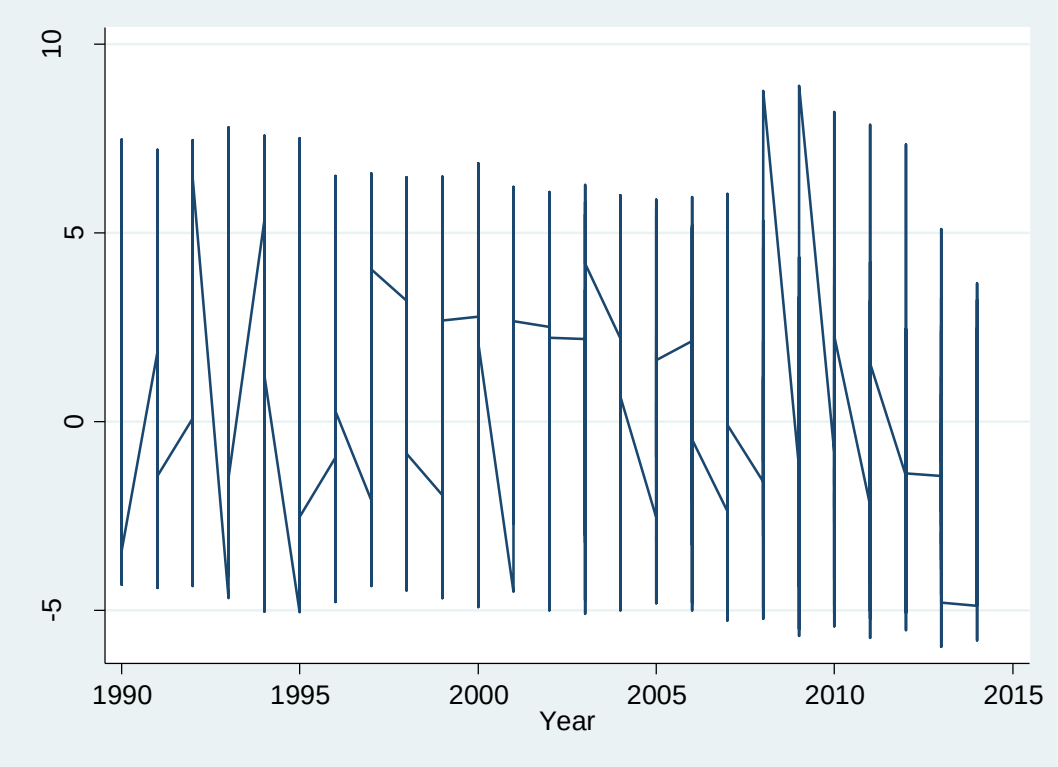



```
. xtserial co2pc swank_left lngdppc trade

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      20) =     17.068
           Prob > F =      0.0005
```

Appendix BG

Autocorrelation or serial correlation for the Study of Political Ideology

Main Model




```
. xtserial co2pc swank_left lngdppc trade pop urban renew forest annexI island latitude

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      20) =     12.616
           Prob > F =      0.0020
```

Appendix BH

Modified Wald test for groupwise heteroskedasticity for the Study of Political Regimes

Parsimonious Model

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (161)  =   2.6e+06
Prob>chi2 =      0.0000
```

Main Model

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (161)  =   1.8e+06
Prob>chi2 =      0.0000
```

Appendix BI

Modified Wald test for groupwise heteroskedasticity for the Study of Federalism

Parsimonious Model

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (183)  =   2.1e+07
Prob>chi2 =      0.0000
```

Main Model

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (177)  =   6.1e+06
Prob>chi2 =      0.0000
```

Appendix BJ

Modified Wald test for groupwise heteroskedasticity for the Study of Political Ideology

Parsimonious Model

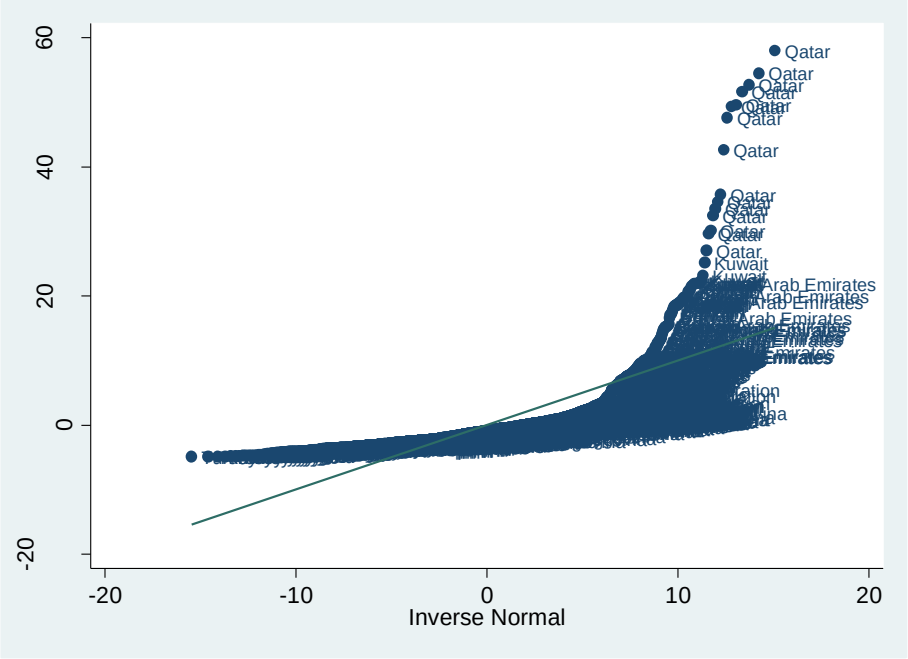
```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (21)  =    1311.08
Prob>chi2 =      0.0000
```

Main Model

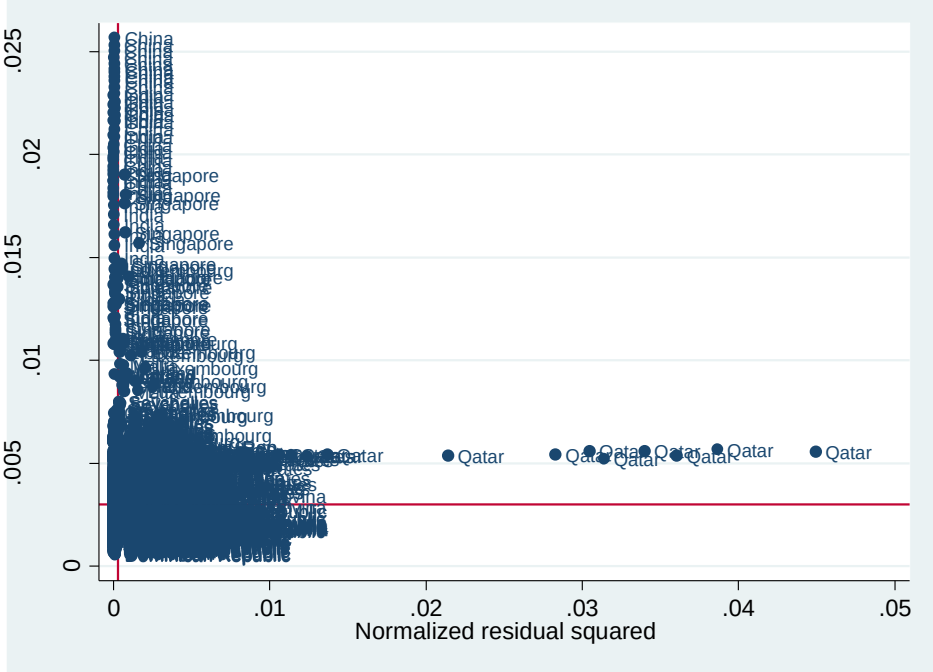
```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (21)  =     523.88
Prob>chi2 =      0.0000
```

Appendix BK

Outlier detection for the Study of Political Regimes

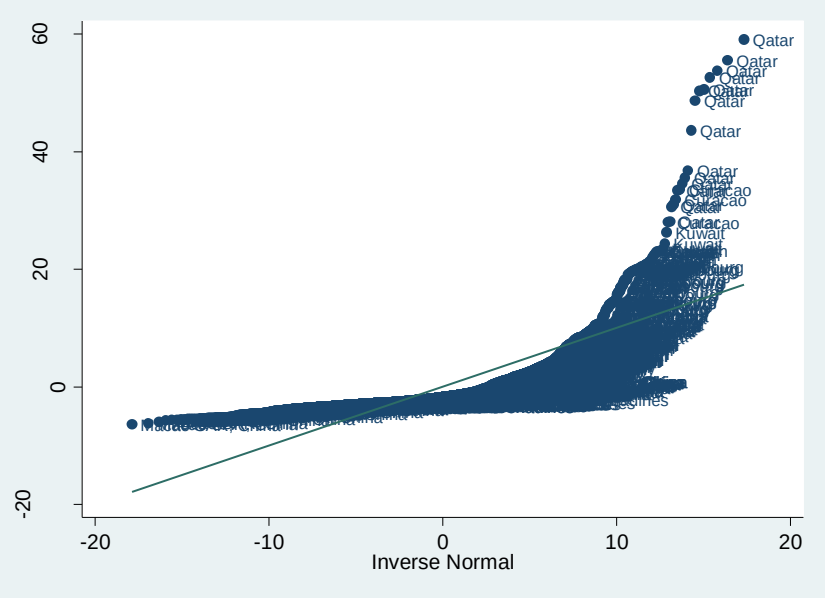


Leverage vs. residual plot

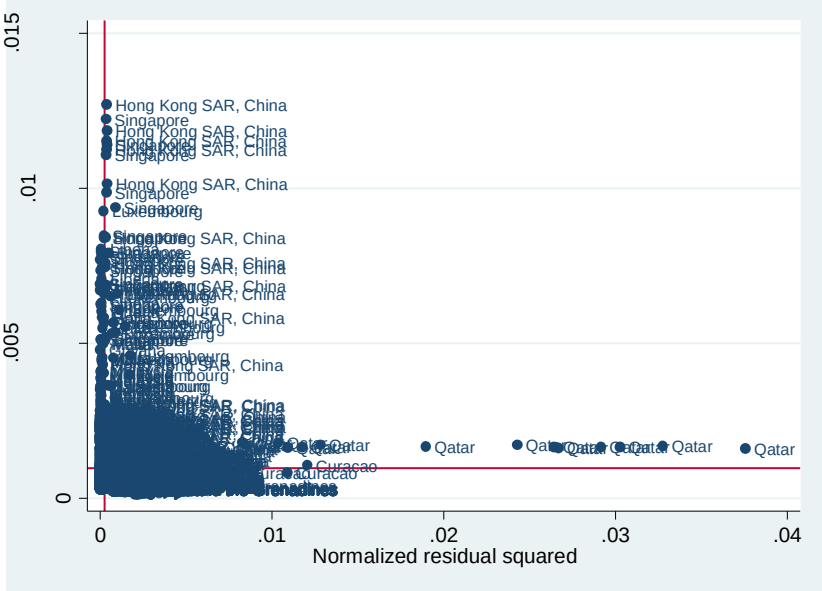


Appendix BL

Outlier detection for the Study of Federalism



Leverage vs residual plot



Appendix BM

Various Parsimonious Model Estimates for the Study of Political Regimes

Table 22: Estimated Variable Impact on CO2 emission per capita for Political Regimes in Parsimonious Model

Variables	*Pooled Cross-sectional OLS With robust*	*Random effects, GLS*	*Panel-corrected standard errors*	*Random-effects GLS with Driscoll-Kraay standard errors*
Democracy	-3.620*** (0.368)	0.332 (0.394)	-0.612** (0.214)	.332 (0.357)
LnGDP per capita	3.598*** (0.088)	2.010*** (0.326)	2.910*** (0.137)	3.626*** (0.077)
Trade (% of GDP)	-0.000 (0.002)	-0.003 (0.003)	0.001 (0.001)	0.001 (0.002)
Population	-	-	-	-
Urbanization (% of total population)	-	-	-	-
Renewable energy cons	-	-	-	-
Forest (% of land area)	-	-	-	-
Annex I	-	-	-	-
Island dummy	-	-	-	-
Latitude	-	-	-	-
Constant	-25.942*** (0.583)	-13.466*** (2.573)	-20.990*** (1.146)	-26.567*** (0.462)
R2	0.607		0.293	0.612
sigma_u	-	3.0123	-	-
sigma_e	-	.91336	-	-
Observations	3,663	3,663	3,663	3,663
Year FE	No	Yes	Yes	Yes
#Country	-	160	160	160

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Table 23: Random Effect Within-Between Estimation for the Relationship between CO2 per capita and Political Regimes in Parsimonious Model				
	Null	**FE**	**RE**	**REWB**
Within-part				
Constant	4.313*** 0.409	-	4.941*** 0.952	1.561 1.742
Democracy	-	0.257 0.252	0.337 0.251	0.367^ 0.201
LnGDP per capita	-	1.517*** -0.124	1.680*** -0.119	1.680*** -0.1
Trade (% of GDP)	-	-0.002^ -0.001	-0.002 -0.001	-0.004*** -0.001
Population	-	-	-	-
Urbanization (% of total population)	-	-	-	-
Renewable energy cons	-	-	-	-
Forest (% of land area)	-	-	-	-
Annex I	-	-	-	-
Island dummy	-	-	-	-
Latitude	-	-	-	-
Between-part				
Democracy	-	-	-	-2.389 1.562
LnGDP per capita	-	-	-	3.506*** -0.251
Trade (% of GDP)	-	-	-	0.005 -0.007
Population	-	-	-	-
Urbanization (% of total population)	-	-	-	-
Renewable energy cons	-	-	-	-
Forest (% of land area)	-	-	-	-
Annex I	-	-	-	-
Island dummy	-	-	-	-
Latitude	-	-	-	-
Level 2: Country				
sigma_u	-	22142.61	-	-
Level 1: Year				
sigma_e	-	-	-	-
Observations	3,663	1,540	1,540	3,663
R2	-	0.164	-	-
#countries	160	67	67	160
Year FE	No	Yes	Yes	Yes

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Table 24: Robustness Check of Various Measures of Democracy for Parsimonious Model

Democracy Measures	***Estimation Strategies***							
	Pooled OLS With robust (1)	**Random effects, GLS (2)**	**Panel-corrected standard errors (3)**	**Random-effects GLS with DK standard errors (4)**	**Fixed effect (5)**	**Random effect (6)**	**Within-part, REWB (7)**	**Between-part, REWB (8)**
Main Model								
V-Dem	-3.620*** (0.368)	0.332 (0.394)	-0.612** (0.214)	0.332 (0.357)	0.257 0.252	0.337 0.251	0.367^ 0.201	-2.389 -1.562
Robustness Check Models								
Polity IV	-0.091*** 0.013	0.008 (0.018)	-0.009 (0.008)	0.008 (0.012)	0.007 (0.009)	0.008 (0.009)	0.007 (0.009)	-0.023 (0.074)
Freedom House	-0.120*** (0.022)	0.030 (0.025)	-0.007 (0.016)	0.037^ (0.023)	0.027 (0.017)	0.028 (0.017)	0.035* (0.017)	-0.174 (0.106)
Democracy Index, EIU	-0.062*** (0.008)	-0.002 (0.008)	-0.039*** (0.009)	-0.002 (0.008)	0.008 (0.006)	-0.001 (0.005)	0.008 (0.006)	-0.073*** (0.014)
Transformation Index (BTI)	-0.583*** (0.087)	-0.091 (0.067)	-0.585*** (0.070)	-	-0.013 (0.062)	-0.085 (0.058)	-0.013 (0.062)	-0.003 (0.062)

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Appendix BN

Various Parsimonious Model Estimates for the Study of Federalism

Table 25: Estimated Variable Impact on CO2 emission per capita for Federalism in Parsimonious Model

Variables	Pooled Cross-sectional OLS With robust	Random effects, GLS	Panel-corrected standard errors	Random-effects GLS with Driscoll-Kraay standard errors
Federalism	1.107*** (-0.191)	1.828^ (-1.026)	1.400** (-0.497)	1.104*** (0.077)
LnGDP per capita	3.164*** (-0.063)	2.023*** (-0.317)	2.797*** (-0.151)	3.187*** (0.064)
Trade (% of GDP)	0.006*** (-0.001)	-0.004 (-0.003)	0.0003 (0.001)	0.007*** (0.001)
Population				
Urbanization (% of total population)				
Renewable energy cons				
Forest (% of land area)				
Annex I				
Island dummy				
Latitude				
Constant	-24.697*** -0.523	-13.512*** -2.602	-20.392*** -1.289	-25.029*** (0.487)
R2	0.572	-	0.221	0.576
sigma_u	-	3.196	-	-
sigma_e	-	1.031	-	-
Observations	3,985	3,985	3,985	3,985
Year FE	No	Yes	Yes	Yes
#Country	-	176	176	176

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Table 26: Random Effect Within-Between Estimation for the Relationship between CO2 per capita and Federalism in Parsimonious Model

	Null	FE	RE	REWB
Within-part				
Constant	4.426*** (0.400)	4.145*** (0.061)	3.984*** (0.316)	1.447 (1.476)
Federalism		-	1.890* (0.861)	-
LnGDP per capita		1.635*** (0.110)	1.926*** (0.101)	1.635*** (0.110)
Trade (% of GDP)		-0.005*** (0.001)	-0.004*** (0.001)	-0.005*** (0.001)
Population	-	-	-	-
Urbanization (% of total population)	-	-	-	-
Renewable energy cons	-	-	-	-
Forest (% of land area)	-	-	-	-
Annex I	-	-	-	-
Island dummy	-	-	-	-
Latitude	-	-	-	-
Between-part				
Federalism	-	-	-	1.385^ (0.797)
LnGDP per capita	-	-	-	3.251*** (0.233)
Trade (% of GDP)	-	-	-	0.011 (0.007)
Population	-	-	-	-
Urbanization (% of total population)	-	-	-	-
Renewable energy cons	-	-	-	-
Forest (% of land area)	-	-	-	-
Annex I	-	-	-	-
Island dummy	-	-	-	-
Latitude	-	-	-	-
Level 2: Country				
sigma_u		4.059		
Level 1: Year				
sigma_e		1.031		
Observations	3,985	3,985	3,985	3,985
R2	-	0.083		
#countries	176	176	176	176
Year FE	No	Yes	Yes	Yes

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Table 27: Robustness Check of Various Measures of Federalism for Parsimonious Model

Democracy Measures	*Estimation Strategies*							
	Pooled OLS With robust (1)	**Random effects, GLS (2)**	**Panel-corrected standard errors (3)**	**Random-effects GLS with DK standard errors (4)**	**Fixed effect (5)**	**Random effect (6)**	**Within-part, REWB (7)**	**Between-part, REWB (8)**
Main Model								
Federalism	1.107*** (0.191)	1.828^ (1.026)	1.400** (0.497)	1.104*** (0.077)	-	1.890* (0.861)	-	1.385^ (0.797)
Robustness Check Models								
Lijphart's Index of Federalism	0.196*** (0.040)	0.394* (0.180)	0.177* (0.082)	0.189*** (0.041)	-	0.413** (-0.14)	-	0.212 (-0.141)
Federalism (author), DPI	0.506** (0.193)	1.154 (1.085)	0.454 (0.560)	0.518*** (0.089)	-	1.135 (1.19)	-	0.058 (1.126)

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Appendix BO

Various Parsimonious Model Estimates for the Study of Political Ideology

Table 28: Estimated Variable Impact on CO2 emission per capita for Political Ideology Data in Parsimonious Model

	Pooled Cross-sectional OLS With robust	*Random effects, generalized least-squares (1)*	*Panel-corrected standard errors (2)*	*GLS random-effects with Driscoll-Kraay standard errors (3)*
Political ideology	-0.044*** (0.006)	-0.003 (0.002)	-0.003 (0.002)	-0.046*** (0.007)
LnGDP per capita	4.877*** (0.630)	4.072*** (1.091)	5.371*** (1.105)	5.633*** (0.907)
Trade (% of GDP)	-0.033*** (0.005)	-0.024^ (0.013)	-0.013** (0.005)	-0.031*** (0.003)
Population	-	-		
Urbanization (% of total population)	-	-		
Renewable energy cons	-	-		
Forest (% of land area)	-	-		
Annex I	-	-		
Island dummy	-	-		
Latitude	-	-		
Constant	-37.977*** (6.420)	-31.215** (10.784)	-45.128*** (11.414)	-45.612*** (9.395)
R2	0.217		0.547	0.251
sigma_u	-	3.283		
sigma_e	-	.704		
Observations	514	514	514	514
Year FE	No	Yes	Yes	Yes
#Country	-	21	21	21

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Table 29: Random Effect Within-Between Estimation for the Relationship between CO2 per capita and Political Ideology in Parsimonious Model

	Null	FE	RE	REWB
Within-part				
Constant	9.501*** (0.805)	8.886*** (0.125)	8.933*** (0.758)	5.790 (8.961)
Political ideology	-	-0.002 (0.002)	-0.003 (0.002)	-0.002 (0.002)
LnGDP per capita	-	4.018*** (0.600)	4.068*** (0.593)	4.018*** (0.600)
Trade (% of GDP)	-	-0.024*** (0.004)	-0.024*** (0.004)	-0.024*** (0.004)
Population	-	-	-	-
Urbanization (% of total population)	-	-	-	-
Renewable energy cons	-	-	-	-
Forest (% of land area)	-	-	-	-
Annex I	-	-	-	-
Island dummy	-	-	-	-
Latitude	-	-	-	-
Between-part				
Political ideology	-	-	-	-0.125** (0.048)
LnGDP per capita	-	-	-	6.003 (3.667)
Trade (% of GDP)	-	-	-	-0.047 (0.029)
Population	-	-	-	-
Urbanization (% of total population)	-	-	-	-
Renewable energy cons	-	-	-	-
Forest (% of land area)	-	-	-	-
Annex I	-	-	-	-
Island dummy	-	-	-	-
Latitude	-	-	-	-
Level 2: Country				
sigma_u				
Level 1: Year				
sigma_e		1.031		
Observations	514	514	514	514
R2	-	0.448		-
#countries	21	21	21	21
Year FE	No	Yes	Yes	Yes

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Table 30: Robustness Check of Various Measures of Political Ideology for Parsimonious Model

Political Ideology Measures	*Estimation Strategies*							
	Pooled OLS With robust (1)	Random effects, GLS (2)	Panel-corrected standard errors (3)	Random-effects GLS with DK standard errors (4)	Fixed effect (5)	Random effect (6)	Within-part, REWB (7)	Betwe en-part, REWB (8)
Main Model								
Swank's Political ideology	-0.044*** (0.006)	-0.003 (0.002)	-0.003 (0.000)	- 0.046*** (0.007)	-0.002 (0.002)	-0.003 (0.002)	-0.002 (0.002)	- 0.125* * (0.048)
Robustness Check Models								
DPI data	0.292*** (0.064)	0.073* (0.032)	0.036 (0.022)	0.073** (0.025)	0.099* ** (0.027)	0.098** * (0.027)	0.073** * (0.020)	0.425 (0.374)
Comparative Political Dataset (CPD)	-0.005*** (0.001)	.0002 (0.0004)	-.0002 (.0003)	- 0.006*** (0.001)	-	-	-	- 0.031* (0.013)

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Appendix BP

Effect of control variables

The study of political regimes

The first study of the dissertation investigates the relationship between political regimes and CO2 emission. In this study, the measures of economic indicator of a country which is typically, GDP per capita in purchasing power parity gives important clue about the relationship between a country's economy and per capita CO2 emission. In summary, it appears that on average, holding all else constant, a one-unit increase in GDP per capita is associated with about a range of 2.7 metric tons of CO2 per capita emission in a year. Interestingly, all the coefficients are statistically significant at 0.001 level. The effect of trade, on the contrary, is mixed and not very influential. The estimate ranges from 0.003 to 0.008. Some estimates appear to be statistically significant and some did not.

The effect of population and urbanization, on average, tend to increase the level of per capita CO2 emission in the country. Most of the estimates are positive and statistically significant at the conventional level. To a different extent, the model includes two other variables which are assumed to reduce the level of CO2 emission. These are renewable energy consumption and forest ratio of the country. These variables exert negative coefficients with the expected direction of relationship and most of the estimates are statistically significant at 0.001 level. In addition, the two dummy variables which are widely used by other researchers e.g., Annex I (if a country enters into the Kyoto agreement receives 1, and 0 otherwise) and small island dummy also show expected direction of relationship. The Annex I countries are typically developed countries. Their economies are stronger- so is their level of production. Thus, as assumed, Annex I shows a positive association with per capita CO2 emission holding other factors constant. But it is not statistically significant. In contrast, as expected, small island dummy demonstrates a negative association with per capita CO2 emission. Because these countries are assumed to be less industrialized and they have fewer options for increased per capita CO2 emission. Finally, the latitude variable also shows a negative sign meaning that a unit increase in absolute latitude tends to show a reduction in per capita CO2 emission level. This parameter, however, is not statistically significant.

The study of federalism

The second study of the dissertation explores the relationship between federalism and CO2 emission. In this study, the GDP per capita (PPP) demonstrates that on average, holding all else constant, a one-unit increase in GDP per capita is associated with about a range of 2.9 metric tons of CO2 per capita emission in a year. Interestingly, all the estimates are statistically significant at 0.001 level. The effect of trade, on the contrary, is mixed and not very influential. The estimate ranges from 0.003 to 0.008. Some estimates appear to be statistically significant and some did not.

The population and urbanization tend to increase the level of per capita CO2 emission in the country. Most of the estimates are positive and statistically significant at the conventional level. The renewable energy consumption and forest ratio variables exert negative coefficients which are in tune with the hypothesized direction and most of the estimates are statistically significant at 0.001 level. Besides, the other dummy variables also show an expected sign in the empirical model.

The study of political ideology

The third study of the dissertation explores the relationship between political ideology and CO2 emission. In this study, if we look at the coefficient estimates of other variables, they suggest important information about the effect of other variables on per capita CO2 emission. Other variables related to economic, demographic, geographic and climatic factors show expected direction of relationship in the model and most of them are statistically significant in the GLS random-effects with Driscoll-Kraay standard errors model which is our major estimate technique of interest.

Most of the covariates in the REWB model reveal expected sign in the model, but not all of the estimates achieve statistical significance. A country's economy, population, and urbanization are associated with more per capita CO2 emission holding all else constant. On the contrary, renewable energy, countries with small island and latitude show a negative association with per capita CO2 emission controlling for other factors.

Appendix BQ

Regression results with and without 'robust' option for the Study of Political Regimes

Parsimonious Model

```
. reg co2pc v2x_polyarchy lngdppc trade if countryname!="Qatar"
```

Source	SS	df	MS	Number of obs =	3663
Model	58145.7367	3	19381.9122	F(3, 3659) =	1882.22
Residual	37678.1502	3659	10.29739	Prob > F =	0.0000
				R-squared =	0.6068
				Adj R-squared =	0.6065
Total	95823.8869	3662	26.1670909	Root MSE =	3.209

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
v2x_polyarchy	-3.620353	.2321711	-15.59	0.000	-4.07555	-3.165155
lngdppc	3.598255	.052679	68.31	0.000	3.494972	3.701538
trade	-.0000304	.0011536	-0.03	0.979	-.0022923	.0022314
_cons	-25.94185	.4070932	-63.72	0.000	-26.74	-25.1437

```
. reg co2pc v2x_polyarchy lngdppc trade if countryname!="Qatar", robust
```

Linear regression

				Number of obs =	3663
				F(3, 3659) =	1163.33
				Prob > F =	0.0000
				R-squared =	0.6068
				Root MSE =	3.209

co2pc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
v2x_polyarchy	-3.620353	.3677558	-9.84	0.000	-4.341379	-2.899326
lngdppc	3.598255	.0876441	41.06	0.000	3.426419	3.770091
trade	-.0000304	.0015583	-0.02	0.984	-.0030857	.0030249
_cons	-25.94185	.5834786	-44.46	0.000	-27.08582	-24.79787

Appendix BR

Regression results with and without 'robust' option for the Study of Political Regimes

Main Model

```
. reg co2pc v2x_polyarchy lngdppc trade pop urban renew forest annexI island latitude if countryname!="Qatar"
```

Source	SS	df	MS		
Model	61588.2826	10	6158.82826	Number of obs	= 3663
Residual	34235.6043	3652	9.37448091	F(10, 3652)	= 656.98
				Prob > F	= 0.0000
Total	95823.8869	3662	26.1670909	R-squared	= 0.6427
				Adj R-squared	= 0.6417
				Root MSE	= 3.0618

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
v2x_polyarchy	-5.065562	.2584967	-19.60	0.000	-5.572374	-4.55875
lngdppc	2.60545	.0947395	27.50	0.000	2.419702	2.791197
trade	.001551	.0011725	1.32	0.186	-.0007479	.0038498
pop	1.00e-09	3.70e-10	2.71	0.007	2.77e-10	1.73e-09
urban	.0322373	.0040973	7.87	0.000	.0242041	.0402706
renew	-.0032514	.0028114	-1.16	0.248	-.0087634	.0022606
forest	-.016537	.0025757	-6.42	0.000	-.0215869	-.0114871
annexI	2.13821	.1799043	11.89	0.000	1.785488	2.490933
island	.8063786	.1537283	5.25	0.000	.5049767	1.10778
latitude	.1831103	.0730331	2.51	0.012	.0399207	.3263
_cons	-18.76975	.8157049	-23.01	0.000	-20.36904	-17.17047

```
. reg co2pc v2x_polyarchy lngdppc trade pop urban renew forest annexI island latitude if countryname!="Qatar", robust
```

Linear regression

Number of obs	= 3663
F(9, 3652)	= .
Prob > F	= .
R-squared	= 0.6427
Root MSE	= 3.0618

co2pc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
v2x_polyarchy	-5.065562	.324094	-15.63	0.000	-5.700985	-4.430139
lngdppc	2.60545	.124968	20.85	0.000	2.360436	2.850464
trade	.001551	.0016714	0.93	0.354	-.001726	.004828
pop	1.00e-09	2.33e-10	4.31	0.000	5.47e-10	1.46e-09
urban	.0322373	.0038388	8.40	0.000	.0247109	.0397638
renew	-.0032514	.0028726	-1.13	0.258	-.0088834	.0023806
forest	-.016537	.0022362	-7.40	0.000	-.0209213	-.0121528
annexI	2.13821	.1947701	10.98	0.000	1.756342	2.520079
island	.8063786	.1802254	4.47	0.000	.4530262	1.159731
latitude	.1831103	.0594434	3.08	0.002	.0665648	.2996559
_cons	-18.76975	1.063658	-17.65	0.000	-20.85518	-16.68433

Appendix BS

Regression results with and without 'robust' option for the Study of Federalism

Parsimonious Model

```
. reg co2pc fedfof lngdppc trade if countryname!="Qatar"
```

Source	SS	df	MS	Number of obs =	3985
Model	63616.9577	3	21205.6526	F(3, 3981) =	1772.43
Residual	47629.4787	3981	11.9641996	Prob > F =	0.0000
				R-squared =	0.5719
				Adj R-squared =	0.5715
Total	111246.436	3984	27.9233023	Root MSE =	3.4589

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fedfof	1.107096	.1703452	6.50	0.000	.7731237	1.441068
lngdppc	3.16353	.0492578	64.22	0.000	3.066958	3.260103
trade	.0062869	.0012476	5.04	0.000	.003841	.0087329
_cons	-24.69684	.418015	-59.08	0.000	-25.51638	-23.87729

```
. reg co2pc fedfof lngdppc trade if countryname!="Qatar", robust
```

Linear regression

Number of obs =	3985		
F(3, 3981) =	958.98		
Prob > F =	0.0000		
R-squared =	0.5719		
Root MSE =	3.4589		

co2pc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
fedfof	1.107096	.1914453	5.78	0.000	.7317557	1.482436
lngdppc	3.16353	.0625017	50.62	0.000	3.040992	3.286069
trade	.0062869	.0014985	4.20	0.000	.003349	.0092249
_cons	-24.69684	.5227121	-47.25	0.000	-25.72165	-23.67203

Appendix BT

Regression results with and without 'robust' option for the Study of Federalism

Main Model

```
. reg co2pc fedfof lngdppc trade pop urban renew forest annexI island latitude if countryname!="Qatar"
```

Source	SS	df	MS	Number of obs =	3985
Model	65569.3517	10	6556.93517	F(10, 3974) =	570.47
Residual	45677.0847	3974	11.4939821	Prob > F =	0.0000
				R-squared =	0.5894
				Adj R-squared =	0.5884
Total	111246.436	3984	27.9233023	Root MSE =	3.3903

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fedfof	.9583966	.1724396	5.56	0.000	.6203183	1.296475
lngdppc	2.792174	.0932031	29.96	0.000	2.609443	2.974904
trade	.0073075	.0012851	5.69	0.000	.0047881	.0098269
pop	7.19e-10	4.17e-10	1.73	0.084	-9.72e-11	1.54e-09
urban	.0143443	.0039751	3.61	0.000	.0065509	.0221377
renew	-.0039557	.0028248	-1.40	0.161	-.0094938	.0015824
forest	-.0273346	.0025122	-10.88	0.000	-.03226	-.0224092
annexI	.6210849	.1757305	3.53	0.000	.2765545	.9656153
island	-.0263241	.1469684	-0.18	0.858	-.3144645	.2618164
latitude	-.1370041	.075536	-1.81	0.070	-.285097	.0110889
_cons	-20.9487	.8100811	-25.86	0.000	-22.53691	-19.36048

.

```
. reg co2pc fedfof lngdppc trade pop urban renew forest annexI island latitude if countryname!="Qatar", robus
> t
```

Linear regression

Number of obs =	3985				
F(9, 3974) =	.				
Prob > F =	.				
R-squared =	0.5894				
Root MSE =	3.3903				

co2pc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
fedfof	.9583966	.1920217	4.99	0.000	.5819264	1.334867
lngdppc	2.792174	.1330128	20.99	0.000	2.531394	3.052954
trade	.0073075	.0016086	4.54	0.000	.0041538	.0104612
pop	7.19e-10	2.44e-10	2.95	0.003	2.42e-10	1.20e-09
urban	.0143443	.0044326	3.24	0.001	.005654	.0230347
renew	-.0039557	.0026572	-1.49	0.137	-.0091652	.0012539
forest	-.0273346	.0029612	-9.23	0.000	-.0331402	-.021529
annexI	.6210849	.2335176	2.66	0.008	.1632594	1.07891
island	-.0263241	.1656302	-0.16	0.874	-.3510522	.2984041
latitude	-.1370041	.0615402	-2.23	0.026	-.2576574	-.0163508
_cons	-20.9487	1.062002	-19.73	0.000	-23.03082	-18.86658

.

Appendix BU

Regression results with and without 'robust' option for the Study of Political Ideology

Parsimonious Model

```
. reg co2pc swank_left lngdppc trade
```

Source	SS	df	MS	Number of obs =	514
Model	1566.35266	3	522.117555	F(3, 510) =	47.07
Residual	5657.42479	510	11.0929898	Prob > F =	0.0000
				R-squared =	0.2168
				Adj R-squared =	0.2122
Total	7223.77745	513	14.0814375	Root MSE =	3.3306

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
swank_left	-.0439101	.0061578	-7.13	0.000	-.0560078	-.0318125
lngdppc	4.877334	.6653439	7.33	0.000	3.570182	6.184486
trade	-.0327819	.0045585	-7.19	0.000	-.0417377	-.0238261
_cons	-37.97744	6.900181	-5.50	0.000	-51.53372	-24.42116

With 'robust' option

```
. reg co2pc swank_left lngdppc trade, robust
```

Linear regression

Number of obs =	514		
F(3, 510) =	37.49		
Prob > F =	0.0000		
R-squared =	0.2168		
Root MSE =	3.3306		

co2pc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
swank_left	-.0439101	.0063664	-6.90	0.000	-.0564178	-.0314025
lngdppc	4.877334	.630271	7.74	0.000	3.639087	6.115581
trade	-.0327819	.004516	-7.26	0.000	-.0416542	-.0239095
_cons	-37.97744	6.420361	-5.92	0.000	-50.59105	-25.36383

Appendix BV

Regression results with and without 'robust' option for the Study of Political Ideology

Main Model

```
. reg co2pc swank_left lngdppc trade pop urban renew forest annexI island latitude
note: annexI omitted because of collinearity
```

Source	SS	df	MS	Number of obs =	514
				F(9, 504) =	37.38
Model	2891.67041	9	321.296712	Prob > F =	0.0000
Residual	4332.10704	504	8.59545048	R-squared =	0.4003
				Adj R-squared =	0.3896
Total	7223.77745	513	14.0814375	Root MSE =	2.9318

co2pc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
swank_left	-.025757	.0059787	-4.31	0.000	-.0375032	-.0140108
lngdppc	2.227061	.7938079	2.81	0.005	.6674804	3.786641
trade	-.015105	.0061595	-2.45	0.015	-.0272065	-.0030036
pop	.0000223	3.38e-06	6.58	0.000	.0000156	.0000289
urban	.0616512	.0161315	3.82	0.000	.029958	.0933445
renew	.0022781	.0142463	0.16	0.873	-.0257113	.0302675
forest	-.0511504	.0094883	-5.39	0.000	-.069792	-.0325088
annexI	0	(omitted)				
island	1.900497	.4392166	4.33	0.000	1.037576	2.763418
latitude	1.770635	.9428259	1.88	0.061	-.0817178	3.622988
_cons	-23.13823	8.133204	-2.84	0.005	-39.11739	-7.159073

With 'robust' option

```
. reg co2pc swank_left lngdppc trade pop urban renew forest annexI island latitude, robust
note: annexI omitted because of collinearity
```

Linear regression

					Number of obs =	514
					F(9, 504) =	61.86
					Prob > F =	0.0000
					R-squared =	0.4003
					Root MSE =	2.9318

co2pc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
swank_left	-.025757	.0065836	-3.91	0.000	-.0386916	-.0128224
lngdppc	2.227061	.7716888	2.89	0.004	.7109374	3.743184
trade	-.015105	.0049622	-3.04	0.002	-.0248541	-.0053559
pop	.0000223	3.49e-06	6.38	0.000	.0000154	.0000291
urban	.0616512	.0103902	5.93	0.000	.0412378	.0820647
renew	.0022781	.0110277	0.21	0.836	-.0193879	.0239441
forest	-.0511504	.0093051	-5.50	0.000	-.069432	-.0328688
annexI	0	(omitted)				
island	1.900497	.28143	6.75	0.000	1.347577	2.453417
latitude	1.770635	1.070979	1.65	0.099	-.3334983	3.874769
_cons	-23.13823	6.749148	-3.43	0.001	-36.39816	-9.878301

Appendix BW

Full Robustness Check Table with Lijphart's Index of Federalism

Table 31: Estimated variable impact on CO2 emission per capita (Lijphart's Index of Federalism)								
Coefficients from OLS and time-series cross-sectional (TSCS) models								
Variables	**Parsimonious Model**				**Main Model**			
	Pooled Cross-sectional OLS With robust	*Random effects, generalized least-squares*	*Panel-corrected standard errors*	*GLS random-effects with Driscoll-Kraay standard errors*	*Pooled OLS With robust*	*Random effects, generalized least-squares*	*Panel-corrected standard errors*	*GLS random-effects with Driscoll-Kraay standard errors*
Federalism (Lijphart's Index)	0.196*** (0.040)	0.394* (0.180)	0.177* (0.082)	0.189*** (0.041)	0.199*** (0.037)	0.197 (0.163)	0.134^ (0.070)	0.193*** (0.022)
LnGDP per capita	3.087*** (0.075)	1.987*** (0.331)	2.804*** (0.159)	3.114*** (0.092)	2.744*** (0.137)	1.584*** (0.365)	2.170*** (0.199)	2.810*** (0.217)
Trade (% of GDP)	0.006*** (0.001)	-0.004 (0.003)	0.000 (0.001)	0.007*** (0.001)	0.008*** (0.002)	-0.004 (0.003)	0.000 (0.001)	0.008*** (0.002)
Population					0.000* (0.000)	-5.86 (1.47)	3.55 (4.11)	6.64* (2.68)
Urbanization (% of total population)					0.014** (0.004)	0.040** (0.014)	0.030** (0.010)	0.014** (0.005)
Renewable energy cons					-0.006* (0.003)	-0.027*** (0.006)	-0.024*** (0.003)	-0.004^ (0.002)
Forest (% of land area)					-0.028*** (0.003)	-0.017 (0.010)	-0.021*** (0.006)	-0.028*** (0.002)
Annex I					0.273 (0.217)	0.921 (0.971)	0.293 (0.492)	0.201 (0.339)
Island dummy					-0.167 (0.162)	0.214 (0.758)	-0.279 (0.419)	-0.173* (0.076)
Latitude					-0.131* (0.061)	-0.008 (0.247)	-0.118 (0.178)	-0.132*** (0.022)
Constant	-24.235*** (0.592) (0.524)	-13.661*** (2.567)	-20.607*** (1.286)	-24.618*** (0.651)	-20.568*** (1.095)	-10.368*** (2.913)	-14.601*** (1.466)	-21.279*** (1.483)
R2	0.572		0.235	0.576	0.590		0.271	0.594
sigma_u	-	3.178	-	-		3.139		
sigma_e	-	1.031	-	-		1.016		
Observations	3,985	3,985	3,985	3,985	3,985	3,985	3,985	3,985
Year FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
#Country	-	176	176	176	-	176	176	176

Note: ^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

Table 32: Estimated variable impact on CO2 emission per capita (Author from DPI2017)

Coefficients from OLS and time-series cross-sectional (TSCS) models								
Variables	**Parsimonious Model**				**Main Model**			
	Pooled Cross-sectional OLS With robust	*Random effects, generalized least-squares*	*Panel-corrected standard errors*	*GLS random-effects with Driscoll-Kraay standard errors*	*Pooled OLS With robust*	*Random effects, generalized least-squares*	*Panel-corrected standard errors*	*GLS random-effects with Driscoll-Kraay standard errors*
Author	0.506** (0.193)	1.154 (1.085)	0.454 (0.560)	0.518*** (0.089)	0.125 (0.218)	0.338 (1.024)	0.120 (0.606)	0.136 (0.181)
LnGDP per capita	3.472*** (0.115)	2.221** (0.677)	3.444*** (0.263)	3.522*** (0.150)	2.423*** (0.222)	1.887* (0.825)	2.461*** (0.431)	2.541*** (0.394)
Trade (% of GDP)	0.007** (0.003)	-0.014^ (0.008)	-0.001 (0.003)	0.008 (0.005)	0.009*** (0.003)	-0.013 (0.008)	-0.001 (0.003)	0.010* (0.005)
Population					1.89*** (4.78)	-1.38 (1.66)	4.87 (9.44)	2.06* (9.92)
Urbanization (% of total population)					0.067*** (0.008)	0.039 (0.028)	0.046** (0.017)	0.067*** (0.014)
Renewable energy cons					0.027*** (0.004)	-0.017^ (0.009)	-0.008^ (0.005)	0.030*** (0.007)
Forest (% of land area)					-0.034*** (0.006)	-0.030 (0.022)	-0.035** (0.013)	-0.034*** (0.006)
Annex I					1.353*** (0.407)	2.018 (2.044)	0.690 (0.968)	1.205* (0.534)
Island dummy					3.783*** (0.491)	3.899 (2.646)	3.258* (1.628)	3.717*** (0.491)
Latitude					0.882*** (0.134)	0.254 (0.519)	0.567 (0.381)	0.930*** (0.088)
Constant	-27.726*** (0.957)	-14.662*** (5.681)	-25.969*** (2.189)	-27.832*** (1.026)	-25.243*** (1.851)	-13.450* (6.441)	-20.292*** (3.534)	-26.055*** (2.308)
R2	0.563		0.275	0.570	0.654		0.327	0.659
sigma_u								
sigma_e								
Observations	1,398	1,398	1,398	1,398	1,398	1,398	1,398	1,398
Year FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
#Country	-	61	61	61	-	61	61	61

^Significant at 10% (p<0.1) *Significant at 5% (p < 0.05). **Significant at 1% (p < 0.01). *** Significant at 0.01% (p < 0.001). Robust standard errors in parentheses.

VITA

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