Institutions and the Environment

Mohammad Salimifar

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Abstract

This thesis empirically investigated the impacts of institutions on the environment. Using the instrumental variable (IV) strategy, the effects of both formal and informal institutions and their interactions were estimated on mitigating the emissions of carbon dioxide across 140 countries over the span of 25 years (1990-2014).

In order to reduce environmental pollution, the conventional collective-action theory calls for an external formal power to monitor and punish people who do not take proper actions. However, there is a lack of sound institutional analysis in empirical studies. There is no consensus among scholars on the efficacy of formal institutions, as both positive and negative effects are documented according to different environmental indicators. In explaining such contradictory results, scholars mainly rely on the risks of free-riding activities that exist in universal collective action problems like mitigating emissions. To minimise free-riding risks, the updated collective action theory introduces reciprocal cooperation, maintaining which depends on virtues, social norms, and high interpersonal trust. With more trust, less protection against and monitoring of free-riding is required. However, the role of informal institutions is broadly ignored in environmental analyses, which indicates the need for empirical testing of the updated theory.

To build strong institutional foundations, I adopted the inclusive SES framework as the conceptual foundation and reshaped it to fit into current cross-country empirical research, taking into account factors such as research questions, focal level of analysis, institutional theories and empirical specifications. In searching the literature for possible estimation techniques suitable for examining the institution-environment nexus, keeping in mind that institutions are inherently endogenous, I noted that the IV strategy has not been employed. Scholars have mainly drawn on simple OLS methods. Data availability is another common issue that I identified in the empirical analyses, especially in the case of poor countries. To rectify the problems and obtain reliable estimations, I constructed a panel dataset and drew on the FE-IV estimator. The proposed empirical specification proved to be compatible with the conceptual framework, cross-country level of analysis, and nature of the institutional and environmental problems.

Nevertheless, existing empirical studies lack proper time-variant instruments for formal and informal institutions. Relying on the current institutional economics literature, I used the

colonial origins of countries as instruments for formal institutions. The instrumental variables were then interacted with time to denote the difference in developmental paths of countries over time, which is caused by having different colonial origins. I further extended the literature by constructing a variable named *distance to conflict zones* for instrumenting the employed measure of trust. This study benefitted from the use of seven different institutional measures, six of which represent formal institutions, including political, legal and economic systems. A new variable, *religious tensions*, was employed for quantifying the level of within-nation trust; compared to the conventional measure, this allowed for far more observations and could be better explained by the constructed instrument.

The thesis carried out the following four empirical studies. First, to test the conventional theory, the impacts of formal institutions were studied. The second study extended current knowledge by incorporating formal and informal institutions into the analysis for the purpose of testing the updated theory. This study represents the main contribution to the existing research. The interaction of institutions was then added to the model specification in the third study. Overall, the results confirmed that carbon emissions are effectively mitigated in countries with stronger formal and informal institutions. The robustness of estimations were further checked in the fourth study, using different estimation techniques (i.e., two-step Sys-GMM), different samples of countries (i.e., resource-rich and resource-poor countries), and different dependent variables (i.e., emissions stemming from different fossil fuels and sectors). The results support the EKC relationship.

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Chapter 1

Introduction

1.1 Research Background

Environmental resources have long been taken for granted and considered to be unlimited. Extracting the resources in order to achieve higher economic growth has led to an increase in environmental degradations at an unprecedented rate. The evidence shows that, since the industrial revolution in the 18th century, significant amounts of pollution, mainly derived from burning fossil fuels, have led to the emergence of global warming. Furthermore, overpopulation and major deforestation have worsened the adverse effects of greenhouse gases (GHGs), resulting in major climatic disruptions at different temporal and spatial scales.

Over the past few decades, environmental challenges have come to be considered as the most pressing and complex issues which cause several severe social-ecological problems globally. The societies most vulnerable to such problems are often the poorest countries that are heavily dependent on exploiting their natural resources for making progress (Arrow et al., 1996). In fact, extreme poverty forces people to put extra pressure on the environment. Therefore, growth must be both inclusive and environmentally sound to reduce poverty and increase prosperity for today's populations and future generations. Strong institutions are the means by which to bring about a more sustained scale of economic activity and efficient allocation of environmental resources, regardless of income levels (P. Dasgupta, 1996).

In September 2015, member countries adopted a set of 17 Sustainable Development Goals (SDGs) as part of the new United Nations agenda to end poverty, protect the planet and ensure prosperity for all. These are intended to be used as a framework for designing new policies for all countries over the next 15 years (2016-2030). In this study, two of these goals are of interest. Goal 13 (climate action), which is placed within the theme of protecting the planet, indicates the need for urgent action to combat climate change and its impacts. Goal number 16 (strong institutions), which is considered as the foundation of this new agenda, highlights the need for building inclusive societies and institutions at all levels.

It is now apparent to almost everyone that the environment should be protected and institutional development has a pivotal role to play (Acheson, 2006). Without effective institutions to limit users ("harvesters"), highly valued common pool resources are overharvested and destroyed (Douai & Montalban, 2012). As highlighted by North (1991), institutions impose constraints on human behaviours and pattern human interactions. They can be divided into two types: formal and informal institutions. Formal institutions are rules of the game (e.g., constitutions, laws, property rights), while informal institutions are social norms, trust and culture (e.g., customs, traditions, codes of conduct).

There is a well-established literature on the impacts of both types of institutions on economic growth and development, using different econometrics methods. For instance, Acemoglu, Johnson, Robinson, and Yared (2008) argued that political institutions play a vital role in shaping economic policies and democracy, when a strong formal political institution, increases GDP by encouraging investment and inducing economic reforms. Also, Nunn and Wantchekon (2011) linked the low developmental outcomes of African countries to their low levels of both interpersonal trust and trust in political institutions. However, regarding environmental sustainability, little is known about the role of countries' institutional capacity (Ali et al., 2019).

The literature on the efficacy of institutions in managing the environment lies within two major groups. The first group of studies relies on the conventional collective action theory, where the role of external formal power is said to be decisive in ensuring that people are taking proper actions for decreasing their environmentally degrading behaviours (Hardin, 1968). Based on this theory, finding long-term solutions is dependent on monitoring and sanctioning systems of formal authorities because it is widely believed that people do not change their behaviours voluntarily. Accordingly, two governance arrangements – privatisation and centralisation – have been frequently prescribed as the only solutions in all types of natural resources. However, the failures of both have been extensively documented.

The second group of studies, however, challenges the standard theory and introduces social and moral norms as fundamental elements in successfully managing the environment. Ostrom (1990) argued that reciprocal cooperation, which tends to appear more in trustworthy societies, can reduce environmental degradations. In global commons, where anyone can easily enter and extract the resource units, only cooperation induced by social and moral norms can efficiently remove the risks of free riding. At the local level, social norms facilitate cooperation among group members. On a broad scale, local social norms may result in substantial universal changes, through spreading among different groups of people over large areas. Therefore, in cases where formal institutions cannot contribute to solving collective problems, good informal institutions such as norms and trust can help to reach desired outcomes (Nyborg, 2018b).

In terms of empirical research, there is a lack of sound institutional analysis in the empirical studies. Regarding formal institutions, the implications of political institutions on environmental performance have not been addressed systematically. There is controversy around the impacts of democracy, as a strong political institution, on the environmental outcomes of countries. For example, Q. Li and Reuveny (2006) claimed that political freedoms are strongly associated with environmental protection, while Midlarsky (1998) stated that democracy is a factor of economic prosperity and, thus, cannot protect the economy. The controversy is even more common regarding the relationship between political institutions and carbon emissions, which is the main indicator of environmental performance in this study.

There is also a paucity of empirical research in terms of the effects of informal institutions on the environment. So far, few empirical studies have been undertaken in which informal institutions proxied by the level of trust indicate positive effects on reducing carbon emissions. As such, this relationship requires further research, especially when the effects of trust are not always predetermined as positive (Tavoni & Levin, 2014). I further propose that even the existing analyses are likely to be biased, mainly due to ignoring issues like the presence of endogeneity embedded in institutions. Therefore, the present study adds considerable value to the existing literature on the relationship between institutions and the environment, in terms of both theory and empirical analysis.

To systematically address the implications of institutions for the environment, the current study includes both formal and informal institutions. In order to estimate their significant effects on carbon dioxide emissions, this study takes account of a broad range of institutional preconditions, including political, legal, economic and social development, and examines the efficacy of each of these in protecting the environment. Therefore, the present study attempts to answer one main question and three sub-questions:

- What are the impacts of formal and informal institutions on carbon dioxide emissions?

In terms of formal institutions:

1. Can well-functioning formal institutions, in terms of constraints on the executive, political freedom, law enforcement, low corruption and property-rights protection, alleviate collective action problems and reduce emissions?

In terms of informal institutions:

2. Does a higher level of within-nation trust facilitate cooperation for improving air quality?

In terms of the interaction of formal and informal institutions:

3. If institutions are interdependent, then how do formal institutions react in different informal institutional contexts? If institutions are independent, then which types of institutions consistently promote cross-country environmental performance?

Based on the above questions, three research hypotheses are specified as follows:

- H1: High quality of formal institutions has a significant and positive impact on curbing emissions.
- H2: High quality of informal institutions play a positive role in mitigating emissions and improving air quality.
- H3: High quality of formal institutions complements the positive effects of good informal institutions on environmental sustainability, and vice versa.

In order to methodically address the above questions, first, the inclusive social-ecological systems (SES) framework (Ostrom, 2007, 2009) is taken as a conceptual basis for identifying influential variables, constructing quantitative models and analysing the results. Subsequently, different statistical techniques in panel data models are utilised. Since the focus of this study is on institutional heterogeneities across different nations, the selected econometric approach should fit the innate characteristics of institutions and the focal level of analysis. Given that institutions are endogenous across countries, the estimation method of fixed-effects instrumental variables (FE-IV) can produce reliable estimations; hence, it is applied as the main econometric approach in this study.

Moreover, as a robustness check, the generalised method of moments (GMM) is also employed to further test the sensitivity of the results obtained on institutions. This type of estimation is suitable because it takes into consideration the dynamism that lies in the analysis of environmental degradations. Further, random-effects and fixed-effects OLS are also implemented for indicating the validity of the results. All the empirical analyses are conducted on a cross-sectional time-series dataset based on the maximum available number of countries and years. Hence, a panel dataset comprises a comprehensive set of 140 countries worldwide studied over 26 years, from 1990 to 2015.

1.2 Significance and Contributions

Access to environmental resources can result in different outcomes for different countries that might be rooted in their political, legal, economic and socio-cultural institutions. Thus, studying the reasons behind the cases of success and failure is of utmost importance. However, empirical analyses in environmental economics studies lack a sound institutional foundation. Therefore, the present cross-country empirical research attempts to rectify this problem by estimating the impacts of both formal (e.g., the concentration of political power) and informal institutions (e.g., the level of trust) and their interactions on reducing the concentration of greenhouse gases (e.g., CO_2 emissions) across 140 countries between the years 1990 and 2015.

This is the first study to examine the effects of both formal and informal institutions and their interactions on the environmental sustainability of countries. So far, the existing literature has mainly concentrated on the effects of formal institutions on environmental performance. However, the implications of political institutions, as the key formal institutions, have not been addressed sufficiently; there are ambiguous findings regarding the relationship between democratic institutions and carbon emissions, which needs further clarifications. In this study, I try to improve this area by employing six different measures of formal institutions, encompassing the three aspects: political, legal and economic institutions. The consistency of estimations is further tested across several multiple regression models. Therefore, the findings of this research provide further insights into the relationship between formal institutions and the environment.

In addition, the main goal of this study is to empirically analyse informal institutions, an area that remains underdeveloped in environmental economics literature. Previous research has neglected the role of trust in increasing cooperation, lessening free-riding risk and, thus, in reducing pollution. Studies usually build their argument on the effects of formal institutions only. In this study, however, I try to extend the current literature by including trust as an indicator for informal institutions and estimate its impact on reducing emissions. This significant contribution of the present research is further enhanced by the inclusion of a new variable for measuring trust. Instead of drawing on the conventional measure, the new variable focuses on the effects of social tensions arising from ethnoreligious fractionalisation on emissions reduction. The social tensions variable offers a higher number of observations per year, and thus improves the estimations related to this variable and the analysis as a whole. This inclusion is in line with the updated collective action theory.

Furthermore, the present study considers both types of institutions as endogenous to countries because they are substantially largely determined by socio-cultural, historical and geographical preconditions. For solving the issue of endogeneity, the choice of the econometric approaches is limited to adopting the instrumental variable (IV) strategy in this study. While it is a standard method for estimating the effects of institutions in the economic literature, existing empirical research in environmental economics studies has mainly drawn on simple estimations such as cross-sectional, random-effects and fixed-effects OLS. This indicates severe model misspecification, which is caused by ignoring the possibility of endogeneity. Therefore, this study is the first cross-country empirical research into the environment that benefits from using the FE-IV technique. The robustness of estimations will be further checked by the dynamic system-GMM model, which is useful for considering the inherent dynamism in environmental analysis.

Now that the use of FE-IV estimation technique has been determined, it should be noted that the presence of the fixed-effects estimator requires using a time-variant instrument for both types of institutions. Unlike for formal ones, there is no appropriate instrument for identifying an exogenous source of variations for informal institutions. This further explains the lack of IV estimations in this field. Since obtaining a time-variant instrument is a difficult task, researchers have focused mainly on using other types of estimations such as cross-sectional analysis, which has dominated empirical analysis in this field. Therefore, for the first time in this field, I construct an instrumental variable named *distance to conflict zones*, for instrumenting informal institutions. This instrument, which is later shown to be successfully implemented by the identification tests, enables me to discuss institutions in more detail.

The employed sample for this study represents another research contribution. The unavailability of cross-sectional time-series data for most of the environmental indicators, especially for the poor countries, has also contributed to the literature on the institution-environment relationship being dominated by cross-sectional analysis. Hence, the estimations are more likely to be biased, as they only provide a snapshot of the situation at a single point in time. In fact, environmental databases, compared to the economic ones, are underdeveloped in terms of offering annual cross-country indicators. This makes building a panel dataset challenging. However, concerning the employed variables, I compile a longitudinal dataset consisting of the maximum available number of countries and years.

The employed sample is divided into two categories of resource-dependent and non-resource-dependent countries. Since most of the resource-dependent countries suffer from major institutional deficits, it is interesting to examine the differences in the institution-environment relationship across these countries. While current empirical studies have focused mainly on advanced economies (i.e., development stage) or high- and low-income countries (ranges of income) in a particular region (e.g., Europe, Latin America, Asia), there is not a single empirical work examining this relationship on a sample of resource-rich countries. Therefore, this study is one of the first attempt to conduct a comparative analysis between the institutional differences among resource-rich and –poor countries.

Finally, yet importantly, this is the first cross-country empirical research that SES framework as the theoretical foundation. The most comprehensive SES framework is capable of solving all challenges embedded in the analysis of the institutions and environment. It is a complex multilevel nested framework that is composed of several internal deeper-level variables useful for finding causes and effects of resource destructions. So far, it has been mainly used for conducting qualitative case studies in micro-scale. However, in this study, the framework is reshaped to fit into this macro level empirical analysis. It is mainly is used for identifying influential variables, building quantitative models and analysing the results. A detailed survey of the adjustments made to this framework is then prepared, which can be useful for further empirical research in this field. Indeed, the present study appears to be the first study to empirically investigate the impacts of institutions on the environment, using the SES framework.

1.3 Thesis Outline

The thesis is organised into five chapters. The chapter herein (Chapter 1 Introduction) introduced the importance of the topic, gave a brief review, identified the research gap, presented the aim, research questions and hypotheses, discussed the research method and signalled the major contributions of the study. The second chapter is the literature review. It is divided into two main parts. The first part is allocated to reviewing the related literature on collective action theory and the role of formal and informal institutions in managing long-standing environmental dilemmas. The second part begins with introducing the SES framework, its core sub-systems and their internal second-tier variables. It is then followed by a detailed survey covering the extensive adjustments that are required for adapting the framework for this cross-country empirical analysis. In this process, I rely on the focal level of analysis, the selected resource system, institutional theories and empirical specifications.

Chapter 3 sets out the methodology: the empirical model and statistical approaches required for estimating the institution-environment relationship are specified. To that aim, first, a basic equation is defined based on the selected second-tier variables from the SES framework. Building on the pros and cons of using each econometric approach suggested by previous research, the second part searches for possible empirical methods suitable for investigating the institution-environment relationship. In this part, several alternative panel estimation methods, including OLS, fixed-effects OLS, fixed-effects IV and system-GMM are discussed as useful for estimating the baseline regression model. The main issues regarding specification design are discussed in the third part. Finally, data and variables required for estimating the equation are provided in the last part. The studied sample is described here as well.

Chapter 4 discusses the results related to the impacts of formal and informal institutions on carbon emissions in the four key studies. The first study evaluates the efficacy of formal institutions for the purpose of testing the conventional collective action theory. The second study extends the current knowledge by incorporating both formal and informal institutions into the analysis for the purpose of testing the updated collective action theory. The interaction of institutions is then added in the third study to further test for the complementary or substitutionary effects of formal and informal institutions. The fourth study further checks the robustness of estimations obtained in the first three studies by a different estimation technique (system GMM), a different sample of countries (resource-dependent vs non-resource-dependent countries) and different fossil fuels and sectors to explores the heterogeneities in the institution-environment relationship.

Finally, Chapter 5, the conclusion, summarises the main areas covered in the thesis, highlights the main findings and policy implications.

Chapter 2

Literature Review

2.1 Introduction

This chapter is divided into two main parts. The first part is devoted to reviewing related literature on the significant role of formal and informal institutions in managing long-standing environmental dilemmas. Initially, the causes and effects of severe environmental issues and the nature of such social and ecological systems are covered. Next, the traditional collective action theory is discussed, followed by the embedded attributes of the global commons. Subsequently, the missing part in the traditional belief is updated by introducing social norms into collective action theory. Finally, for delving deeper into the governance area, relevant research on the appropriate institutional structure, concerning formal and informal institutions in governing the environment at local, national and global scales, are discussed.

For systematically addressing the research questions, a conceptual framework is required. Thus, the second main part begins with introducing an inclusive framework, capable of solving the challenges embedded in the analysis of institutions and the environment. This complex framework, however, requires adjustments in order to be utilised and fitted into this research. Therefore, a substantial part of this section is dedicated to explaining how the framework is adapted in order to provide the required theoretical and empirical foundations for analysing the research questions. In this process, I rely on the focal level of analysis, the selected resource system, institutional theories and empirical specifications. Indeed, adopting this framework for empirical purposes is one of the significant contributions of this study. Finally, this chapter concludes with a discussion on the novelty of this research.

2.2 Climate Change, Global Warming and Greenhouse Gas Effects

Since the late 20th century, environmental challenges have come to be considered as the most pressing and complex problems worldwide. The issue of climate change causes several severe ecological, social and economic problems; for instance, it intensifies poverty and inequality within and across countries.[1] As the world's stock of greenhouse gases (GHGs) is constantly increasing, their extreme adverse effects are aggravating the problems and are likely to threaten human existence eventually. Hence, a large and growing body of environmental economics literature has investigated the causes and effects of the global environmental commons' problems over the past decades (Carattini, Levin, & Tavoni, 2019; Holling, Berkes, & Folke, 1998; Kinzig et al., 2013; Levin, 1999; Milinski, Semmann, & Krambeck, 2002; Ostrom, 1990, 2000, 2009; Poteete, Janssen, & Ostrom, 2010; Tavoni & Levin, 2014).

The evidence shows that, since the industrial revolution, anthropogenic causes such as overpopulation, overexploitation of natural resources and higher levels of pollution, have led to the emergence of global warming (IPCC, 2013). Since then, a significant amount of harmful gasses, including carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NO_x) and methane (CH_4) emitted from the production and consumption of fossil fuels, power plants, industries and livestock, have been polluting the air (Ostrom, 2010a). These polluting-intensive activities largely disrupt the earth's atmosphere, increase the temperature, and thus lead to global warming.[2]

Worsening greenhouse gas effects eventually result in the collapse of many social-ecological systems operating at different temporal and spatial scales. For instance, extreme climate disruptions (e.g., frequent intense storms, heavy floods and longer droughts), accelerated ice sheet melt (such as in Greenland and Antarctica) and sea-level rise, extinction of different inhabitants (i.e., loss of biodiversity), emerging diseases (e.g., lung cancer) and reduction of global GDP by 5% to 20% (Wagner & Weitzman, 2016), are some of the negative consequences of global warming.

In addition, the substantial rate of deforestation (e.g., cutting down ancient tropical forests in Malaysia and Amazon for agricultural purposes) increases the effects of global warming through releasing more carbon (that has been held locked up in their tissue) to the atmosphere (Ostrom, 2010a). In fact, deforestation amplifies the harmful effects of atmospheric GHGs

[1] These two global issues are claimed to be the most pressing problems of the century (Carattini, Gosnell, & Tavoni, 2020).

[2] During the last century, ecosystems have been degraded faster relative to any other periods in history, resulting in increased possibilities of their nonlinear collapse and lower expected benefits (i.e., poverty) for future generations (Millennium Ecosystem Assessment, 2005).

concentration on the weather, oceans, natural habitats, food sources and human health. Although the effects of global warming are universal, its roots are local, highlighting the role and responsibility of each individual person in emitting pollution.

In sufficiently large open-access resources, where any person can easily enter and harvest potential benefits, the benefits cannot be restricted to those who strive for conservation. When available resource units decrease (through, for example, releasing pollutants into the atmosphere), the benefits that might be enjoyed by conservators are taken away (Ostrom, 2008). Therefore, to solve the dilemma of global warming, it is expected that many actors at different levels make the required decisions and change their daily activities (e.g., personal transport pattern) in favour of the environment (Ostrom, 2010a).

2.3 Collective Action Theory

There are two important strands of literature that deal with issues embedded in managing collective goods. The first group of studies emphasise the role of external formal power in ensuring that proper actions are taken by individuals to reduce their environmentally degrading behaviours (Hardin, 1968; Olson, 1965). The second category challenges the standard economic theory of collective action and introduces social and moral norms as fundamental elements in successfully managing the environment (Ostrom, 1990, 2000, 2010a). In the following sections, both strands of studies will be reviewed carefully.

2.3.1 Traditional Collective Action Theory

The traditional collective action theory in environmental conservation was initiated with Hardin (1968) seminal work *The Tragedy of the Commons*, in which the presence of external power is shown to be essential in avoiding environmental tragedies. The traditional theory assumed that finding long-term solutions for decreasing environmental degradations, such as a reduction in carbon emissions and energy wastages, is only dependent on the existence of an external formal power to monitor people's behaviours and impose sanctions on those who do not take proper actions. It continues to be widely believed that people do not change their behaviours voluntarily (Ostrom, 2010a). Accordingly, three management structures have been recommended for maintaining natural resources.

Some authors, including Lovejoy (2006) and Terborgh (2000), suggested the imposition of *(i)* government ownership for managing natural resources. They argue that conservation is achievable if only the central government set and support environmental goals through the imposition of law. Others, including Demsetz (1974), emphasised the system of *(ii)* private-property rights as the only method for avoiding the tragedy of the commons because it provides enough economic incentives for owners to maintain the resources sustainably.[3] Also, it has been observed that some communities were thriving in managing their resources (e.g., fisheries, forests, etc.) by establishing robust local institutions. Therefore, *(iii)* common property management, which is dependent on the capacity of local communities and their members in developing sustainable resource governance, has been proposed as the third type of ownership (Ostrom, 2008, 2012b).

Based on the traditional theory, establishing a formal governance system is considered as the first mandatory action. Thus, a large body of literature has concentrated on the adoption of any one of the mentioned governance regimes as a single solution (or a "one-size-fits-all" recommendation as Ostrom (2008) stated). For example, the first two governance regimes (public and private ownerships) are frequently prescribed as effective systems for governing natural resources (Hardin, 1968; Olson, 1965), yet failed and successful examples of implementing each of them have also been recorded extensively (Ostrom, 2012b; Ostrom & Cox, 2010). Therefore, there is no such thing as a single solution (a panacea) that can be proposed for all types of natural resources[4] because the same rules that fit well in one setting may not succeed in another.

In line with the traditional theory, some research found solutions to devise required policies for stopping degradations only in regional and global institutional arrangements. Despite some successful examples of unilateral climate policy[5], there is very little support for the efficacy of

[3] When one does not possess a resource, s/he has no long-term interests in conservation and cannot act favourably toward its sustainability, therefore causing destruction.

[4] A panacea is built on two false assumptions. First, all environmental problems such as air pollution or biodiversity are assumed to be comparable, while they are entirely different from each another. Second, individuals involved in different commons have the same preferences, enough information and equal power to act, while their behaviours when facing the same situation vary considerably. These are implicitly reflected in Scott Gordon (1954) model, which has been used for decades for explaining the overexploitation of CPRs Gordon (1954).

[5] For example, the European Union has continued to implement climate mitigation policies (known as the European Trading Scheme) since the late 1990s, despite the US withdrawal from the Kyoto Protocol in 2001 (see Calel and Dechezlepretre (2016)). Also, Scandinavian countries and the Netherlands unilaterally introduced a carbon tax in 1995 (before the Kyoto treaty). Such mitigation policies successfully reduced emissions and encouraged technological innovations across the EU region (see Aklin and Mildenberger (2020).

such individual actions in the literature (Helland, Hovi, & Sælen, 2018).[6] By focusing on the global public good nature of global warming, Almer and Winkler (2017), McLean and Stone (2012) and Skodvin and Andresen (2006) concluded that the EU's efforts in saving the Kyoto protocol after the US withdrawal had minimal effects on the climate mitigation process; hence, a universally enforceable treaty is required for tackling this tragedy. However, little consensus around such a treaty has been reached by all countries as a result,[7] due to the presence of two significant concerns; the monitoring of, and punishments for, cheaters.[8]

2.3.2 The Characteristics of Common Pool Resources (CPRs)

The fact that all three of the abovementioned governance systems have been fully or partly unsuccessful in reducing environmental pollution across countries is due mainly to the problematic characteristics of CPRs. There is a relatively large body of literature concerned with the presence of free-riding risks resulting from non-excludable benefits that are innately embedded in environmental goods (Bernauer, 2013; Carattini et al., 2019; Keohane & Victor, 2016; Nordhaus, 2015; Ostrom, 2010a, 2016; Weitzman, 2017). These studies attributed the failure of mitigating emissions to the traditional collective action theory, through which the risk of free riding on the costly efforts of others has not been addressed adequately.

Global warming, cumulatively, stemmed from polluting activities done by millions of people worldwide. Each of us at multiple scales has been contributing to this tragedy to various extents. At the same time, however, the comparatively smaller number of people, firms or state governments that have been reducing emissions benefit a larger portion of society. Undoubtedly, there are always some members in every community that do not contribute at all or at an appropriate level to avoid this tragedy. This opportunistic behaviour results from the resources' non-excludable benefits, through which individuals become incentivised to free ride

[6] By using a two-country model, Hoel (1991) showed that a country would not be induced to follow the leader (the first country) to abate its pollution. This result is also supported by Buchholz, Haslbeck, and Sandler (1998).

[7] So far, only two significant international treaties have been introduced to decarbonise the economies. First, the Kyoto Protocol, which is a climatic agreement ratified by more than 190 countries in December 1997. Another ambitious deal was struck at the Conference of the Parties (COP) in December 2015. It is known as the Paris Agreement. The target of this agreement is fostering sufficient emission abatement to limit global warming to below 2°C.

[8] Even with an international agreement, a transition to a carbon-free economy might not be achieved if uncertainty remains around the extent of current emissions reduction and the level of different countries' responsibilities for mitigating previous emissions, and if no consensus is achieved on the potential instruments for curbing pollution globally (see Ostrom (2016) and Tavoni and Levin (2014). Furthermore, the withdrawal of major polluters such as the US, China and EU countries as pivotal actors in international agreements will crumble the efficacy of treaties.

on the efforts of (trustworthy) people who invest a great deal of time and energy in abating their polluting activities.

In addition, the asymmetric costs and benefits of implementing climatic policies is another factor preventing all individuals from cooperating to achieve a common goal (Aklin & Mildenberger, 2020; Ostrom, 2016). Apart from the presence of free-riding behaviour (i.e., cheating), because of which only one (or a few) individuals might end up bearing the costs of mitigation, the uneven distribution of adverse greenhouse gas effects brings about inadequate local and regional efforts. The produced GHGs, while spread over the atmosphere more or less equally, unevenly influence people and regions by their geographical, ecological and economic conditions. Therefore, individuals ranging from local people to central governments always have enough incentives to misuse their power and excessively exploit this global common in their favour.[9]

Furthermore, contemporary efforts for mitigating pollution can be enjoyed by future generations as this process (i.e., reducing pollution) happens slowly over a long period of time (Carattini et al., 2019). Therefore, a temporal externality is involved in this situation. However, nations would also like to avoid global warming's detrimental effects and care about (or at least show off their good intentions in) reducing their emissions because such open access resources will no longer be provided if everyone behaves like this. As previously mentioned, some countries have been adopting climatic policies to reduce their emissions, regardless of the presence of external power (in contrast with standard theory) and behaviours of other countries (Carattini & Jo, 2018).[10]

Consequently, if the concerns of externalities, asymmetric costs and benefits and, above all, free-riding risks involved in the global commons are effectively addressed, different parts of society are willing to cooperate to be better off. As in the classical Prisoners' Dilemma game, when two players both decide to cooperate, they achieve optimal outcome relative to a situation where they both prefer to follow the opposing strategy (cheating) (Aklin & Mildenberger, 2020). However, in the context of climate change and emissions mitigations, since the

[9] Cost of climate mitigation for developing nations is relatively higher; hence some of them may not benefit from cutting their GHGs emissions.

[10] The European Union aims at reducing 40% of its emitted GHGs by 2030 relative to the level in the 1990s. The region-wide plan is to continue abatement to 80-95% by 2050. In particular, Norway tries to be a carbon-free economy by 2030.

likelihood of cheating is high even in the presence of formal authority, incentivising individuals to cooperate consistently is still challenging, turning this social problem into the hardest dilemma of all time.

2.3.3 Updated Collective Action Theory

So far, the traditional collective action theory, and, more specifically, Hardin's (1968) prediction on the overexploitation of natural resources in the absence of external power, is considered as the fundamental model for explaining individuals' free-riding behaviours. However, the outcomes of different studies on common pool resources have challenged the standard economic theory of collective action.[11] In the updated version of the traditional collective action theory, it is argued that individuals would invest a great deal of time and energy to address such collective issues, regardless of the presence of any external power (Ostrom, 1990, 2000, 2010a).

In contrast with the traditional theory, in which sustainable use of CPRs through cooperation is claimed to be unlikely, Ostrom (1990) built the updated theory on the foundation of cooperation. From an economic perspective, cooperation runs against what rationality theory[12] suggests about individuals. As Ostrom (2000) stated, cooperation is a facet of human behaviour yet appears in standard economic models as an anomaly which is difficult for them to explain. This is a position also taken up by Sen (1977). He challenged the logic behind self-interested rationality as the sole principle of human behaviour and argued that people might be more sophisticated than the theory predicted, as cooperation occurs in the real world. Further, Dawes and Thaler (1988), by providing evidence of cooperative behaviours, claimed that cooperation cannot be predicted by the rationality theory. These studies suggest that individuals are enabled to remove the free-riding risks in social dilemmas by adopting cooperative behaviours.

In a similar vein, Buchanan (1967) stated that a person increases his/her contributions toward environmental conservation if their fellow citizen (or neighbour) responds with cooperation. Carattini et al. (2019) refer to this process as conditional cooperation, meaning that people behave reciprocally. Even in an anonymous setting, cooperation is conditional upon the extent

[11] Self-governed CPRs regimes often outperform formal ones.

[12] The term *homo economicus* holds that individuals are rational and selfish beings who pursue their objectives, including maximization of utility (by consumers) and profits (by producers). These purely self-interested subjects do not participate in public good games (see Helland et al. (2018)).

to which other participants are willing to contribute to public goods (Chaudhuri, 2011). Ostrom (2010a) also focused on the concept of reciprocal cooperation and claimed that cooperation will be observed in the global commons if individuals reciprocate. She based this on the evidence provided by a number of local communities that successfully organised and collectively engaged in mitigating climate change.

The major problem, however, is sustaining cooperation, which is particularly crucial for lessening the likelihood of individuals' free-riding activities. Ostrom (1990) proved that if individuals trust each other, then the positive outcomes derived from cooperation will be sustained. Whenever people are capable of building a setting where a high level of trust can be developed, proenvironmental actions will be taken without the presence of an external authority to devise rules, monitor behaviours and impose sanctions. This proposal is supported by Carattini et al. (2019). They highlighted the significant role of trust in the updated version of the theory and further discussed how individuals (referred to as *conditional co-operators*) are likely to cooperate and reciprocate as long as they believe others (e.g., neighbours, colleagues and citizens) are trustworthy and contribute to the same extent.

Therefore, as can be seen, in cases where formal institutions cannot help in solving collective problems, good informal institutions such as social norms and trust enable us to reach desired environmental outcomes (Nyborg, 2018b; Nyborg et al., 2016). For that reason, more recent attention has been paid to the provision of informal institutions as effective factors in mitigating global warming (Spencer, Carattini, & Howarth, 2019). For instance, a large body of literature on the updated theory has focused on the role of cooperation in governing commons at the local scale, where involved actors know about each other and can monitor behaviours (Dixit, Levin, & Rubenstein, 2013; Milinski et al., 2002; Ostrom, 1990; Ostrom & Ahn, 2003; Poteete et al., 2010). As Dixit (2004) and Tabellini (2008) discussed, cooperation is easily sustained in a small group of people who are closely connected. This is because information about cheating is highly likely to reach members nearby, and thus easily damage the perpetrator's reputation.[13]

At the local level, social norms facilitate cooperation among group members. On a broad scale, local social norms may result in substantial universal changes. They can spread across different groups of people over large areas, and thus alter a wide range of behaviours. They can help to

[13] It can be drawn from these studies that the likelihood of cooperation decreases as the distance between individuals increases, hence, making it challenging to explain global cooperation.

transform vicious behaviours into virtuous ones, for example, smoking bans in public, racial and gender inequity and overconsumption (Nyborg, 2018b; Nyborg et al., 2016).[14] In a given context, norms can help individuals to choose proper behaviours, and following such norms can lead to gaining the reputation of "being trustworthy" amongst fellow citizens. This status is important for individuals, as it becomes their self-image. Trustworthy individuals are willing to contribute voluntarily. In societies filled with trustworthy reciprocators, a high level of cooperation is expected; hence, global warming is likely to be avoided (Carattini et al., 2019).

Individuals care about others' decisions and are willing to adopt new environment-friendly behaviours and technologies (e.g., installation of solar panels and purchasing fuel-efficient cars) if enough of their peers have adopted such behaviours.[15] Hence, when more people are encouraged to engage in cooperative actions, collective goals are likely to be achieved (Carattini et al., 2020). In this way, social interactions help to disseminate virtuous behaviours, and the speed of dissemination depends on the strength of social links. Hence, the more easily good deeds are distributed, the better the cooperation is supported (Tavoni & Levin, 2014). Therefore, social interaction is central to solving resource management issues (Ostrom, 1990).

Consequently, human behaviour is driven by more than self-interest because human choice, which is a social phenomenon, can be substantially affected by social norms (Tavoni & Levin, 2014). Social norms and generated trust facilitate cooperative outcomes, even if there are imperfect information and incomplete contracts (Algan & Cahuc, 2013). Hence, cooperative behaviour, which can further replace enforced formal contracts (Chandrasekhar, Kinnan, & Larreguy, 2018), exists between humans and resource extraction. The key to successful cases of cooperation is trust between involved parties or the capability of gaining a reputation for being trustworthy. Overall, as opposed to what Hardin (1968) predicted, environmental sustainability is embedded in ethical considerations.

2.3.4 Need for Governance: Multilevel Institutional Structure

In order to decarbonise economies, cooperation at multiple scales is required because solutions to global dilemmas involve interactions among individuals, communities, private firms, public

[14] Key drivers of adopting virtuous norms are internal motivation, social pressure (Spencer et al., 2019), the prevalence of conditional cooperation and learning through observing others' behaviours (Nyborg et al., 2016).

[15] Empirical evidence suggests that local social norms matter for the adoption of green behaviours as nearby individuals can learn about existing proenvironmental behaviours through observation (see Spencer et al. (2019).

organisations and state governments, indicating that both formal and informal institutions are fundamentally required to achieve sustainability in the long-term. As previously discussed, the existing research mainly has focused on formal institutions (e.g., property rights and rules and regulations) and market-based policy instruments. However, Ostrom (2000) argued that, while the traditional approach of neoclassical economics is highly useful for a range of purposes, cooperation (facilitated by social norms) is required for successfully managing the commons in the absence of external enforcement.

Consequently, for managing the global commons, a complex arrangement of multiple governance regimes (the interaction of local and central state institutional structures) must be adopted. For instance, to successfully reduce emissions at the global level, an enforced platform is needed, through which nations can cooperate to establish effective monitoring rules and sanctions on those who rely on other countries' mitigation efforts (free-riders).[16] At the national level, depending on the settings, each of the extremes of centralisation, privatisation or decentralisation ownership, individually or jointly, can be implemented. For instance, several resources are now co-managed by combining government and private ownership, or by governments and locals together.[17] In addition, at the local level, empirical evidence suggests that people tend to follow social norms as they facilitate cooperative behaviours and the adoption of green technologies.

Hence, to achieve sustainable ecological outcomes, a proper governance system that contains formal and informal institutions is needed for improving the level of monitoring, learning, adaptation, trust and cooperation. Ostrom (2010a) referred to this arrangement as a *polycentric* governance regime. In this system, small- and medium-scale units have major roles to play, through which cooperation among several authorities at different scales is enhanced. For instance, within a specific domain (e.g., household, firm, local and national governments),[18] each unit has independent power to devise rules and norms, and, within each unit, users have

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[16] This requires a mechanism, through which every state can remain informed about whether others will play their part. See Aklin and Mildenberger (2020). If there is no international enforceable treaty, such that cooperation is no longer guaranteed, states will no longer make efforts to reduce their share of pollution, due to a relative loss of competitiveness in their industries. See Carattini et al. (2019).

[17] Even in a particular setting, all forms of governance may be appropriate for sustaining a resource. In fact, as a long-term solution, national efforts need to be supported by unified global efforts.

[18] Within a household, decisions on the means of transportation, purchasing fuel-efficient cars, recycling waste and reducing energy use by investing more in renewables (solar panels) will impact the amount of atmospheric GHGs. In the US, firms, including government offices, are responsible for more than 70% of electricity consumption and 40% of GHGs emissions, indicating the significance of their decisions on emissions levels.

the advantage of using local knowledge and learning from others' trial and error processes (Ostrom, 2016).

Ostrom and Cox (2010) argued that contemporary environmental problems are likely to be handled well by polycentric governance regimes. They stated that putting the responsibility of CPRs' challenges on only regional or international bodies discourage people and local executives from solving global problems that have local roots. Further, on the national level, governments can be pressured by the efforts of small-scale units to take necessary actions for maintaining the quality of the environment. As a result, multiple private and public units can jointly affect the benefits and costs of the policy adoption process (Ostrom, 2016). Also, local users are not interested in the implementation of those governance regimes where their preferences, norms and particular characteristics are not included. This makes the regime less adaptive and subject to failure.

Moreover, local communities have a comparative advantage in collecting the required information for maintaining the resource, which would be difficult and costly to gather for the central government. However, they have a less comparative advantage in governing large CPRs. Hence, the inclusion of larger institutional arrangements is essential for improving abatement outcomes. Polycentric governance, which is developed by different users at multiple scales, is indeed useful for solving collective dilemmas, because different units, cumulatively, make costly efforts to avoid the tragedy of the commons (Ostrom, 2010a).

Without exaggeration, global warming is the largest universal collective action dilemma of all time, since its extreme adverse effects are the cumulative results of polluting activities done by millions of people worldwide. Whether or not they are willing to pay the relevant costs, they would all receive advantages of clean air. Given the complexity, instability and multilevel nature of collective public goods, there will be no optimal solution for reducing pollution. Hence, instead of relying on simple static theoretical and mathematical models, one needs to adopt sophisticated dynamic approaches (i.e., multilevel institutional structures) and learn how to implement mitigation policies for reducing the risks associated with the collective action problem and achieving environmental sustainability.

2.4 Theoretical Framework

As mentioned before, environmental disturbances caused by global warming involve many interlinked social-ecological systems operating at multiple scales. In order to find proper resolutions to prevent resource destruction, one needs to identify the complexity, non-linearity, cross-temporal and -spatial scales, dynamism and multivariable nature of such systems for devising effective rules (Ostrom, 2012b). These factors were also mentioned by Holling et al. (1998) and Levin (1999). They described the complexity of environmental problems as inseparable natural and social systems, which are non-linear in nature across temporal and spatial scales and have unpredictable behaviour. These inherently complex environmental problems have multiple causes and an evolutionary character (historical dependency) which feed back to the systems over time (Tavoni & Levin, 2014).

Moreover, the increasing size of the population, the growing level of economic development, overexploitation of natural resources and a higher rate of deforestation intensify this complexity. Combining these factors with humans, who are capable of controlling the system on the one hand, and causing damages on the other, have made the governance of CPRs challenging (Basurto, Gelcich, & Ostrom, 2013; Ostrom, 2012b). In order to understand different institutional structures and theories within an environmental context, in particular, the role of both formal authorities and informal norms in mitigating atmospheric GHGs emissions across countries, a diagnostic framework capable of addressing different environmental problems in diverse settings (across scales and over time) is required. To enable this, the famous social-ecological systems (SES) framework is adopted for analysing the research questions. Therefore, a compelling, detailed survey on the framework, its components, and the specific approaches for adapting the framework to fit the attributes of this particular study is thoroughly discussed in the next following sections.

2.4.1 The Social-Ecological Systems (SES) Framework

The social-ecological systems (SES) framework was first introduced by the 2009 Noble Prize laureate Elinor Ostrom in her work entitled “A diagnostic approach for going beyond panaceas” (2007) and further developed and revised a few more times.[19] It is a complex multilevel nested framework consisting of four first-tier components: *(i)* resource systems (RS); *(ii)* resource units (RU); *(iii)* governance systems (GS); and *(iv)* actors (A). Each of these cores is comprised of a set of attributes that can be individually decomposed into sub-attributes, shaping the lower levels of the framework (Ostrom & Cox, 2010). In other words, each of the first-tiered variables contains several second-tiered variables (attributes), and likewise, each of the second-tiered

[19] The initial SES framework is once developed in 2009 and revised twice more in her 2010 and 2014 articles.

ones might be further comprised of the third-tier variables (sub-attributes), and so on and so forth. These attributes, which are arranged into a tiered organisation, make the SES a multi-tiered conceptual framework.

Subsequently, these four core categories and their multiple internal variables interact with one another and produce different social and ecological outcomes. The shaped interactions (I) and outcomes (O), which are positioned in the heart of the SES framework focal action situation" (FAS) (McGinnis & Ostrom, 2014), are also linked to and affected by macro-level Social, economic and political settings (S) and related ecosystems (ECO). Like the four cores, these key components can also be further unpacked into multiple deeper-level variables (Basurto et al., 2013; Nagendra & Ostrom, 2014). Furthermore, due to the evolutionary character of environmental goods, the generated structure of interactions and outcomes at time t will further affect the main cores and their lower-tiered variables at time $t + 1$ (Ostrom, 2009). The latest graph of the SES framework is presented in Figure 2.1.

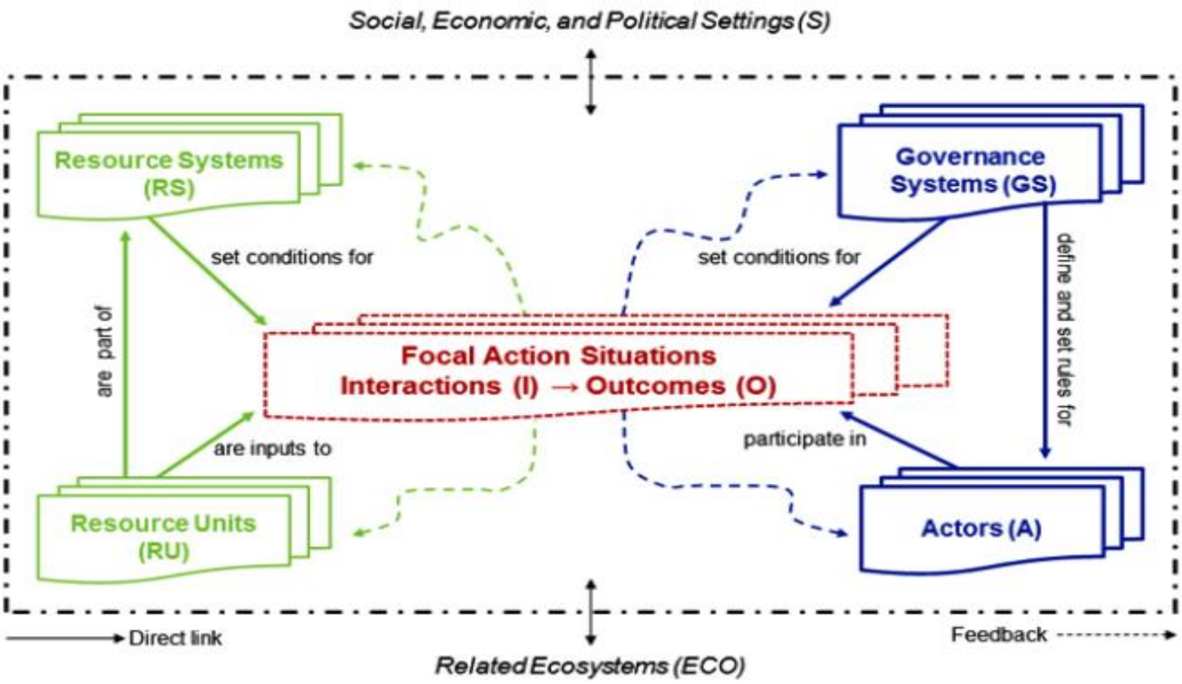

Figure 2.1. The Social-Ecological Systems (SES) Framework

Source: McGinnis and Ostrom (2014, p. 4)

The revised SES diagram presents a straightforward conceptual map and an overview of how biophysical characteristics of *(i)* resource systems and *(ii)* their units, alongside local attributes of *(iii)* users[20] and *(iv)* governance systems, *(v)* interact with each other and produce *(vi)*

[20] In this study, users (U) and actors (A) are used interchangeably.

outcomes at a particular temporal and spatial scale. In each social-ecological system, users take the units of a well-defined resource system out and cause either destruction or conservation of that resource system. In the absence of adequate governance arrangements, anti-environmental actions are expected to be taken, while proenvironmental behaviours can emerge and be sustained if an overarching governance system is actively enforced. All of these characteristics are finally influenced by large-scale contextual factors of *(vii)* related ecosystems and *(viii)* social, economic, political and ecological settings.

Fundamentally, the SES framework enables researchers to analyse the underlying reasons for the success and failure of natural resource management. Given the complexity and instability of the environmental problems, combinations of multilevel variables that mainly influence harvesters' motivations need to be primarily identified in order to design effective institutions. Hence, various biophysical attributes of resource systems and their generated units must be taken into account, which means that the structure of any resources and how they might change over time must be analysed (Ostrom, 2012b). For instance, one must first recognise the complexity of the atmosphere and become well-informed about the causes and effects of disruptions.

In addition, users' behaviours are affected by the attributes of the adopted rules and norms. By studying the framework, one is able to find (written and unwritten) rules that cause preservative outcomes, such as maintenance and stability of an individual resource system, or destructive outcomes such as overexploitation and conflicts. For instance, one should be capable of distinguishing effective policies because actors are continuously being monitored by different rules imposed by local, national or international governing bodies (Ostrom, 2007). Therefore, within an environmental context, developing a diagnostic framework capable of investigating the impacts of different types of institutions on individuals' incentives, behaviours and actions is essential in managing natural resources.

2.4.2 The Subsystems

The SES framework includes eight primary subsystems, which can be divided into two groups of four. The first group includes four core components: resource systems, resource units, governance systems and actors. As can be seen from the diagram (Figure 2.1), each of these is placed in a solid green or blue box and followed behind by several boxes, showing that there might be some simultaneous actions taking place within each core. Although these subsystems are relatively separable, they are connected in some ways to each other. For instance, *RU* are parts of the *RS* and inputs to the whole system, as they are being extracted by actors, continuously. Likewise, *A* who participate in the situation, through extracting *RU* from the *RS*, are affected by the rules set by *GS*, meaning that their actions and behaviours are being monitored and sanctioned. Two cores of the *RS* and *GS* set conditions for *A*, who consume the generated *RU*. Notes attached to the arrows in the diagram highlight their connections.

The second group can be further rearranged into two sections. The first comprises the interactions of four first-tier components and their generated outcomes. All actions taken by multiple actors at different scales (interactions) are positioned in the focal action situations (*FAS*) as inputs, which will be later transformed into outputs. Depending on the extent and type of the interactions, the *FAS* may involve one to four top-tier components (McGinnis & Ostrom, 2014; Ostrom & Cox, 2010). The second section contains the broad social, economic and political settings and related ecosystems, which are linked to the cores. The various outcomes drawn from the *FAS* at time t are affected by the exogenous macro settings and related ecosystems. Simultaneously, these outcomes impact on the entire SES and each top category at time $t+1$. In the SES, green and blue dashed lines originating from the *FAS* and the black dotted-and-dashed line that surrounds the interior parts of the SES indicate these dynamic connections. All the top-tier cores and their multiple internal variables are listed in Table 2.1.

Table 2.1. List of the SES framework's second-tier variables

Top-tier Categories and Their Internal Second-tier Variables					
1	**Social, Economic, and Political Settings (S)**				
S1	Economic development	S2	Demographic trends	S3	Political stability
S4	Other governance systems	S5	Markets	S6	Media organisation
		S7	Technology		

2	**Resource Systems (RS)**	**3**	**Resource Units (RU)**
RS1	Sector (e.g., water, forests, pasture, fish)	RU1	Resource unit mobility
RS2	Clarity of system boundaries	RU2	Growth or replacement rate
RS3	Size of resource system	RU3	Interaction among resource units
RS4	Human-constructed facilities	RU4	Economic value
RS5	Productivity of system	RU5	Number of units
RS6	Equilibrium properties	RU6	Distinctive characteristics
RS7	Predictability of system dynamics	RU7	Spatial and temporal distribution
RS8	Storage characteristics		
RS9	Location		

4	Governance Systems (GS)*	5	Actors (A)
GS1	Policy area	A1	Number of relevant actors*
GS2	Geographic scale of governance system	A2	Socioeconomic attributes
GS3	Population	A3	History or past experiences
GS4	Regime type	A4	Location
GS5	Rule-making organisation	A5	Leadership/ Entrepreneurship*
GS6	Rules-in-use	A6	Norms (trust-reciprocity)/ Social capital*
GS7	Property-rights system	A7	Knowledge of SES/ Mental models*
GS8	Repertoire of norms and strategies	A8	Importance of resource (dependence)*
GS9	Network structure	A9	Technologies available
GS10	Historical continuity		
6	**Interactions (I)**	**7**	**Outcomes (O)**
I1	Harvesting		
I2	Information sharing	O1	Social performance measures (sustainability, accountability, efficiency, and equity)
I3	Deliberation processes		
I4	Conflicts		
I5	Investment activities		
I6	Lobbying activities	O2	Ecological performance measures (sustainability, overharvested, resilience, and diversity)
I7	Self-organising activities		
I8	Networking activities		
I9	Monitoring activities	O3	Externalities to other SES
I10	Evaluative activities		
8	**Related Ecosystems (ECO)**		
ECO1	Climate patterns	ECO2	Pollution patterns
ECO3	Flows into and out of focal SES		

Notes: This table includes the most recent revisions made to the original lists of the second-tier variables (2007; 2009), including relabelling, relocation and addition or elimination of variables within each core category. Here, the core of GS refers to a tentative list of variables—source: (McGinnis & Ostrom, 2014, p. 5).

Since the introduction of the SES framework in 2007 through to its latest revision in 2014, the main cores remained unchanged. However, the internal variables within each core have been developing in various ways; for example, variables were added or eliminated, labels were changed and even a set of relevant variables was entirely revised and improved.[21] For example, (McGinnis & Ostrom, 2014) introduced an alternative list of second-tier variables for governance systems to replace the original one. Accordingly, over time, the list of second-tier variables was further unpacked, refined and upgraded to help researchers identify important factors that affect the shape of interactions and outcomes within a particular SES framework.

[21] The aim of all changes was in the interest of generalisability of the framework (McGinnis & Ostrom, 2014).

These critical variables are required to be learnt, identified and measured by researchers in studying diverse resources.[22]

While the framework considers a broad set of potentially applicable variables, not all of them are relevant to every study as SES are partially decomposable[23] systems. Thus, one must choose appropriate lower-tiered variables based on three factors: *(i)* the particular questions under study; *(ii)* the type of the SES; and *(iii)* the spatial and temporal scales of analysis (Nagendra & Ostrom, 2014). Further, in order to have a meaningful understanding of top categories and their internal variables, one must delve deeper into each of the selected second-tier variables, find lower-tiered ones and explore the relationships amongst them. Therefore, diverse sets of focal action situations can be studied by identifying and picking the potentially relevant variables(Ostrom, 2007). Finally, a theory is required to guide the analytical focus as SES are inherently complex (McGinnis & Ostrom, 2014). Hence, by using the framework, researchers are enabled to build and test a variety of theories and models, based on which relevant variables can be selected for collecting data, building models, conducting fieldworks and analysing the studied SES's outcomes in terms of sustainability (Basurto et al., 2013; Ostrom, 2012a).

2.5 The Application of the SES Framework

To apply the SES framework in any case, a two-step process should be followed (McGinnis & Ostrom, 2014). For the first step, a clear research question must be specified. This is because, in some cases, the question under study might involve the broad social, economic and political settings *(S)* as a focal system in which one compares these settings across a number of countries over time. While in some other cases, one may examine a particular *RS* located in an area within a specific setting *(S)* in a single point of time. Hence, the second-/third-tier variables need to be explored in order to explain the differences in the resulted outcomes (Ostrom, 2007). In other words, depending on the question under study, micro and macro variables individually or jointly can significantly affect the outcomes. Therefore, selecting the focal level of analysis should be considered as the entry point for studying any SES.

[22] The listed variables are not in any order, as their importance varies in different studies (Ostrom, 2007, 2009).

[23] Decomposability of SES stems from three facets: *(i)* SES is a multi-tiered framework, conceptually dividing variables into categories and sub-categories. *(ii)* Categories and sub-categories are relatively separable, which means they are independent of each other but concurrently affect each other's performance. *(iii)* Different combinations of variables lead to different interactions and outcomes.

For undertaking the analysis, the second step in the process, relevant lower-tiered variables must be identified. The influential variables can comprise: *(i)* biophysical attributes of resources; *(ii)* socio-cultural aspects of communities; and *(iii)* governing rules and regulations, which can have significant impacts on human behaviours and, thus, social-ecological outcomes. However, as SES are decomposable, one does not need to select all the internal variables within each core. The third-/fourth-tier variables should be considered only when their associated second-tier variables are found to be significant (i.e., sufficiently influential) in the pattern of interactions and outcomes. Hence, the selection of useful variables, those which are required to be measured for achieving desired results, is considered as the second step of the process.

Therefore, researchers' goals in studying SES must include recognising a particular combination of variables that are likely to generate long-term sustainability of natural resources at specific spatial and temporal scales. In fact, it is unlikely that anyone can record the variations in all of the listed variables. Hence, one should hold some of them fixed and focus on the ones that make significant impacts on the structure of interactions and outcomes (Basurto et al., 2013; Ostrom, 2007). In the following sub-sections, I explain the combination of variables that I believe are effective enough for examining this study's research questions. To achieve this aim and illustrate how the complex framework fits into the current research's attributes, I consider three criteria: *(i)* the particular research question; *(ii)* the focal level of analysis; and *(iii)* empirical limitations.

2.5.1 Fitting the Framework into This Study: A Slice of SES

The current study is attempting to address one main question and three sub-questions. The key research question is what the effects of formal and informal institutions are on the environmental performance of countries. Considering this, in the first sub-question, I am particularly looking at the role of significant formal institutions such as political systems in this process. Additionally, in the second sub-question, I include informal institutions such as social norms and social capital, to the baseline regression model to check if there is any statistically significant relationship between these two variables. Finally, as the third sub-question, I add the interactions of formal and informal institutions to see how their effects change in different institutional contexts.

This cross-country empirical research intends to estimate, as precisely as possible, the impacts of formal political institutions (the quality of democratic institutions) and informal social norms (the level of trust) on reducing greenhouse gas emissions (CO_2 emissions) across all countries[24] between the years 1990 and 2015. For estimating the relationship, different statistical techniques in panel data models, including ordinary least squares (OLS), fixed-effects OLS (FE-OLS), fixed-effects instrumental variables (FE-IV) and system generalised method of moments (Sys-GMM), are employed. To conduct the analysis, the SES framework is taken as a conceptual basis for selecting influential variables, collecting the required data, constructing quantitative models and analysing the results.

Adopting the SES framework is actually one of the key elements of this study that makes it unique. Up until now, this framework has been used mostly for conducting qualitative case studies at a micro level. This research intends to push forward the frontiers by employing such framework for empirical purposes at a macro level (estimating the relationship across several countries and over 26 years). As previously discussed, the framework is deliberately adapted in a way that matches the research characteristics perfectly. In this process, I build my argument on three main criteria: *(i)* the focal level of analysis; *(ii)* significant attributes of core categories; and *(iii)* employed empirical strategies and data availability[25]. It will enable me to narrow down the focus of this research further, identify and limit the number of useful variables and meet the empirical specifications' requirements.

2.5.2 Broad Social, Economic and Political Settings (S): Focal Level of Analysis

As previously mentioned, determining the focal level of analysis should always be the starting point for studying any SES. To that purpose, the main research question needs to be briefly reviewed: It aims at estimating the cross-country relationship between institutions and the environment over several years. It highlights that to test the hypothesis, I need to capture the cross-country heterogeneities. Therefore, country-level variables should be mainly included in the model, indicating that the focal level of analysis is at the macro level. As a result, it is crucial to incorporate large external factors such as broad social, economic, and political

[24] The sample is later classified into resource-rich/-poor countries, in terms of fossil fuels (oil, gas and minerals).

[25] Availability of reliable data is one of the major concerns of this study, especially with regard to institutional variables.

settings into the regression models, as they represent the macro level of analysis and improve the empirical assessment of larger institutional measures.

As illustrated in the SES, the category of settings includes seven second-tier variables, which should be included in the regression models as control variables.[26] They capture cross-country variations in areas of economic development, demographic trends, political stability, the media system and technology, and give an overall picture of countries' capacities in combating environmental degradations. Proposed variables for measuring each of the areas are: *income per capita; population growth; government stability; freedom of the press;* and *total factor productivity growth*, respectively. They will be discussed in the next chapter.

Additionally, there might be a Kuznets-type (non-linear) relationship between economic development *(S1)* and emissions levels, meaning that as income grows, the pollution first worsens but later improves. The inverse U-shaped plot, which has been labelled as the environmental Kuznets curve (EKC),[27] summarises the relationship and interaction of four parts of an economy. First, if a country is developing, in the initial stage, the scale of activities increases; thus, pollution will increase with the economic growth (scale effect).[28] Next, if the composition of the produced goods is changing because of changes in tastes or trade pattern, then the pollution may either decrease or increase with growth (composition effect). Third, if income per person increases, the importance of environmental quality rises, so people tend to demand and use more green products and fewer natural resources (income effect). Finally, if countries use less pollution-intensive technologies, growth leads to less pollution (techniques effect) (Levinson, 2008; Q. Li & Reuveny, 2006).[29]

Therefore, to capture the EKC income-pollution pattern, the squared form of the economic development will be added as another control variable to the GMM regressions equation only[30].

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[26] Subject to the availability of reliable data. See Appendix I (Table 2.A1) for further details.

[27] The EKC was first described by Kuznets (1955) and later popularised by Grossman and Krueger (1995).

[28] The larger the economy, the more the outputs, and thus the more the pollution would be. In the scale effect, the technological progress that results in more growth may also damage the environment by releasing GHGs; an example of this is the transformation of an economy from agricultural-based products into polluted-intensive industries.

[29] Consequently, the world's poorest and wealthiest countries are expected to have relatively better environments, compared to the middle-income ones that are the most polluted.

[30] For correctly testing the validity of the EKC hypothesis, GMM is preferred over other empirical methods. As Halkos (2003) mentioned, the complex interaction between income and emissions is dynamic rather than linear; hence, the use of RE-/FE-OLS in previous research cannot appropriately indicate the EKC pattern.

Finally, the focal level of analysis can be identified as the most influential aspect of this research as it determines how far up or down in the hierarchical SES framework one must go to find appropriate variables that have significant effects on the environmental performance of countries. Accordingly, the process of selecting relevant variables is limited to the second-tier variables of all the top-tier categories. The deeper-level variables (third-tier, fourth-tier, etc.) might be used for further clarification on choosing the right top-tier variables that are essential for inclusion in the model.

2.5.3 Resource Systems (RS) and Resource Units (RU): Earth's Atmosphere

Resource systems and resource units denote two top-tier categories. As illustrated in the SES diagram, *RU*, while is a separate subsystem, has a compositional relationship with *RS*, showing that they are closely connected (McGinnis & Ostrom, 2014). On the one hand, *RU* is part of the *RS* as they are withdrawn by harvesters. On the other hand, they are inputs to the particular *FAS* because they have been being extracted to various degrees[31] by many actors at multiple scales. Therefore, both core categories will be better explained together. Hence, in this section, I discuss these two cores' second-tier variables, from which influential ones are chosen based on the selected resource system.

As shown in Table 2.1, the *RS* category consists of nine second-tier variables, representing a general list of biophysical characteristics that apply to any resource system, ranging from forests and fisheries to the atmosphere. As all humanly-used resources are embedded in the SES (Ostrom, 2009). Seven factors of type, size, location, clarity of boundaries, productivity, available storage and predictability are directly related to the resource system, while "human-constructed facilities" indirectly affect the *RS.* Another core subsystem, *RU*, consists of seven internal variables, five of which represent the biophysical and chemical qualities of units including number, mobility, growth rate, spatial and temporal distribution and the interaction among units. The last two traits indicate the value and the physical appearance of the units.[32]

The unique attributes of the *RS* and its generated *RU* are considered as exogenous factors in the framework because they are not directly in the hands of officials, but are treated as key

[31] Extraction degree is subject to change based on the conditions (monitoring and sanctioning rules) set by the *GS*.

[32] See Appendix I (Table 2.A2-3) for the full list of *RS's* and *RU's* variables.

drivers of changing circumstances. They have significant impacts on the adoption of rules (Ostrom, 2012a), denoting that the governing rules for a specific resource system might be entirely different from the rules used for another *RS*. For instance, in fisheries where the resource units (fish) are mobile, the rules will be different from the ones used for fixed units (trees) of forests. Alternatively, the carbon storage capacity of forests is different from other resource systems like oceans (Ostrom, 2007); hence, to avoid emissions concentration, a certain number of trees can be chopped down, which must also be reflected in adopted rules and policies.

Among all types of environmental problems that the world is currently experiencing, mitigating air pollution is considered as the most pressing and complex social dilemma. For that reason, I focus on the earth's atmosphere as the *RS* in this research. Extensive emissions of several harmful gases, including CO_2, SO_2, N_2O and CH_4 are increasing the greenhouse effects and contributing to the threat of global warming. Additionally, the disruption is being intensified by the dramatic increase in the world's population, overexploitation of natural resources and the increasing size of economic activities. Substantial deforestation also strengthens the adverse effects of global warming through lowering the world's capacity in storing carbons and thus releasing more pollution into the atmosphere. Consequently, many interlinked social-ecological systems at different spatial and temporal scales are collapsing.

One significant attribute of the studied *RS*, earth's atmosphere, is the productivity level, which is derived from the production-consumption rate of oxygen. In other words, the generated oxygen *(RU)* is consumed and contaminated in various ways and by different rates worldwide, indicating considerable variations across countries. Thus, it should be included in the analysis. However, there is no such data available for directly measuring the productivity level. As a result, I instead draw on factors through which the natural productivity rate of the selected *RS* is mainly affected. In other words, factors affecting the storing and releasing rates of carbon into the atmosphere will be substituted with *RS5* (productivity of system). Therefore, to measure the production-consumption rate, two factors of the amount of forestland and fossil fuels consumption that are measured by *forests biocapacity* and *energy use* are included in the regression models.[33]

[33] By including forests in the analysis, along with the earth's atmosphere, two *RS* are studied concurrently. In this situation, where more than one resource system is involved, if both resource systems are inter-related, then they can be treated as one aggregated component (an integrated *RS*) (McGinnis & Ostrom, 2014). Therefore, as forests improve the air quality and help to prevent global warming, they can be treated as one aggregated *RS*.

Finally, the chosen *RS* and *RU* also fit the focal level of study as they involve all countries worldwide. This is because, *(a) RS* is open access - everyone has equal access to it as no effective limitations for any actors can be established; and *(b) RU* are mobile and, thus, the locally produced pollution can spread over regions and affects people unevenly. Although I am trying to take all the influential variables into account, considering the specific attributes of this study, I should select ones through which comparing countries across the different timespans become feasible. Therefore, I draw on factors that indicate particular biophysical attributes of the earth's atmosphere and its oxygen, which are unique in nature and different from the attributes of other types of natural resources such as fisheries and pastures.

2.5.4 Governance Systems (GS) and Actors (A): Formal and Informal Institutions

It has been discussed so far that there is no single solution for solving collective problems, and ideal governance regimes including public, private and local community ownerships can either individually or jointly work in different settings. I then discussed how multiscale cooperation is required for dealing with such complexities, underpinning the need for multiple institutional structures. Basically, each governance regime consists of *(i)* a set of rules specifying the extent of access to the resources, *(ii)* monitoring the actions, and *(iii)* imposing sanctions for noncompliance. However, the key is that the determined institutional diversity fits the local communities' socio-cultural norms at the same time as being compatible with the studied *RS's* and its *RU's* biophysical characteristics (Ostrom & Cox, 2010). These institutional structures, adopted from the institutional analysis and development (IAD) framework[34], are embedded in two subsystems of *GS* and *A* in the SES framework. Hence, before going through these two subsystems, I briefly review the framework.

The IAD framework, upon which the SES framework is built, enables scholars and policymakers to considers all aspects of *(i)* the rules in use (not only the formal written ones); *(ii)* key biological, chemical and physical attributes of the resource systems, and the type of the good (ranging from private to public goods); and *(iii)* the level of trust and shared norms as the qualities of a society (McGinnis & Ostrom, 2014). The term *institutions* in the IAD refers to the rules and shared norms, designed and developed by both government authorities and the

[34] The IAD framework, which was used initially by Kiser and Ostrom in 1982, is a conceptual map that links the institutional arrangements to the social-ecological outcomes (McGinnis & Ostrom, 2014).

public, and used by individuals who interact in a wide range of rule-structured situations at multiple scales (Ostrom, 2008, 2012b). This definition is consistent with that of Douglass North (1991), in which the concept of institutions is described as *(i)* rules of the game that constrain people's behaviours; *(ii)* humanly devised, meaning that it is under human control; and that *(iii)* their effects are achieved through the incentives (Acemoglu & Robinson, 2010).

Institutions can be divided into two categories of formal and informal institutions. Formal institutions are written rules and laws determined by an external authority that give information to individuals about what actions are permitted or prohibited. Informal institutions are unwritten norms, such as customs, traditions or cultures (the specific identity of a community), which define codes of behaviour and are required to be followed by each individual person (North, 1990). Institutions are useful for mediating self-interest, enhancing collective actions and reducing uncertainties (Ostrom & Cox, 2010). They can be modified as people learn more about the consequences of their activities, leading to achieving better environmental outcomes (Ostrom, 2008).

These biophysical *(RS&RU)* and institutional *(GS&A)* elements, known as contextual factors in the IAD, are inputs to the decisions made by individuals. Aggregated decisions then generate patterns of interactions and outcomes in the *FAS*, denoting that both the IAD and SES frameworks are closely interconnected. In fact, when action situations are strongly affected by influential *RS's* and *RU's* attributes, the SES is likely to be used more.[35] In fact, by using the SES framework, scholars are enabled to analyse the interactions generated in the social and ecological systems within an institutional context (McGinnis & Ostrom, 2014; Ostrom & Cox, 2010). In the two sections below, I discuss how the institutional requirements are predicted in the two subsystems of the SES framework.

2.5.4.1 Governance Systems (GS)

GS is considered as one of the most important cores. This subsystem sets conditions and defines rules for actors who participate in the process of depleting and/or consuming resource units. The rules and policies made by local and national authorities affect the incentives and behaviours of the multiple actors who are involved in the process. Initially, it contained eight

[35] While the lack of the said variables might instead emphasise the use of IAD (Ostrom, 2011). It also shows the degree to which the SES and IAD frameworks are closely interrelated.

second-tier variables; however, McGinnis and Ostrom (2014) revised the whole structure of internal variables. They then introduced a tentative list of 10 potential second-tier variables, in which all original variables were included albeit in different locations and organisations.[36] For instance, original *GS1* and *GS2* are now combined and added as third-tier variables to *GS5* in the new list. Also, three types of rules, which were initially grouped as *GS5-7*, are now combined and rearranged as one broad variable (*GS6*: rules-in-use). In addition, they added other factors to *GS* as second-tier variables. One of them, for instance, is policy area (new *GS1*), the role of which is exactly like the resource sector in a particular *RS*. Regime type (new *GS4*) is another proposed variable referring to a political system that can be interpreted in two ways: democratic and autocratic or monocentric and polycentric.

In this study, I rely on the new list of the *GS*,[37] as it better matches with the purpose and approach of this study. I adopt an economic perspective, in which formal institutions are classified into three main groups of political, legal and economic institutions. In economics, political institutions are referred to as a set of enforceable laws that: *(i)* shapes the process of governmental policymaking; and *(ii)* constraints the politicians' decisions (S. Dasgupta & De Cian, 2018). Likewise, in the updated list of *GS*, I have a separate variable for the quality political institutions *(GS4: regime type),* which is useful for showing whether a country is run by a strong democratic system or an autocratic one.

From this perspective, economic institutions: *(i)* establish effective property-rights systems; and *(ii)* facilitate transactions (Acemoglu & Robinson, 2010). However, the scope of their functions is controlled by political institutions. In other words, they overlap with each other, and hence are difficult to entirely disentangle (Acemoglu, Johnson, & Robinson, 2005). The new *GS7 (property-rights system)* directly highlights the performance of economic institutions within a country. Finally, legal institutions refer to: *(i)* the quality of the legislature; and *(ii)* public-/private-devised legal institutions. The corresponding *GS6 (rules-in-use)* captures the effects of legal institutions. Henceforth, when referring to *GS*, I mean the new list of *GS*.[38]

A large body of the existing empirical literature concentrates on the relationship between institutions and economic growth and development, where their positive correlation is

[36] For detailed revisions made to the initial list of the second-tier variables, see pp. 8-10 of the said article.

[37] See Appendix I (Table 2.A4) for the full list of *GS* variables.

[38] The original *GS* list fits the socio-technical definition of institutions. These studies stress the process of decision-making, in which multi-level agents beyond government make required decisions (S. Dasgupta & De Cian, 2018).

extensively documented (Acemoglu, Naidu, Restrepo, & Robinson, 2019). However, there is a lack of sound institutional analysis in the empirical studies within the context of the environment (Hassan, Khan, Xia, & Fatima, 2020). Further, previous empirical research within applied economic literature found a mixed relationship between formal institutions (and more broadly political factors) and environmental performance indicators (S. Dasgupta & De Cian, 2018). While some authors have argued that democratic governments could reduce environmental degradations, others have proved the opposite by proposing that democracy is shown to be a neutral or a negative factor that harms the environment.

The theoretical argument for government involvement in managing the environment has arisen from traditional collective action theory, within which the need for an external authority to monitor rules and punish cheaters is strongly emphasised. This theory, which is fully discussed in previous sections, concluded that the presence of effective formal institutions is mandatory for solving major collective action problems such as climate change. To increase the provision of public goods, governmental bodies can design new environmental regulations and policies to lessen the risks of free riding and motivate people to contribute sufficiently. The efficacy of this theory has been tested empirically by measuring the degree to which the environment is protected in democratic systems compared to autocratic ones. This hypothesis has been widely tested so far in several studies; however, the results were ambiguous.

On the positive side, democracy as a strong formal institution supplies more environmental public goods and policies (Bernauer & Koubi, 2009; Deacon, 2003). Strong democratic systems perform better in terms of reducing different air pollutants (Binder & Neumayer, 2005), protecting natural areas (Neumayer, 2002), improving air and water quality (Barrett & Graddy, 2000), lowering carbon and nitrous oxides emissions, water pollution, deforestation and land degradation (Q. Li & Reuveny, 2006) and achieving sustainability (Ward, 2008). It is stated that in a country with democratic institutions people can collect information more easily and are more aware of environmental problems (freedom of media). While democracy allows for free media, by which environmental problems are more likely to be reported, autocratic regimes censor free flows of information; hence fewer people are informed and thus fewer act on environmental issues (Payne, 1995). Therefore, more environmental degradations are expected in autocracies.

Also, political rights, which are protected better in democratic systems, can promote environmental outcomes. In democracies, people can express their preferences (freedom of expression) and create lobby groups to put pressure on the government (freedom of association) to form appropriate environment-friendly institutions and policies (Fredriksson & Neumayer, 2013). Moreover, people have the right to vote for their favourite politicians; hence, the elected political leaders are prompted to implement policies that satisfy the public (Fredriksson & Neumayer). Unlike autocratic systems, where political power is concentrated in the hands of a few elites, in democracies, free elections are regularly held. Therefore, new political parties (e.g., Green parties) have a chance to come to power, showing that democratic regimes are more responsive to the environmental needs of the people[39] (Q. Li & Reuveny, 2006). Similarly, democracies are associated with greater participation in and higher compliance with environmental agreements (S. Dasgupta & De Cian, 2018), and thus they demonstrate a better environmental performance.

With current technology, environmental regulations on mitigating pollution impose higher costs on the few ruling elites[40] in autocracies than their median-voter counterparts in democracies (Congleton, 1992). Stringent environmental policies reduce industrial activities. While the benefits are equally dispersed throughout society, the costs are disproportionately borne by the elites. Therefore, they are less pro-environment than the public in democratic countries. In addition, Congleton (1992) argued that few autocratic leaders are interested in using financial resources for implementing proenvironmental policies because they face the prospect of substantial losses if there was a regime-breakdown compared to the masses in a democracy. Therefore, they allocate more money today for oppressing potential rebels. For the same reason, Gleditsch and Sverdrup (2002) argued that autocracies are more engaged in wars. Hence, on this argument, democracies are likely to have a higher quality environment.

On the other side of the debate, some studies (Carlsson & Lundström, 2003; Jorgenson, 2006; Scruggs & Rivera, 2008; Shandra, 2007) showed that democracy is unable to affect the environment positively, and others (Deacon, 2003; Ehrhardt-Martinez, Crenshaw, & Jenkins, 2002; Joshi & Beck, 2018; Midlarsky, 1998) that democracy is a cause of destruction by increasing carbon and lead emissions, soil erosion and deforestation. It is emphasised that in democracy, the short duration of electoral cycles motivates political leaders to adopt policies favourable to their re-election. At the same time, non-democratic politicians do not face

[39] As long as the median voters prefer a better quality of the environment.

[40] In autocratic countries, small elites hold a large share of national income as they misuse their political power to create personal wealth from their countries' resources (self-enrichment).

frequent re-elections, thus can make costly environmental decisions without having the fear of being punished by the voters (Bernauer & Koubi, 2009). In addition, elected governments may have short planning horizons, yet many forms of environmental degradation develop slowly over a long period of time (e.g., global warming) (Congleton, 1992). Thus, the social costs of current economic behaviour and political choices often appear over the long term and are carried by future generations.

Further, democracy is a factor in economic prosperity as the system is generally biased toward protecting the interests of the large profit-oriented corporations that do not necessarily seek to improve environmental quality. They are often reluctant to make sacrifices in the interest of society. In other words, democratic countries are market-based economies, where such businesses have substantial controlling power over legislative and administrative processes, while environmental organisations can hardly succeed, resulting in policy inaction when environmental degradation is concerned (Q. Li & Reuveny, 2006).[41] Finally, population is another important factor in the process of degradations.[42] While in autocracies, autonomous decision-makers can restrain people and curtail human reproduction, democratic systems must respect citizen rights (Heilbroner, 1991). Accordingly, democratic governments undersupply environmental goods relative to non-democratic regimes.

Overall, the ambiguity that lies in the relationship between formal political institutions (e.g., democracy) and environmental protection needs further clarification. Therefore, in this study, I draw primarily on the index of the *political constraints* to see the extent to which the concentration of political power (in the hands of the head of the state) helps to reduce emissions. Also, this variable, to some extent, represents the level of democracy in a country as democracy is aligned with more executive constraints. In any event, the two most popular variables that have been used for measuring the quality of democratic systems *(revised combined polity score* and *the level of democracy)* are further used to show the robustness of the results for political institutions. All of these three variables are in line with *GS4* in the framework.

Although the overall quality of formal institutions is already taken into account to a large extent by the abovementioned three variables (i.e., political institutions), the inclusion of variables

[41] A similar argument is also made by Midlarsky (1998), who argued that democracies might be reluctant to prevent degradations as some groups are expected to gain (or lose) from environmental policies more than others.

[42] There is a perfect correlation (99%) between population growth and GHG emissions (Newell & Marcus, 1987).

representing the other two categories of formal institutions (i.e., economic and legal institutions) can improve the empirical estimations for formal institutions. To do so, I employ three more variables, two of which represent legal institutions *(law and order* and *corruption)* and correspond to *GS6* in the SES framework. With respect to *GS7 (property-rights system)*, I draw on the famous *investment profile*,[43] through which the quality of economic institutions can be measured. Overall, all of these six variables enable me to thoroughly assess the extent to which the possession of high quality formal political, legal and economic institutions improves air quality across countries. As a result, an empirical relationship can be built which is more robust than that which appears in existing research in this area.

2.5.4.2 Actors (A)

Another top-tier category that contains institutional attributes is actors *(A)*. This category, which was initially known as Users *(U)*, consists of nine second-tier variables,[44] all of which potentially affect actors' interactions with one another and with resources within the *FAS* (Ostrom, 2012a). External factors like the number of relevant actors and their locations, along with their internal attributes, such as economic, social and human capital and leadership capabilities, affect actors' experiences in extracting a resource (which may be different from one another). In this process, available technologies and the resource-dependency rate weaken or strengthen the interactions' effects. This subsystem can be considered as the most important top-tier in the SES framework because users' behaviours and actions result in both destruction and conservation in social and ecological systems, depending on the presence and efficacy of *GS*. Hence, actors can be considered as dual-role users.

For four reasons, the inclusion of informal institutions, such as social and moral norms, into the analysis is crucial. The first relates to asymmetric information. Informal institutions can play an important role in dealing with situations where negative environmental externalities of a polluting activity cannot be recorded by a formal organisation. As major environmental issues involve millions of actors worldwide, it is unlikely that an external authority can effectively monitor everyone's behaviours and punish cheaters. Thus, there will be no formal warning, penalty or additional (emission) taxes on a polluter. Therefore, social disapproval by the polluter's peers (in case they have observed his/her anti-environmental activity) or the moral

[43] *Investment profile* measures expropriation risks and is widely used by Acemoglu, Johnson, and Robinson (2003) for evaluating the quality of the property-rights system (economic institutions) across countries.

[44] See Appendix I (Table 2.A5) for the full list of *A* variables.

norms one believes in (in case only one knows about his/her actions) can disincentivise him/her from doing this (Nyborg, 2018b).

The second reason involves market failure. In order to remove the risks of free riding embedded in global public goods, such as air and water quality, solutions cannot be limited to the presence of formal powers only. Due to the presence of free-riding risks, people are less motivated to contribute to an appropriate share to stop their pollution. Because, whether or not they are willing to pay the relevant costs, they would all receive the advantages of clean air. Therefore, when it comes to polluting global public goods, markets fail severely. In this situation, informal mechanisms are more likely to be the solution, for example, moral norms prevent people from polluting drinking water.

Undesired outcomes underpin the third reason. As Arrow (1970) stated, in the absence of adequate formal institutions, informal institutions may arise. Ignoring the existing informal institutional structure in the economic analysis may lead to obtaining an undesired outcome, for example, by implementing policies through which informal institutions are weakened (Ostrom, 1990, 2000). The fourth reason takes into consideration the universal influences of local social norms. Behaviours that are induced by local social norms have substantial environmental impacts at the global scale through being diffused between different groups of people over large areas and time, and thus alter behaviours. For instance, socially discouraging driving fuel-inefficient cars or avoiding habits that encourage light indoor-clothing in cold weather, result in better environmental outcomes, including less air pollution and energy consumption (Nyborg, 2018b).

Therefore, to decrease environmentally unfavourable activities, different parts of the society, ranging from local units (e.g., households) to the national ones (e.g. state government), are required to cooperate, and the key to sustaining cooperation and reciprocation in the long term is trust. As Uslaner (2018) stated, in societies where there is higher trust in other participants, less protection is required against free-riding activities. Also, in such societies, it is easier to implement policies that require broad-scale cooperation among a large portion of the population. Hence, in this study, I will include the variable *A6 (norms, trust-reciprocity, and social capital)* in the quantitative model. This is actually one of the main contributions of this study, as previous empirical research in the environmental analysis has mostly failed to consider the empirical effects of informal institutions on mitigating emissions.[45]

To the best of my knowledge, there are only two studies that empirically test for the role of trust in mitigating emissions across countries. In the first study, Carattini, Baranzini, and Roca (2015) found a positive relationship between within-country trust (measured by word values survey (WVS)) and GHG emissions in 29 European countries between 1990 and 2007. Also, a recent study by (Carattini & Jo, 2018) showed the causal effects of the inherited trust of descendants of immigrants to the United States[46] (which showed the level of trust in their countries of origin) on CO_2 emissions of 26 countries. Using the WVS data, they found that carbon emissions were substantially less in trustworthy countries than in low-trust ones between the years 1950 and 2010.

However, in order to measure the quality of informal institutions across countries, I will use the variable of *religious tensions* as the main proxy for trust in my regression models. By using this variable, the empirical analysis largely benefits from better data coverage as more annual observation is provided for a comprehensive set of countries over several years. In addition, the degree to which a society is ethnoreligiously diverse can be taken into account because cooperation might be, in a sense, easier in homogenous societies (Esfahani & Ramírez, 2003). For the purpose of this study, this argument is especially relevant because it implies that trust is relatively lower in terms of ethnic or religious composition in less homogeneous countries.[47] Simply put, the idea here is that the higher the social tensions, the higher the likelihood of conflicts, and thus the lower the level of social trust will be.

Fostering cooperation and promoting reciprocity is easier among people who have the same religious and ethnic identifications. This is because it is easier for people to predict the behaviours of those who come from the same background than those who are different (e.g., refugees and immigrants) (Field, 2003). In addition, people tend to connect and interact with their peers (who are from the same ethnic and religious groups). This willingness is notably

[45] So far, trust or social capital has been recognised as one of the key drivers of economic development. There is a well-established literature on this relationship Knack and Keefer (1997), Zak and Knack (2001) and Algan and Cahuc (2010). In this study, however, the focus is on extending its beneficial effects to emissions mitigation.

[46] For example, they estimate the differences in trust between France and Germany by comparing Americans whose ancestors came to the US from France and Germany in different periods: 1920, 1950 and 1980.

[47] Ethnic homogeneity is said to be one of the main reasons that the level of trust is high in Scandinavian countries (Delhey & Newton, 2005).

stronger among religious groups, as different religions may have different attitudes toward social interactions (Alesina & La Ferrara, 2002). Hence, strong intra-group networks lessen inter-group interactions, and this promotes social inequality and tensions (Field, 2003). Hence, people are less likely to adopt trust-based behaviours when they are dealing with members of another group. Being part of a minority group that has been historically discriminated against, as argued by Alesina and La Ferrara (2002), is one of the key determinants of lower trust in society. Therefore, tensions arise from ethnoreligious fractionalisation and hinder social cohesion.

While higher levels of social tensions in a religiously- and/or ethnically-divided society[48] decrease the level of social interaction, they increase the likelihood of conflicts among different groups of people at the same time (Rohner, 2011). As Rohner, Thoenig, and Zilibotti (2013) stated, social fractionalisation and civil conflict is detrimental to the creation of trust. When the radius of trust is limited to the members of a specific group, it is no longer able to facilitate cooperation and reciprocation in the society (beyond the group's members) necessary for achieving collective goals (Field, 2003). When historical ethnic and religious tensions adversely affect a country, it is often challenging to build trust. Therefore, ethnoreligious tensions may raise the threat of violence and the likelihood of conflicts, and thus lower the level of trust among people and politicians, which in turn lowers public goods provisions (Esfahani & Ramírez, 2003; Rohner, 2011; Rohner et al., 2013).

In addition, it would be useful to incorporate the interaction of formal and informal institutions into the model. This would contribute to understanding how informal institutions react in a different formal institutional context. For instance, when there are high (low) quality formal institutions, higher (lower) levels of informal institutions enhance (exacerbate) their total effects on reducing emissions. In contrast, when the quality of formal institutions is weak (strong), strong (weak) informal institutions complement (substitute) their total impacts on pollution. For example, when people are not happy with their government's policies (i.e., weak formal institutions), cooperative societies may either make up for their inefficiency (substitutionary effect) or exert extra pressure on government by protesting and refusing to comply with the rules (complementary effect).

[48] The society is divided into dis-/less-connected divisions, within which only small groups of homogenous people in terms of ethnic background and religious views are interacting.

Another important factor that is expected to have a positive association with preventing environmental degradation is knowledge or educational level. If a large portion of the population is educated, then it is expected that more people are informed about the social costs of their degrading activities; therefore, they are less likely to take anti-environmental actions and more likely to support environmental policies (Davino, Esposito Vinzi, Santacreu-Vasut, & Vranceanu, 2019). It is also strongly emphasised by Ostrom (2011) that a lack of communication about and learning from each actor's behaviours is the source of overexploitation and destruction of resources; that is, as individuals learn more about the results of their past actions, they may alter their strategies towards sustainability. Therefore, *human capital index*, which shows the level of knowledge across countries and is in line with the variable *A7* in the SES framework, is employed in the regression model.[49]

Finally, based on what has been discussed, it can be determined that formal and informal institutions are the main parts of the two social cores, namely *GS* and *A*, upon which the sustainability of natural resources is dependent. As previously discussed, there is a paucity of research on the impacts of institutions on the environmental quality of countries and, in particular, on informal institutions, as they do not necessarily play a positive role in societies. Nyborg (2018a) argued that reciprocity can either help or hamper the mitigation efforts, and Tavoni and Levin (2014) describe social capital as a "double-edged" feature. In fact, the inclusion of informal institutions makes this study more interesting; therefore, delving deeper into this part of the analysis is crucial. Overall, this research pushes forward the frontiers by including both formal and informal institutions and their interaction effects in the empirical models; this will enable me to fully grasp the extent to which the presence of institutions is decisive for decreasing carbon emissions.

2.5.5 Focal Action Situations: Interactions (I) and Outcomes (O)

In the focal action situation, one can identify and analyse multiple actors and their assignments at different scales. They are individually or jointly interacting in various ways. For example, actors sometimes cooperate for solving problems or fight over access to a resource system.[50] Regardless of the type of their interactions, action situations, at time t, take all inputs from all

[49] This variable is also a rough indicator of the overall belief of a nation in climate change.

[50] See Appendix I (Table 2.A6-7) for the full list of *I* and *O* variables.

(or part) of the top-tier categories[51] and produce an outcome(s), which will subsequently affect the whole system at time $t + 1$. The entire process occurs in the context of broad settings and related ecosystems. While the dynamism of the system is not immediately apparent, it links the outcomes to the relevant variables through the feedback paths (dashed lines) (McGinnis & Ostrom, 2014). Therefore, the subsystems can be considered as inputs and outputs from at least one action situation (Ostrom, 2007).

Among all interactions, those that are self-organising are mentioned as the most important in the SES framework. The term "self-organisation" refers to resource users who invest a great deal of time and energy in conserving the environment to prevent the tragedy of the commons. The traditional theory assumes that users will never self-organise because individuals focus on maximising their short-term benefits and not cooperating unless an external authority such as government affects user incentives by imposing rules and sanctions. Early studies predicted that diverse harvesters fail to develop required rules and norms for governing natural resources if they do not engage in proper communication (Ostrom, 2009).

However, analysing individual behaviours shows that if users *(U)* believe some people (e.g., neighbours) are trustworthy and available to respond to cooperation with cooperation, then they tend to continue their cooperative activities (conditional cooperation). Reciprocation provides a chance to achieve substantial long-term benefits through people gaining a reputation for being trustworthy (it can act as an asset for improving individual- and joint-level outcomes). Consequently, unlike the standard economic theory of human behaviour, trust, reciprocity and cooperation are the main factors that inspire individuals to solve social dilemmas (Ostrom, 2010b). Consequently, for analysing the relationship between multiple actors and natural resources, an updated theory is adopted in which the levels of trust of those who are involved in social dilemmas are considered.[52]

Ostrom (2009) has identified a set of 10 second-tier variables which establish the likelihood of users self-organising (and engaging) in solving collective action problems. Depending on the context of the study, not all of the 10 second-tier variables are relevant so do not need to be

[51] Depending on the research question, specific combinations (not all) of variables from *RS*, *RU*, *GS* and *A* are used.

[52] Traditional theory contradicted the capability of self-organisation in limiting harvesters, and, thus, suggested privatisation/centralisation for sustainable use of resources (Tavoni & Levin, 2014). However, several recent research found the opposite, where the resource destruction was accelerated by governmental policies (Ostrom, 2009).

considered. However, obtaining measurements of those variables that are relatively important is the first step in analysing the probability of users' self-organisation in a community. Although, consumers with a long-term interest in sustainability are willing to do more self-organised activities, considering the studied resource system and its unique attributes, the likelihood of maintaining the earth's atmosphere is relatively lower than that of any other resource system.

Table 2.2. The likelihood of self-organisation in the studied resource system

Core	Self-organisation's internal variables	Expectation
Resource Systems (RS)	**Size of resource system (RS3)** Among three groups of small-, medium- and large-sized territories, the medium-sized RS is likely to be relatively more self-organised, because defining clear boundaries (with signs or fence), monitoring processes and obtaining ecological knowledge are more feasible than for the other territorial sizes. *Since the absolute and relative spatial extent of the studied RS (earth's atmosphere) is immense, and the given costs of defining boundaries, monitoring actors and gaining knowledge are high, the likelihood of self-organisation is low.*	***Low*** *No considerable cross-country variations*
	Productivity of system (RS5) The motivation for actors to self-organise is scarcity, without which users are unlikely to call for governance for an abundant or almost exhausted resource. *The studied RS is abundant in nature; hence, it is less likely to be conserved. However, when it is extensively polluted (i.e., the production-consumption rate becomes unbalanced), some people start taking proenvironmental actions, as the RS seems scarce to them now. Hence, the productivity of RS has a curvilinear effect on self-organisation.*	***Medium*** *Substantial cross-country variations*
	Predictability of system dynamics (RS7) If resource users could estimate what would happen if they needed to create special harvesting rules or no entry territories, then it means that the RS is sufficiently predictable and, thus, likely to be self-organised. *The present global warming is indicating the extent to which the RS is unpredictable. However, it might also be caused by the selfishness of some actors. If a factor like reducing the use of non-renewables is taken into account, then positive outcomes are expected. Hence, self-organisation may slightly differ across countries.*	***Low*** *No considerable cross-country variations*
Resource Units (RU)	**Resource unit mobility (RU1)** Mobile RU such as wildlife or water is relatively less likely to be self-organised compared to stationary units, such as trees or water in the lake. *Due to the costs of observing and managing mobile air pollutants, the studied RS is less likely to be protected.*	***Low*** *No considerable cross-country variations*

Governance Systems (GS)	**Rules-in-use (GS6): Collective-choice rules (GS6-b)** Having autonomy in constructing and enforcing formal rules for shaping human behaviours and governing social interactions at the collective level lower transaction costs. *Due to the presence of free-riding risks and non-excludable beneficiaries, devising rules and policies targeting the conservation of the selected RS is complicated. However, the outcomes would be different across countries, depending on the efficacy of the rules.*	***Medium*** *Substantial cross-country variations*
Actors (A)	**Number of relevant actors (A1)** The overall effect of a group size of actors on self-organisation depends on other SES variables because the bigger the group size, the higher the transaction costs of self-organising would be, due to the higher costs of getting users together and reaching an agreement. On the other hand, the costly task of monitoring large communities is easier for a large group of people because they can better mobilise necessary labour. *While the probability of self-organisation, in this case, depends on two driving factors; the effects of the total population that are involved in contaminating the RS outweighs the costs of monitoring; thus self-organisation is difficult.*	***Low*** *Substantial cross-country variations*
	Leadership/ Entrepreneurship (A5) Self-organisation is more likely to occur when some resource users have entrepreneurial skills and are also respected as local leaders. *The presence of college graduates and influential elders is positively linked to better resource governance. Hence, the likelihood of self-organisation depends on the level and quality of the education, and thus varies across countries.*	***Medium*** *Substantial cross-country variations*
	Norms (trust-reciprocity)/Social capital (A6) Social and moral norms facilitate trust-based reciprocity. The presence of social capital is based on three attributes: trustworthiness, network and norms. They empower users to solve collective challenges (Nagendra & Ostrom, 2014). *Since ethical standards result in lower transaction and monitoring costs, depending on the level of trust, the likelihood of self-organisation varies.*	***Medium*** *Substantial cross-country variations*
	Knowledge of SES/ Mental models (A7) When users share their knowledge of relevant SES features, the costs of self-organisation will be lowered. *The presence of educated people in society makes self-organisation easier. Depending on the extent of information sharing, self-organisation ability varies across countries.*	***Medium*** *Substantial cross-country variations*
	Importance of resource (dependence) (A8) In successful cases of self-organisation, actors are highly-dependent on the RS for their livelihoods, or the RS is economically and/or culturally valuable for them. Otherwise, it may not be worth the effort. *Since human life is threatened if the selected RS is extensively-polluted; people are highly self-organised.*	***High*** *No considerable cross-country variations*

Notes: This table provides the list of 10 second-tier variables upon which self-organisation is dependent. For each variable, the definitions are adopted from Ostrom (2009). The analyses (italic texts), however, represent my interpretation of the relevant concept in the context of the earth's atmosphere.

It can be observed from Table 2.2 that the long-term sustainability of SES is dependent on users and governments establishing rules consistent with the attributes of the resource system and local communities; this process is known as self-organisation in the SES framework. Concisely, self-organisation ability mainly depends on three main factors: formal institutions (such as rules-in-use); informal institutions (such as social norms); and some characteristics of the resource system (such as productivity). Although, for the reasons discussed in Table 2.2, the likelihood of protecting the earth's atmosphere is relatively low; the purpose is yet to find the most powerful combination of variables that increase the probability of self-organisation for reducing atmospheric pollution.

In this study, as previously mentioned, I focus on the earth's atmosphere as the *RS*, which is largely disrupted by the massive stock of greenhouse gasses, including CO_2, SO_2, N_2O and CH_4, all of which contribute to the threat of global warming. To study the degree to which the opted *RS* is protected, I mainly draw on the variable *carbon footprint per capita*, through which the extent of CO_2 emissions in the atmosphere is captured. Among GHGs, carbon is the most common particulate in the atmosphere and the biggest source of emissions; hence, by taking this variable, I can measure the degree of disruption to a large extent.[53] This variable also corresponds to the ecological sustainability of resources *(O2)* in the SES framework.

Additionally, to delve deeper into these carbon emissions-related issues, I will look at different sources to check where the pollution comes from. For instance, CO_2 stems from different sectors such as heat and electricity production and manufacturing industries. Moreover, fossil fuels, ranging from gas to liquid (e.g., oil) and solid fuels (e.g., coal), are the primary sources of CO_2. Having information on the source of the pollution enables me to build a robust institution-environment relationship, and hence help analysts and policymakers to adopt the right policies. Therefore, along with the total CO_2 emissions, emissions by sectors and sources can further be used as dependent variables.

For estimating the institution-environment relationship, I use two econometric approaches of fixed-effect instrumental variable (FE-IV) and system generalised method of moments (Sys-GMM), each of which is useful for addressing a specific type of issue.[54] For instance, to solve the endogeneity problem that lies in institutional analysis, the standard empirical method of

[53] CO_2 accounts for around three-fourths of total greenhouse gas emissions. See Ritchie and Roser (2020).

[54] Both methods will be discussed in detail in Chapter 3.

FE-IV estimations is employed (Eicher & Leukert, 2009). Because institutions, either formal or informal, are inherently endogenous, they are greatly affected by their countries' socio-cultural, historical and geographical preconditions, including culture, religion, ethnicity and colonial and legal origins. The FE-IV approach enables one to study the institutional determinants in depth by introducing exogenous instrumental variables.

In addition, the empirical analysis in the field of the environment can benefit from the GMM model (Tamazian & Rao, 2010), as it can consider the dynamic interactions between natural resources and human activities and capture the feedback generated from this cycle (Tavoni & Levin, 2014). To consider the dynamism in the model, a lagged form of the dependent variable — environmental performance indicator *(carbon footprint per capita)* — will be added to the right-hand side of the equation, because previous years' emissions can likely predict its current emissions. The dynamism is also illustrated in the SES framework, in which the whole system at time $t + 1$ will be affected by the generated feedback from ecological outcomes at time t. This indicates that socio-economic and ecological systems cannot be analysed in isolation. In this study, I mainly rely on the FE-IV estimation and use Sys-GMM technique for checking the robustness of the results.

Depending on the size of the rules and regulations, the resulting outcomes would be different. For instance, when there is no limit on the number of relevant actors and their activities, the increasing benefits from extraction result in resource destructions and high social costs. In other words, the generated destructive or preservative outcomes depend on the degree to which the actors self-organised and were: *(i)* internally motivated by social and moral norms; and *(ii)* effectively limited by law. On the other hand, empirical documents found mixed results on CO_2[55] (S. Dasgupta & De Cian, 2018), indicating that further research is still required to establish a clear relationship between institutions and carbon emissions.

To correctly analyse this relationship, I take account of both types of institutions in the model to proxy rules and norms. This is also in line with both traditional and updated collective action theory, in which the simultaneous presence of external formal power and cooperative behaviours are required for successfully removing the risks of free riding embedded in managing global public goods. It is expected that strong formal and good informal institutions in a country, individually or jointly, cause the least atmospheric concentration of greenhouse

[55] In contrast, the positive effects of institutions on particulates, such as SO_2, N_2O and CH_4 are well documented.

gases. Therefore, I expect to achieve an inverse statistical relationship between institutions and environmental degradation.

2.6 Discussion

In this section, all the revisions made to the SES framework, its subsystems and their internal variables will be discussed and reviewed carefully. So far, it has been shown that the framework can be applied to the current cross-country empirical study concerning the role of formal and informal institutions in improving air quality. I began initially by using the revised version of SES as the theoretical framework, and then shaped it in order to fit in the attributes of this study. In this process, the list of the second-tiered variables was modified based on the specific features of the particular research question, focal level of analysis and empirical specifications. The specific combination of the selected variables should finally be influential in the pattern of the studied interaction *(I7: self-organising activities)* and outcome *(O2: ecological performance measures)*. Below, the process of selecting the second-tier variables are discussed.

In this study, the earth's atmosphere is adopted as the *RS*, and the generated oxygen is the *RU*. They are consumed and contaminated in various ways (and by different rates) worldwide, indicating considerable variations across countries. However, *RS* and *RU* are treated as one aggregated component because, by definition, this global public good cannot be divided into smaller units. Due to the specific biophysical attributes of the *RS* and the macro level of analysis, only variables that can capture cross-country heterogeneities in the chosen *RS*, are considered useful in the structure of interaction and outcome. One of them is the *productivity of system (RS5)*. However, as previously discussed, there is no variable for measuring productivity; hence, I draw on two variables of *forests biocapacity (RS5-a)* and *energy use (RS5-b)* to control for the factors affecting *RS's* production-consumption rate. Also, the variations of *human-constructed facilities (RS4)*[56] and *predictability of system dynamics (RS7)*, though important factors, can be broadly captured through the inclusion of *S7 (technology)* and even *RS5* itself. Therefore, they will not be directly presented in the analysis.

The *GS*, in this study, refers to the alternative list of variables since it matches better with the employed theories. Due to the focal level of analysis, three critical variables of *regime type*

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[55] It affects actors' abilities to interfere into the system's natural process through the physical and technological constructions. It can be roughly shown by the technological level of a country, which potentially indicates people's overall ability to access the available technologies.

(GS4), rules-in-use (GS6) and *property-rights system (GS7)* are included in the model. They provide information on the qualities of formal political, legal and economic institutions across countries. For instance, *GS4,* which represents political institutions, is captured in this study by three variables: *political constraints index, polity score* and *the level of democracy*. Moreover, *GS6* stands for legal institutions and is further divided into three types: operational, collective and constitutional rules. However, due to data limitation, I can only include one variable for capturing the overall quality of the regulatory system in a country. Accordingly, two indicators of *law and order* and *corruption* are employed. Finally, *GS7,* which denotes the quality of economic institutions, for example, protection against expropriation risks, is measured in this study by *investment profile*.

Furthermore, a political system with deep historical origins is likely to be more stable than the governance arrangements that have been made more recently. They are also expected to produce relatively different outcomes. According to the prevailing theory, new governments tend to implement more economic-related policies, which are unfavourable to the environment, to satisfy public interests. However, long-lasting governance systems have longer horizons, which enable them to make more environment-friendly decisions. Therefore, in mature and politically stable (or durable) countries, regardless of their regime type, governments may supply more environmental goods (Fredriksson & Neumayer, 2013). As a result, scholars are encouraged to include a variable for capturing *GS10 (historical continuity)* (McGinnis & Ostrom, 2014, p. 10). In this study, however, it is captured by one of the broad Settings' variables *(S3: political stability),* as both capture the durability/stability of a political system.

Previously, it was mentioned that *A6 (norms, trust-reciprocity and social capital)* is selected for introducing informal institutions in the framework. However, *GS8 (repertoire of norms and strategy)* is a better proxy for this type of institutions. This is because it is an encompassing variable referring to the broad norms and strategies available to all actors engaged in the relevant social and cultural settings, while *A6* can be treated as the qualities of one actor. The same applies to informal institutions, because it is also a broad term including all norms, beliefs, culture and traditions. Therefore, informal institutions might be better interpreted as a feature of *GS* and not *A.* As McGinnis and Ostrom (2014) stated, *GS8* reflects numerous ways through which decisions related to the SES are influenced by culture, while *A6* refers to an actor who considers a norm or belief relevant to his/her actions in a particular setting. Therefore, informal institutions, from now on, is shown by the SES variable of *GS8*.

In the SES framework, the core category of *A* refers to different sets of relevant actors participating in various activities: extraction, production and consumption. Considering the particular attributes of this study, the critical factor of *A7 (knowledge of SES/ mental models)* will be directly included in the models by employing the variable, *human capital index*. It highlights the importance of learning, which can transform current harvesting practices into sustainable ones. Hence, it can also affect past extracting experiences that might have resulted in the destruction of resources, implying its correlation with *A3 (history or past experiences)*. Similarly, *A5 (leadership/entrepreneurship)* or leadership capabilities might also be affected by the existence of highly educated people in society. Thus, higher investment in education is positively correlated with conserving the environment as more actors are informed about and aware of their degrading activities and less likely to take polluting actions. Carattini and Jo (2018) found no effects of trust on GHG emissions between 1920 and 1980. They relate their results to the absence of awareness about global warming or climate change during that time.

Furthermore, *population (GS3)* and a *number of relevant actors (A1)* refer to the number of people affected by the *GS* and the ones who directly consume the *RS*, respectively. Although they are different from each other, they refer to the same factor (i.e., total population) in this study. This is because the level of analysis is at the country level and the studied resource system is a global common. Therefore, it involves the total population of a country (and all people worldwide). However, as they are strongly connected to the demographic trend *(S3)*, both will be excluded. Likewise, important variables of *A2 (socioeconomic attributes)* and *A9 (technologies available)* are strongly linked to *S1 (economic development)* and *S7 (technologies)*; thus, they can be excluded from the analysis.

Overall, a total of 12 different second-tier variables are selected to be incorporated into the regression models.[57] Specifically, seven variables are chosen from the three categories of resource systems *(RS5: productivity of the system; RS5-a: forests biocapacity; and RS5-b:*

[57] One may argue that the SES framework provides some degree of freedom to the researchers, since there are multitude of factors that are contained in the framework. Hence, a risk of cherry-picking existed (i.e., researchers select factors that they deem useful or for which they have data that proves their hypothesis). While this is a concern, Ostrom (2007) stated that this issue can be tackled by appealing to sound testable theories to select the relevant variables and build the quantitative model. In this study, as discussed above, I have appealed to political economy and collective action theories to build my empirical model. In addition, while the SES considers a broad set of potentially applicable variables, not all are relevant to every study. Because SES is a decomposable framework, meaning that one does not need to select all the internal variables within each core. Consequently, it provides enough structure in building empirical models for quantitative macro-scale studies like the present research.

energy use), governance systems *(GS4: regime type; GS6: rules-in-use; GS7: property-rights system; and GS8: repertoire of norms and strategies)*[58] and actors *(A7: knowledge of SES/mental models)*. Additionally, I also control for five of the broad Settings' variables, including *economic development (S1), demographic trends (S2), political stability (S3), media organisation (S6)* and *technology (S7)*. In addition, as discussed before, a variable representing the interaction of institutions will also be included in the quantitative models. Similarly, in GMM models only, the validity of the EKC relationship will be tested by incorporating a squared form of economic development into the dynamic models. All the above variables will, then, be regressed over the *O2 (ecological performance)*, which in this study is *carbon footprint per capita*.

Furthermore, the inclusion of 12 variables in my model can potentially cover 12 more second-tier variables as they are either fully or partly correlated with them.[59] To avoid confusion, all 24 variables (aside from *I&O*) are presented in Table 2.3, in which the coloured ones are directly included in my model, while the black ones are showing the potentially covered areas. As can be seen, the six factors (out of 10) that are correlated with self-organisation are among the selected variables. While only three of them *(RS5, GS6 A7)* will be included in the analysis directly, the other three variables *(RS7, A1, A7),* implicitly and through their association with other selected variables, will be considered. Because the scale of the study is at the macro level, the analysis will be limited to the inclusion of second-tier variables only. Still, relevant deeper level variables will also be used in case there is a need to delve deeper into the root causes of a problem within the system. Finally, the reasons for any inclusion or exclusion of the SES's variables are discussed further in Appendix I (Table 2.A1-2.A8).

[58] It is worth noting that not all of the selected *GS* variables will be simultaneously included in the model. In each regression model, one of the formal institutional variables *(GS4, GS6, or; GS7)* will join the informal one *(GS8).*

[59] The number of second-tier variables listed in the broad *S* and three cores of *RS*, *GS* and *A* (9) equals 35 in total. Two other subsystems of *RU* and *ECO* are excluded because they are not relevant to this study due to the focal level of analysis, empirical limitation and the specific resource system under study. From all the interactions and outcomes in this study, I only focus on two variables of *I7* and *O2*. See Appendix I, for further details.

Table 2.3. Selected second-tier variables and ecological performance

Top-tier Categories and their Selected Internal Second-Tier Variables					
1	**Social, Economic and Political Settings (S)**				
S1	Economic development	S2	Demographic trends	S3	Political stability
S6	Media organisation			S7	Technology
2	**Resource Systems (RS)**				
RS4	Human-constructed facilities	RS5*	Productivity of system	RS7*	Predictability of system dynamics
		RS5a	Forest biocapacity	RS8	Storage characteristics
		RS5b	Energy use		
4	**Governance Systems (GS)**				
GS2	Geographic scale of governance system	GS3	Population	GS4	Regime type
GS6*	Rules-in-use	GS7	Property-rights system	GS8	Repertoire of norms and strategies
		GS10	Historical continuity		
5	**Actors (A)**				
A1*	Number of relevant actors	A2	Socioeconomic attributes	A3	History or past experiences
A5*	Leadership/ Entrepreneurship	A6*	Norms (trust-reciprocity)/ Social capital	A7*	Knowledge of SES/ Mental models
		A9	Technologies available		
6	**Interactions (I) & Outcomes (O)**				
I7	Self-organising activities	O2	Ecological performance measures (sustainability, overharvested, resilience, and diversity)		

Notes: This table provides the list of 24 variables (aside from I&O). The coloured variables are directly included in the empirical model, while the black ones show the potentially covered areas. Six variables (out of 10) that are marked by asterisks in the table are among the variables upon which self-organisation is dependent. The colours in the table are those that Ostrom used in her papers for showing the SES's subsystems.

Although the long-term sustainability of SES is initially based on the actors or governments establishing required rules, the desired outcome might not be achieved if the implemented rules are not consistent with the attributes of the resource system, resource units and the norms of local people. Overall, the main challenge in finding the reasons for resource destruction or conservation is to identify useful multi-tiered variables from each core category and include their relationships in the analysis. To crack this complexity, one is required to gain knowledge about the variables and use interdisciplinary theories to uncover their connections. In this study, depending on the particular research question, the focal level of analysis and the empirical restrictions, the SES's subsystems are modified and structured in a way that can fit the research's particular attributes, highlighting the capability of the SES framework for studying the role of institutions in preventing environmental degradations across countries.

2.7 Conclusion

Access to natural resources can result in different outcomes for different countries caused by their institutional quality. In this research, I try to address this issue by empirically estimating the significant impacts of both formal and informal institutions on the environmental performance of poor, emerging and developed countries over 26 years, using FE-IV models. To that aim, I initially reviewed the traditional collective action theories, in which the presence of external formal authority is emphasised for achieving collective goals. Extensive failed examples of implementing public and private governance systems in all settings led to the emergence of the updated theory. These studies challenged the standard theory and proposed that, due to the presence of the risks of free riding in such commons, conservation would not be achieved unless cooperation and reciprocation induced by social and moral norms were observed among all individuals. They further introduced trust as a critical element in sustaining cooperation and reciprocation.

Now that the theories confirm the importance of including both formal and informal institutions in the analysis of environmental sustainability, to conduct the empirical study I need to rely on a conceptual framework for estimating the institution-environment relationship. To that purpose, the social-ecological systems (SES) framework is taken as the theoretical foundation for identifying relevant variables, collecting data, building my quantitative models and analysing the results. The significant part of this chapter was, thus, allocated to explaining how the SES framework works for performing the above jobs. On this basis, alterations were made to the SES framework and closely examined. This framework, which is usually employed for conducting qualitative case studies in micro-scale, was further reformed and reshaped to fit into this cross-country empirical study in macro scale. Indeed, adapting the SES framework for empirical purposes is what makes this study unique. It enables me to build a sound institutional foundation within the environmental context, which is one of the significant contributions of this study.

Moreover, as tackling the stock of carbon is the most pressing collective action problem confronting all people globally, it requires both governments and people's awareness and a range of actions at multiple levels to maintain and improve the environmental quality in a way that leads towards the sustainability. Therefore, building an inclusive community where all people from different backgrounds can trust each other and cooperate (reciprocate) to achieve collective goals becomes a significant issue for governments. As such, the results of this study can shed new light on how the level of trust can help to improve environmental challenges across different countries. Also, it helps to determine which types of institutions are more important in achieving sustainability in the global commons. Finally, the findings of this chapter will be used as a basis for collecting required data on the selected variables and building the quantitative model for estimating the institution-environment relationship in Chapter 3.

Chapter 3

Methodology

3.1 Introduction

This chapter presents the empirical model and statistical approaches required for estimating the effects of institutions on the environmental quality of countries. To that aim, the chapter is organised in three main parts. In the beginning, a basic equation is defined, constituents of which are the second-tier variables that are adopted from the SES framework. This part is then followed by an analytical section on possible empirical methods that are suitable for investigating the institution-environment relationship, and are suggested by previous research. By drawing on the positive and negative points of using each econometric method outlined in the first part, the next main part provides the baseline regression model, describes its components and reviews the main issues regarding its specification design.

Several alternative panel estimation methods, including ordinary least squares (OLS), fixed-effects OLS (FE-OLS), fixed-effects instrumental variables (FE-IV) and system generalised method of moments (Sys-GMM), will be utilised to estimate the specified regression model. Indeed, the present study is the only research in the environmental economics literature so far that utilises the FE-IV technique to explore the institution-environment relationship. Finally, after specifying the detailed empirical model, the data and variables required for measuring the quantitative equation are provided in the third part. In addition to evaluating the quantifiable variables and their sources, this part examines the employed sample of countries. This chapter ends with a conclusion.

3.2 Method Analysis

In order to empirically investigate the effects of formal and informal institutions on the environmental performance of countries, a basic equation is initially specified to give an overall picture of what the detailed empirical model would be. In this way, I try to maintain the consistency of the equation and its components by using the terms for describing the SES framework's sub-systems. Subsequently, the suggested statistical approaches in the literature are reviewed, followed by the estimation techniques I use for evaluating the relationship. This section aims to provide a basis for building the detailed empirical specifications and proposing econometric methods for carefully studying the institution-environment relationship, which will be presented in the last section of this chapter.

In this study, I hypothesised that environmental quality is a function of institutions:

$$Environmental\ Quality = f(Institutions, Controls) \quad (3.1)$$

In the SES framework, environmental quality is expressed as ecological performance ($EcoP$), and institutional attributes are condensed in the core of governance system (Gov). Although several more factors are controlled in the equation, they are mainly located in the core of broad settings in the framework, hence labelled by Set in the equation below:

$$EcoP = f(Gov, Set) \quad (3.2)$$

Where:

$EcoP$ corresponds to the sustainability of the resource system *(O2)* in the framework. It indicates the degree to which the selected resource system (earth's atmosphere) is disrupted by the amount of atmospheric CO_2 emissions.

Gov comprises four different factors concerning the rules and norms through which the incentives and behaviours of individuals are influenced. The key variables of interest in this study are listed as follows:

1. *Regime type (GS4)* represents the significance of the political system (e.g., democracy or autocracy) in managing the environment.
2. *Rules-in-use (GS6)* indicates the degree to which policies are implemented and constitutions are respected by a state government.
3. *Property-rights system (GS7)* reflects the positive effects of protection against expropriation risks in reducing pollution in a country.
4. *Repertoire of norms and strategies (GS8)*[60] includes all norms, cultures and beliefs that represent the quality of a community.

[60] It is substituted with the variable A6 norms, trust-reciprocity and social capital.

The first three factors refer to the political, legal and economic aspects of formal institutions, while the last one corresponds to the quality of informal institutions only. Furthermore, the interaction of informal institutions and any of the formal ones are helpful in understanding how informal institutions react in a different formal institutional context. Therefore, as discussed above, the term Gov is constituted of three parts, in which the possibility of including *(i)* any of the three formal rules are predicted to complement *(ii)* the norms and *(iii)* the generated interaction term.

Hence, I define Gov as a vector of the following variables:

$$Gov = \left(GS_{4,6,7}, GS_8, GS_{4,6,7} * GS_8\right), \tag{3. 3}$$

$$GS_{4,6,7} \in \{GS_4, GS_6, GS_7\}.$$

As said before, the term Set represents all the control variables that are required for capturing the cross-country heterogeneity. It is labelled as Set for the purpose of consistency only. It is essential to include these eight second-tier variables, as they actually improve the empirical assessment of the studied relationship. They are adopted from three main SES sub-systems:

I. *Social, Economic, and Political Settings (S)* comprises five significant factors:
   1. *Economic development (S1);*
   2. *Demographic trend (S2);*
   3. *Political stability (S3);*
   4. *Media organisation (S6);*
   5. *Technology (S7);*

   An increase in economic growth, overpopulation, overexploitation of resources and deforestation intensify concentration of GHGs, thus must be incorporated in the model. Hence, S is a vector of five variables:

$$S = (S_1, S_2, S_3, S_6, S_7) \tag{3. 4}$$

II. *Resource System (RS)* includes only one important biophysical attribute of the earth's atmosphere, and that is the *productivity of the resource system (RS5)*. However, the problem with *RS5* is that there is no data available for directly measuring it; instead, I draw on sources through which the natural rate of resource's productivity rate is affected. These sources focus on the rates of storing and releasing the carbon of a country:

6. *Forests (RS5-a):* One plausible way to measure the level of storing capacity is the extent to which a country is covered by forestlands.
7. *Fossil fuels (RS5-b):* The primary source of releasing air particulates into the atmosphere is from burning fossil fuels, varying from gas to liquid (e.g., oil) and solid fuels (e.g., coal).

$$RS = \left(RS_5^a, RS_5^b\right) \tag{3. 5}$$

III. *Actor (A)* also has one crucial factor that affects the likelihood of self-organisation:

8. *Knowledge of SES/mental models (A7):* the level of knowledge possessed by a nation affects its level of pollution. The more aware the people are, the less the pollution will be.

Now, I define Set as a vector of all the above variables:

$$Set = (S, RS, A) = \left(S_1, S_2, S_3, S_6, S_7, RS_5^a, RS_5^b, A_7\right) \tag{3. 6}$$

By combining expressions (3.3) and (3.6), (3.2) can be finally rewritten as:

$$\begin{aligned} EcoP = \quad & f(Gov, Set) \\ = \quad & f\left(GS_{4,6,7}, GS_8, GS_{4,6,7} * GS_8, Set\right) \\ = \quad & f(GS_{4,6,7}, GS_8, GS_{4,6,7} * GS_8, S, RS, A) \\ = \quad & f(\mathrm{GS}_{4,6,7}, GS_8, GS_{4,6,7} * GS_8, S_1, S_2, S_3, S_6, S_7, RS_5^a, RS_5^b, A_7) \end{aligned} \tag{3. 7}$$

As (3.7) shows, the ecological performance (*O2)* or carbon emissions is regressed over 11 second-tier variables, grouped into Gov and Set, respectively. The above expression is also consistent with the process of self-organisation in the SES framework. It says if the rules and norms are consistent with the attributes of the resource system and local communities, the likelihood of self-organised activities would be higher, and thus the long-term sustainability of

SES is achievable. This is actually what (3.7) indicates: the probability of an actor's self-organisation depends on the quality of formal (rules) and informal (norms) institutions, complemented by the qualities attributed to the studied resource system (productivity) and actor (knowledge). All mentioned factors are incorporated in the last expression (3.7).

For testing the institution-environment relationship through quantifiable variables, empirical studies in the applied economics literature mostly relied on cross-sectional and longitudinal data (S. Dasgupta & De Cian, 2018). To estimate (3.7), different econometric approaches in panel data models including OLS, FE-OLS, FE-IV and Sys-GMM are beneficial. Building on previous works, I explain conventional econometric approaches used for estimating the relationship and several design issues related to the empirical analysis. These proposed approaches are discussed below.

3.2.1 Ordinary Least Squares (OLS)

Some studies in the field of environmental economics used simple OLS for estimating the effects of political institutions on environmental indicators. For instance, Ehrhardt-Martinez et al. (2002) estimated the effects of democracy and scope of governmental actions (as parts of the political modernisation variables) on the average annual rate of deforestation for 74 less developed countries (LDCs) between 1980 and 1995, using OLS with Huber-White heteroscedasticity-consistent standard errors. The same empirical method was also taken by Scruggs and Rivera (2008) for estimating the impact of democracy on three groups of air, water and land degradation indicators in 1990 and 2000 for 169 countries.

OLS regression is appealing because of its simplicity. It is the first point of estimation in almost any study. It fits a linear line through all data points and produces results accordingly. On the one hand, OLS estimation enables one to have an overall picture of the potential relationships among the specified variables. On the other hand, coefficients and the statistical significance of independent regressors are not reliable, particularly when the condition of strict exogeneity is violated. Additionally, OLS would generate biased and inefficient standard errors when heteroscedasticity is presented. Considering these issues, it can be said that the established relationship with OLS might be just a correlation; thus, the reported results are unreliable.

Further, this statistical approach is mainly adopted because of data limitations (Esty & Porter, 2005; Q. Li & Reuveny, 2006; Ward, 2008). For instance, Ward (2008) examined the role of political factors such as democracy, stability and the presence of a green party in the government on *carbon footprint per capita* for up to 128 countries around the year 2000, using cross-sectional OLS. Q. Li and Reuveny (2006) also used cross-sectional analysis for four environmental indicators of nitrogen oxides emissions, deforestation, soil erosion and land degradation, and applied panel data analysis for carbon and water pollution for different samples of countries.[61]

The literature using the statistical approach indicates that for carbon emissions, annual cross-country data is available; however, for deforestation, land degradation, or several types of pollution, only cross-sectional datasets can be constructed, resulting in domination of the literature by the cross-sectional approach (Bättig & Bernauer, 2009; Jorgenson, 2006; Q. Li & Reuveny, 2006; Midlarsky, 1998; Neumayer, 2002; Shandra, 2007; Ward, 2008). In fact, the choice of empirical specification in this field is dictated by data availability; this is the most common restriction that several scholars faced for conducting analyses on the effects of different types of institutions on multiple environmental indicators. In this study, I try to overcome this obstacle by adopting high quality data from reputable databases.

3.2.2 Fixed-Effects (FE) OLS

One of the main flaws of the simple OLS regression is that this econometric approach does not take into account the unobserved heterogeneity and country-specific factors that can significantly influence the institution-environment relationship. Variables like national structural variables (e.g., climatic and geographical features) may affect environmental degradation. Failing to account for such factors (as in pooled OLS) may affect the whole regression negatively and produce biased results. Thus, in a panel data model, the vector of country-specific effects is essential, as the imposition of the limit, in which underlying structure is the same for each cross-sectional unit, is required (Castiglione, Infante, & Smirnova, 2015).

Since unobserved country-specific factors are hardly measurable by quantifiable variables, they can be considered in the model by the addition of a two-way fixed-effects estimator. The inclusion of such estimator in the simple OLS regression incorporates a separate intercept for each country in each year, resulting in the application of fixed-effects analysis (Q. Li & Reuveny, 2006). The panel FE-OLS, in fact, fits a separate line through data points for each

[61] Q. Li and Reuveny (2006) used different samples of 105 or 102-143 or 142 countries over 1961-1997. The number of countries varies because of the data limitation arisen from adopting different environmental indices.

country. The final fitted line that represents the entire sample regression line is the aggregation of all separate lines fitted for each country.

Therefore, compared to simple OLS models, rather more reliable results can be estimated. In the case of only carbon emissions and water pollution, Q. Li and Reuveny (2006) concluded that statistical results and inferences which are estimated with FE-OLS are likely to be more reliable than estimations with both pooled and cross-sectional OLS. Comparatively, fewer studies have used FE-OLS to estimate the institution-environment relationship. In one of the early studies, Deacon (2003) employed a sample of 130 countries between 1980 and 1996 and estimated the effects of democracy/autocracy on the lead content of gasoline using panel FE-OLS. The same approach was also used by S. Dasgupta, De Cian, and Verdolini (2017) in a recent study on the effects of good governance on energy transition for a panel of 20 countries (1995-2010).[62]

3.2.3 FE-Instrumental Variable (IV)

The second most common specification problem concerns the issue of endogeneity. Most of the studies mentioned above treated the right-hand-side of the equation as exogenous. However, when one or more explanatory variables are correlated with the error term, fixed- or random-effects OLS models are no longer beneficial. The fixed-effect analysis can adequately address the issue of unobserved heterogeneity; however, it is implemented under the strict assumption of exogeneity, which presumes that the distribution of explanatory variables is independent of any other source of variations. Moreover, it cannot address the issue of time-varying unobserved heterogeneity. The failure of FE-OLS estimates in solving issues related to potential endogeneity results in the violation of the zero conditional mean assumption. In this case, this type of regression is not reliable anymore as it generates biased and inconsistent results.

In order to correct for endogeneity, an instrument must be specified through which the endogenous regressor is affected solely. In other words, the instrument can affect the dependent variable only through the endogenous variable (i.e., the indirect effect). This instrument should also be exogenous and independent from the error term. Specifically, the excluded instrument must meet three conditions of having *(i)* an independent distribution from the error term, *(ii)*

[62] In two studies conducted by Barrett and Graddy (2000) and Neumayer (2003) on small samples of countries over more than 10 years, both panel fixed- and random-effects linear regressions were adopted to empirically evaluate the strength of left-wing/green parties on the reduction of multiple air particulates.

high correlation with the endogenous regressors and *(iii)* an indirect effect on the response variable (exclusion restriction). In fact, the instrumental variable approach relies on the above conditions (Baum, Schaffer, & Stillman, 2003, 2007).

However, it is not easy to find valid instruments that satisfy all three conditions simultaneously. Because institutions are inherently endogenous, determined by deep historical factors (Acemoglu, Johnson, & Robinson, 2001; Eicher & Leukert, 2009), the standard empirical strategy in the institutional analysis is the application of the IV method (Eicher & Leukert, 2009). Regarding model specification, the fixed-effects estimator is still required to be added to the model to control for the cross-sectional unobserved factors.[63] However, the presence of the FE estimator makes the process of finding a valid instrument even more difficult. Therefore, a time-variant instrument must be used for solving the issue of endogenous institutions (Cole, 2007). The difficulty in finding one has resulted in there being almost no research on environmental analysis using the FE-IV approach. Therefore, to my knowledge, the present study is the only research in the environmental economics literature so far that utilises the FE-IV technique to explore in the institution-environment relationship.[64]

The following four studies implemented the IV strategy; however, they used either cross-sectional data or random-effects in the case of panel data. For instance, Fredriksson and Neumayer (2013) and Tebaldi and Elmslie (2013) utilised cross-sectional data, and thus implemented IV-2SLS estimator to instrument institutions such as democratic capital stock (i.e., countries' historical experience with democracy), the rule of law and contract enforcement in order to remove the potential endogeneity. Using data for 94 countries covering 14 years (1987–2000), Cole (2007) applied random-effects IV to estimate both direct and indirect impacts of corruption on air pollution emissions, including carbon and sulphur dioxide. Likewise, Binder and Neumayer (2005) implemented RE-IV estimation to evaluate the strength of environmental NGOs and democracy on air pollution for a panel of 35 countries (1977-88).

3.2.4 Generalised Method of Moments (GMM)

In comparison with the above empirical strategies, the method of GMM recently has become popular amongst scholars. It is particularly beneficial for capturing the inherent dynamism in

[63] FE-IV estimator is a form of two-stage least squares within the estimator.

[64] In this research, by using the IV strategy, I tried for correcting two main sources of endogeneity: measurement error and omitted variables bias. However, in an extreme case, where climate disasters lead to riots, the reverse causality can also be considered as another source of endogeneity. Therefore, in a sense, this study corrects for all three types of endogeneity sources.

environmental analysis (Tamazian & Rao, 2010) and confirming the traditional EKC relationship (Budhi Utomo & Widodo, 2019). As Halkos (2003) noted, the complex interaction between carbon emissions and economic development is dynamic rather than linear; hence, the use of random-/fixed-effects OLS in the previous research cannot appropriately indicate the EKC pattern mainly due to misspecification problems that suffer from heteroscedasticity and endogeneity.

Two common approaches for estimating dynamic panel data models are the difference- and system-GMM. Difference-GMM was first introduced by Arellano and Bond (1991). In this type of estimation, the lagged-levels of the explanatory variables are used as instruments for the corresponding variables in the first-differenced equation. To avoid the problem of the weak instrumental variable in Diff-GMM, Arellano and Bover (1995) and Blundell and Bond (1998) further proposed the system-GMM estimator. In order to increase model efficiency, in system-GMM, the transformed equation (in difference) is coupled with the original equation (in level). In this case, the lagged differences of variables will be then added as further instruments for endogenous variables.

In addition, GMM dynamic panel data models are robust to the presence of a potential endogeneity problem, in which explanatory variables are dependent on the past or present values of themselves, as a result of constructing several instruments from the variables. Moreover, GMM models can also eliminate the unobservable country-specific heterogeneity through first-differencing all variables. The estimations are also robust to the presence of heteroscedasticity. The researchers mentioned below used either Diff-/Sys-GMM approach to estimate the impacts of policy- or income-related indicators on the rate of carbon emissions and income-emissions (EKC) relationship across different samples of countries.

For instance, Apergis and Ozturk (2015) and Joshi and Beck (2018) analysed the impacts of political variables, including political freedom and stability, quality of regulation and corruption for a panel of 14 Asian (1990-2011) and 109 non-/OECD countries (1995-2010), respectively using difference and system GMM model estimations. Likewise, the sole effects of economic indicators, including economic growth and (non-/renewable) energy consumption, were also estimated for samples of 28 provinces in China (1996-2012) (T. Li, Wang, & Zhao, 2016), 42 developed countries (2002-2011) (Ito, 2017) and 116 countries (1990-2014) (Acheampong, 2018), using one- and two-step difference- and system-GMM.

Compared to the OLS estimations, the dynamic panel GMM model can perform better in the presence of misspecification problems like endogeneity. Also, it is a form of an IV estimation technique that can achieve consistency and accuracy (Halkos, 2003) by relaxing the assumptions of serial correlation and heteroscedasticity (Ito, 2017).[65]

3.3 Empirical Model Specification

In order to measure the effects of institutions on the level of pollution, this study's methodology is based around the estimation of the following general baseline regression model. Using the above-mentioned variables, I re-specify the basic equation (3.7) as:

$$y_{it} = \alpha + \boldsymbol{\beta_1}\, \boldsymbol{X_{it}} + \boldsymbol{\beta_2}\, \boldsymbol{Z_{it}} + \gamma_i + \kappa_t + \varepsilon_{it} \qquad (3.\ 8)$$

Where:

y_{it} is the dependent variable indicating *carbon footprint per capita*. Subscripts i and t denote *country* and *year,* respectively. α is the *constant term*, and $\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$ are *the vectors of unknown parameters.* In addition, $\boldsymbol{X_{it}}$ is *the vector of institutions*, including formal, informal and the interactive term. For formal institutions, *political constraints index* is used as the primary variable. The other formal institutions can be substituted. For informal institutions, *religious tensions* is employed. For the interaction of formal and informal institutions, the product of the abovementioned variables is used.

Equation (3.8) also includes $\boldsymbol{Z}$, *a vector of additional explanatory variables*. It includes *log-transformed of GDP per capita* in order to capture the level of: economic development; *population growth rate* for showing the demographic trend; *government stability* for representing political stability; and *press freedom* and *total factor productivity growth* for representing media organisation and technological development. These explanatory variables have been commonly used within the literature. Additionally, three more variables are controlled in (3.8) in the same vector ($\boldsymbol{Z}$), two of which are about the biophysical attributes of the atmosphere, and the third one represents the quality of people. Hence, *forest biocapacity*,

[65] One main problem with GMM estimation is that it can be easily manipulated by altering the number of lags, defining instruments, and choosing between diff- and sys-GMM estimators. Therefore, it is difficult to find papers that explain the procedures they followed to obtain their GMM estimations. For instance, one study refer to its GMM method very briefly in one sentence in a footnote Esty and Porter (2005, p. 410) without providing any further details.

energy use and *human capital index* are included. Finally, γ_i and κ_t represent *country-specific* and *year effects* and ε_{it} denotes *the error term.*

Several alternative panel estimation methods, including OLS, FE-OLS, FE-IV, and Sys-GMM, are utilised to estimate the above regression model. First, I estimate regression (3.8) with the OLS model, ignoring any mismeasurement issue. Since cross-sectional time-series data is employed, I then add the fixed-effects estimator (γ_i) to protect against the potential risks of missing unobserved country-specific heterogeneity in the model. So, (3.8) is re-estimated by FE-OLS in the second step. Additionally, equation (3.8) suffers from the potential endogeneity problem, since *carbon footprint* is a function of formal and informal institutions, yet both types of institutions are likely to be the function of other variables called instruments. To be successful, instruments should not be correlated with the error term (ε_{it}) in (3.8). The presence of the fixed-effects estimator also (γ_i) implies that instruments must be time-variant. Therefore, to deal with the common issue of endogeneity, the FE-IV approach should be applied in the third step.

Finally, to capture the dynamic nature and evolutionary character of the environmental problems, the GMM approach should be utilised. The dynamism can be modelled empirically through the inclusion of the lags of the dependent variable as additional explanatory variables to the right-hand-side of the equation. Therefore, model (3.8) can be redefined as follows:

$$y_{it} = \alpha + \lambda\, y_{it-1} + \boldsymbol{\beta_1}\, \boldsymbol{X_{it}} + \boldsymbol{\beta_2}\, \boldsymbol{Z_{it}} + \kappa_t + \varepsilon_{it} \tag{3. 9}$$

Where:

y_{it-1} indicates lag of the dependent variable,[66] and λ is *an unknown parameter* to be estimated. Additionally, to confirm the validity of the Kuznets-type income-emissions relationship in the model, *the vector of* $\boldsymbol{Z}$ now includes *income per capita squared*. By doing that, the traditional EKC specification is augmented by the inclusion of the selected institutional variables. Moreover, panel-level effects (or cross-sectional heterogeneity) are eliminated from GMM models. Therefore, it is not required to have an individual fixed-effects estimator in (3.9). To avoid the problem of the weak instrumental variable, I use the two-step system-GMM estimator, in which further instruments can be constructed by adding the lagged-difference of

[66] The possibility of including a higher order of lags are predicted in GMM.

explanatory variables to the lagged-level variables. These additional moment conditions are orthogonal to the levels of disturbances (ε_{it}). Finally, κ_t represent *year effects* and ε_{it} denotes *the error term.*

In order to estimate the institution-environment nexus and evaluate the robustness and sensitivity of the results, four alternative panel econometric approaches are utilised. The FE-IV approach is considered as the main approach in this study; however, in all estimation techniques I use, including simple OLS, the risks of heteroscedasticity and serial correlation are adequately addressed. To avoid getting inefficient and biased standard errors, OLS and IV, as well as GMM models, have been estimated with Huber-White heteroscedasticity-consistent and Windmeijer (2005) bias-corrected (robust) standard errors, respectively.

Furthermore, to control for possible serial correlation, year dummies are also included to capture general trends observed during the sample period, due to the existence of macro shocks (e.g., trend in income and economic activities) that may affect countries in the same way. The inclusion of the lagged dependent variable also helps time trend to capture the temporal dynamics in panel data. Besides, the inclusion of the fixed-effects estimator and lagged dependent variable, make finding statistically significant results even harder, as they absorb the variations in the dependent variable that could otherwise be explained by other explanatory variables (Q. Li & Reuveny, 2006).

Finally, the inclusion of all the above three factors ($\gamma_i, \kappa_t, y_{it-1}$) in equations (3.8) and (3.9) help to control for different causal determinants of environmental degradations, which means, for instance, that the comparison of the effects of institutions (e.g., democracy) on different environmental performance indicators is plausible (Q. Li & Reuveny, 2006).

3.4 Data

In the empirical literature on the institution-environment relationship, the main hypothesis that has been broadly tested is about the role of democracy in ensuring environmental quality, meaning that the impacts of institutions on different environmental outcomes are mainly examined through the inclusion of political factors (S. Dasgupta & De Cian, 2018). The most frequently used institutional indicators are the measures of democracy (from Polity IV and Freedom House databases), corruption and the rule of law. Indicators related to the strength of civil society and to economic institutions have also been used. Likewise, the most commonly adopted environmental indicators are focused on different types of air pollutants (i.e., emissions indicators) such as carbon and sulphur dioxide, nitrogen oxides, methane and other air pollutants.

As discussed in the previous chapter, 12 different second-tier variables are adopted from the SES framework. These variables, which are extracted from three cores of *GS*, *RS*, *A* and broad *settings*, will be incorporated into the baseline regression models. Below, I will present the quantifiable variables employed for measuring each of the SES' variables. I will describe what each proposed variable is capturing and from which source is adopted.

3.4.1 Dependent Variable

In this study, I focus on ecological performance *(O2)* of the SES framework. It measures the degree to which the resource system is protected or degraded. Because the earth's atmosphere is selected as the *RS*, *O2* corresponds to the extent to which the *RS* is disrupted.[67]

It has been discussed that the atmospheric disruption is caused by the extensive emissions of greenhouse gasses, including carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NO_x), methane (CH_4) and other pollutants. They vary in terms of their relative contributions to global warming.[68] For instance, while CO_2 is the most prevalent GHG present in the layers of the atmosphere, it has 28-times less destructive power than CH_4 (Ritchie & Roser, 2020). Hence, global warming would be intensified if a more substantial amount of CH_4 was released into the atmosphere.

However, given the time frame of this study, an appropriate variable is the one that can capture to a great extent the contamination level of the atmosphere and its generated oxygen. Moreover, reliable data should be available for almost all countries and more extended periods. It matters especially when the sources of pollution (i.e., the polluting sector or type of fossil fuels) are needed for carrying out the in-depth investigation. Consequently, in this study, I focus on the emissions from CO_2, as they have the above two features. They are the most significant source of atmospheric emissions by far, accounting for three-fourths of the total atmospheric emissions.[69] In addition, reliable annual data can be found by country, sectors of a country and

[67] In the case of air pollution, it is easier to measure the disruptions than the conservation.

[68] These variations in terms of their relative impacts on the atmosphere can be measured by their Global Warming Potential on a 100 year-time-scale (GWP_{100}).

[69] Currently, carbon is the most significant portion of humanity's footprint.

type of the fossil fuels a country uses, and for much earlier than the commencement of this study (1990 to almost the current day).

Further, it can be concluded from the existing literature that CO_2 is a particularly problematic gas. There is well-stablished literature on the positive effects of institutions on mitigating other greenhouse gasses. However, several seminal works have not been able to conclude a definite relationship on CO_2 emissions per se, within which both positive (Castiglione et al., 2015; Cole, 2007; Q. Li & Reuveny, 2006; Neumayer, 2003) and negative (Carlsson & Lundström, 2003; Joshi & Beck, 2018; Midlarsky, 1998; Scruggs & Rivera, 2008) impacts of institutions are documented. Some of the mentioned studies attributed these mixed results to the employed dependent variable.

In this study, I try to scrutinise this relationship by focusing on a different variable for capturing cross-country variations in carbon emissions. Therefore, I take *carbon footprint per capita* from the Global Footprint Network (GFN) (Lin et al., 2018) as the main dependent variable in the baseline regression model. Analogous to other variables, it measures CO_2 emissions stemming from burning fossil fuels, covering the years between 1961 and 2014. This variable actually measures total carbon emissions produced within the geographical borders of a country, thus comes from the production side. It has been previously used by (Ward, 2008, p. 390).[70]

However, *carbon footprint per capita* is different from other such variables, primarily in terms of the unit of measurement employed. The most common environmental indicator used in the literature is *CO_2 emissions* reported in the World Development Indicators (WDI) from the World Bank database. It is expressed in different units such as kilo/million tonnes of emissions. The *carbon footprint*, however, reports the tonnes of CO_2 emissions as the size of biologically productive land area (in hectare) that is required for sequestering the emitted carbon. Biological productivity of the land area is, in fact, indicating the biological capacity of a country for absorbing the emissions (i.e., productive land area = biocapacity), given current technology and management practices.

If there is not enough biocapacity, the emitted carbon will be accumulated in the atmosphere; thus, the country is prone to experience the effects of global warming. However, the

[70] Ward (2008) considered *carbon footprint* as a strong measure of sustainability in his analysis.

productivity of the land area is not the same across countries, and this should be reflected in the construction of the variable. Therefore, to make biocapacity comparable across space and time, each land area needs to be proportionately adjusted to its productivity level. Hence, the areas are converted to a globally comparable standardised hectare. These adjusted areas are expressed in global hectares (gha). In effect, a combination of two conversion factors (yield factors and equivalence factors) translates hectares into global hectares.[71]

Moreover, *carbon footprint per capita* better matches with the theories on which the SES framework is based. I mentioned above that the *O2* signifies the degree to which the *RS* is disrupted by anthropogenic causes. Burning fossil fuels along with the ratio of a land covered in forests affects the *RS* disruptions by changing the process of storing-releasing carbon into the atmosphere (i.e., productivity of the *RS*). While both of these two criteria are considered in the construction of *carbon footprint*, *CO_2 emissions* can only capture one aspect, and that is the amount of carbon emitted from fossil fuel burning.

As a matter of fact, *carbon footprint per capita* represents the area of forestland required for absorbing all the anthropogenic CO_2 emissions. It highlights the presence of two *RSs* at once in the analysis. In this situation, as McGinnis and Ostrom (2014) stated, if both *RSs* are inter-related, then they can be treated as one aggregated *RS*. Hence, the variable is not contradictory with the framework. Higher values indicate the higher biocapacity required to absorb carbon emissions in a country. Measuring it in this way can adequately address problems caused by global warming because it emerges due to the insufficient biocapacity of the earth to neutralise all the carbon dioxide emissions.

3.4.2 Independent Variables

In this sub-section, only the key independent variables of this study are going to be explained. Four critical regressors that are related to the measures of formal and informal institutions all reside within the core of governance system in the SES framework. As discussed earlier, formal institutions are categorised into political, legal and economic institutions, a classification that is also aligned with the SES framework. They are indicated by three SES variables *(GS4: regime type; GS6: rules-in-use; GS7: property-rights system)*, each of which will be used separately in regression models. The fourth one shows the quality of informal institutions *(GS8:*

[71] The details of the conversion are presented in Appendix II.

repertoire of norms and strategies). Further, a separate variable will also be specified for taking account of the interaction of formal and informal institutions.[72]

Political Institutions

In the empirical literature, political institutions are examined more frequently than the other two, indicating the importance of such factors in reducing environmental degradations. Below, the measures used for proxying formal political institutions are described.

As *GS4* shows, for formal political institutions, I focus on the possession of democratic (or autocratic) institutions by a country. It is empirically shown that, unlike autocracy, democratic systems are in favour of protecting the environment because, in this political system, politicians can be elected by people. In other words, they can be pressurised by the public as well. If people care about preserving the environment, and politicians seek re-election, then it is expected that more environmental policies are adopted in democratic countries. In a sense, politicians, by implementing policies, are trying to satisfy public demands.

However, the opposite is empirically documented as well, indicating that democracy is not always in favour of environmental conservation. One potential reason for explaining such an outcome is that democracy is a factor of economic prosperity. In the short-term, economic development comes at the expense of degrading the environment, through exploiting more natural resources and releasing pollutants. Therefore, democracy degrades the environment. To reveal the effects of democratic systems on reducing different types of GHG emissions, especially CO_2, many studies have been conducted. However, the relationship remains unclear.

To avoid obtaining ambiguous results and to build a robust relationship, I adopt three different variables from the most reliable databases. First, for representing the quality of political institutions, I use *political constraints index V* [73] from POLCON dataset (Henisz, 2017) as the primary independent variable in my baseline regression model. *Political constraints index* determines the extent of constraints faced by politicians in changing a status quo policy in a country in a given year. In other words, it measures the feasibility of a change in government policy as a result of the change in any one political elite's preference.

[72] In each model, only the interaction of one of the formal institutions *(GS4; GS6; GS7)* with *GS8* will be used.

[73] The data for this variable is available for 157 countries from 1960 to 2016.

Political constraints index ranges from zero (the least constrained - no checks and balances) to one (the most constrained – extensive checks and balances). Therefore, higher values show higher constraints and lower possibility of overturning a government policy. It is based on *(i)* the number of de jure veto points in a given political system; and *(ii)* the extent of alignment across and within branches.[74] Therefore, it is expected that each additional independent branch of government with veto power over policy change provides a positive effect on the total level of constraints. Countries without valid veto points are assigned with the lowest score.

This political measure was first constructed and used by Henisz (2000) and further used by other scholars, including Cole and Fredriksson (2009). I draw on *political constraints index* as the main variable for formal political institutions because, on the one hand, it does not judge the whole political system of a country by the label. Regardless of whether a country is democratic or autocratic, it explains the extent to which political elites and their decisions are constrained effectively in a given polity. On the other hand, it indirectly measures democracy to some extent, through the extent of constraints imposed on executives, as better democracies are in line with higher constraints.

This variable is also consistent with Ostrom and Cox (2010), who claimed that decentralised systems are a suitable institutional structure for handling contemporary environmental challenges. This is because the higher the constraints, the higher the decentralisation, and thus the higher the likelihood of decreasing emissions will be. The claim is also supported by Acemoglu et al. (2003). They said that constraints on executives proxy the concentration of power in the hands of the ruling group. This also links to one of the three features of the North's definition of institutions, that is, the rules of the game that place constraints on human behaviours (Acemoglu & Robinson, 2010).

Next, to be consistent with the literature, I also look into the role of democracy in reducing carbon emissions. To do so, I take the two most common variables of *polity score* and *level of democracy*. They are adopted from the most reliable and reputable databases of Polity IV Project and Quality of Government (QoG), respectively. The Polity IV dataset provides data on the *polity score*, covering 167 major independent countries (with a total population of 500,000 or more in the most recent year) around the world over the period 1800-2017.

[74] Whether the legislature is aligned with (independent from) the executive, the measure of constraints is affected negatively (positively). Further, the degree of heterogeneity (homogeneity) of party preferences within an aligned (opposition) branch of government is positively correlated with constraints on the executive and policy change.

Polity score is the most closely scrutinised data series on political issues. It is a combination of *democracy* and *autocracy scores*. It is derived simply by subtracting the *autocracy* value from the *democracy* value, each of which is an additive 11-point indicator $(0 - 10)$. The unified score ranges between -10 (strongly autocratic - hereditary monarchy) and $+10$ (strongly democratic – consolidated democracy). If a country's political system were characterised as or lean toward an autocracy, it would receive a value from zero to 10 in the original *autocracy score*. Likewise, it would receive a value from zero to positive 10 in the original *democracy score*, if it were among democratic countries.

The combination of these two variables captures the spectrum of a regime authority on a 21-point scale. The higher score a polity receives, the more democratic it is. Nonetheless, many polities have mixed authority traits, and thus can have middling scores on both *autocracy* and *democracy* indices. In this vein, the *polity score* can be converted into three regime classifications: "autocracy" (-10 to -6), "anocracy" (-5 to $+5$ including three values of $-66, -77$ and -88)[75]; and "democracy" ($+6$ to $+10$). In this study, I take the revised version of the *polity score;*[76] which is also adopted by Fredriksson and Neumayer (2013, p. 13); Koubi, Bernauer, Kalbhenn, and Spilker (2012, p. 120); Q. Li and Reuveny (2006, p. 941).

The third measure of formal political institutions used in this study is the *level of democracy*. It is the enhanced version of *polity score*, in which two variables of political rights and civil liberties are added. In other words, the *level of democracy* is based on three variables of *polity score*, *political rights* and *civil liberties*, each of which is initially transformed into an 11-point indicator $(0 - 10)$. They are then averaged into a single variable, by which the *level of democracy* is measured in 174 countries on an 11-point scale (1972-2017). The scale ranges from 0 to 10, where 0 shows the least democratic and 10 shows the most democratic countries.

These additional two features are essential in reducing emissions, as *(i)* their positive effects on reducing emissions have been established in the literature (Barrett & Graddy, 2000, p. 435; Neumayer, 2002, p. 145; Scruggs & Rivera, 2008, p. 13); and *(ii)* their addition to the *polity score* made a better measure of democracy. As Hadenius and Teorell (2005) claimed, the *level*

[75] Standardized Authority Codes of $-66, -77$ and -88 are further converted and revised, and thus create the variable *revised combined polity score*.

[76] All the revisions made to the original *polity score* are further discussed in Appendix II.

of democracy performs better in terms of both reliability and validity than its three components. In this study, I take the imputed version[77] of the variable.

Legal and Economic Institutions

In the SES framework, I have a separate variable (*GS6: rules-in-use)* that refers to the overall regulatory quality (i.e., legal institutions) of a country. To measure such institutions, I take two variables of *law and order* and *corruption* from International Country Risk Guide (ICRG) dataset.

The first one, *law and order*, which is used by Ivanova (2011, p. 59) and Busse and Hefeker (2007, p. 400), is comprised of two elements. The "law" component measures the strength and impartiality of the legal system. The "order" part measures popular observance of the law (i.e., how frequently laws are ignored for different aims, e.g., political purposes). In other words, *law and order* assesses the laws, per se, in terms of transparency and independency, and whether they are predictable, impartial and equally enforced. This variable ranges from 0 to 6, with higher scores, show a better quality of the legal system (i.e. the higher the value, the lower the risk), and hence an inverse relationship with carbon emissions.

The second variable, *corruption*, measures the level of corruption within the realm of politics (e.g., suspiciously close ties between politicians and businesses), which can be seen in the forms of financial aids, excessive patronage, favouritism granted to close families including job reservations, and secret party funding. This variable indicates whether public officials respect the laws by measuring their degree of compliance. *Corruption* ranges between 0 and 6, with higher scores indicate lesser risk of corruption. Hence, the higher the values are, the lower the corruption is in a given country, showing an inverse relationship with carbon emissions. This variable was first introduced in the seminal work of Knack and Keefer (1995, p. 211) and subsequently used by several authors including Cole (2007, p. 640); Ivanova (2011, p. 59) and Fredriksson and Neumayer (2016, p. 452).

For economic institutions, as denoted in the framework *(GS7: property-rights system)*, I need to focus on a variable that can adequately measure the quality of the property-rights protection. I will draw on the *investment profile* from the ICRG database, as it is an inclusive measure that

[77] Where data on *polity score* is missing, the values are imputed by regressing *polity score* on the average of *political rights* and *civil liberties*. Hence, this produces more observations for countries.

covers factors affecting the risks associated with inward investment, which are not covered by other political, economic and financial risk components. It is a compilation of three elements: expropriation risks (or contract viability);[78] profits repatriation; and payment delays. For assessing economic institutions in the literature, the proxy of protection against expropriation risks has been extensively used by Acemoglu et al. (2001); Besley and Reynal-Querol (2014); Knack and Keefer (1995). For further details on the variable, see Appendix II.

As shown above, several empirical research projects found a strong positive link between the legal and economic institutions' variables and emissions reduction within and across countries. I use those measures in the empirical models for two important reasons. The first reason is to be consistent with the conceptual framework. As mentioned in the SES framework, one is required to explore (rather than eliminate) as much as possible in the second-tier variables in order to be able to establish a clear relationship between different components of the social and ecological systems.

The second reason is to build a robust relationship. One of the main purposes of this study is to build a clear and robust relationship between formal institutions and CO_2 emissions. One way to do that is to employ various widely-used variables, representing different aspects of political, economic and legal institutions and check how they statistically behave within an environmental context. Alternatively, one can utilise different statistical methods with the same combination of variables to see if the results are consistent within one's study and across the literature. I do both. I draw on six different formal institutional variables and estimate their impacts on carbon emissions using four statistical methods: panel OLS, FE-OLS, FE-IV, and Sys-GMM. Therefore, the regressions' results are expected to be robust.

Informal Institutions

In the SES framework, there are two variables that are directly related to social and moral norms. In a sense, this indicates the importance of informal institutions in solving ecological challenges. The first one is *GS8* (repertoire of norms and strategies), which reflects numerous ways through which actors' decisions are influenced by culture. The second one is *A6* (norms, trust-reciprocity/social capital), which refers to an actor whose actions are shaped by his/her norm or belief. Theoretically speaking, informal institutions is better interpreted as a feature of *GS*

[78] Expropriation risks is a proxy for property-rights protection. It used to be defined as a separate variable; however, since 1997, it has become one of the sub-components of the *investment profile*.

because it is a broad term that includes all norms, beliefs, cultures and traditions, while *A6* can be treated as the qualities of one actor.

Now that *GS8* is preferred over *A6*, I need to specify a variable that can be a good proxy for informal institutions. One of the most common variables for quantifying informal institutions is the World Value Survey (WVS) measure of "trust." There is, in fact, well-established literature on the strong positive effects of *WVS trust* on economic growth (Algan & Cahuc, 2010; Knack & Keefer, 1997; Zak & Knack, 2001). However, previous institutional studies in the context of the environment have failed to include trust or, more broadly, informal institutions in their analysis.

In this study, I also do not focus on *WVS trust* for two reasons.[79] To avoid losing observations and obtaining biased and unreliable estimations, I need to focus on another variable as the leading factor for informal institutions. Therefore, I instead draw on *religious tensions* from the ICRG dataset, in which annual data is available for 140 countries during the studied period. The theory in support of choosing tensions for measuring trust is quite simple. Social tensions that arise from ethnoreligious fractionalisation increase the likelihood of conflicts and, thereby, decreases trust (Alesina & La Ferrara, 2002; Rohner, 2011; Rohner et al., 2013).[80]

Therefore, for measuring the quality of informal institutions, I will use the indicator of *religious tensions* as the main proxy for trust in my quantitative models. In the ICRG dataset, *religious tensions* measures the degree of tensions arising from a situation where a country is dominated by a single religious group. This dictating religious group proceeds to:

- Exclude other religions from the social and political processes;
- Suppress religious freedom;
- Replace civil law by religious law;
- Dominate governance; and
- Express its own identity and separate it from the whole country.

[79] The main problem with this variable is that it does not cover the sufficient number of years and countries. The first wave of WVS was published in 1985 (1981-1984) and the most recent one (sixth wave) in 2015, though the latest available data is for 2010-2014. By having published a wave approximately every five years, the number of observations is substantially low. This would further lead to achieving unreliable and inconsistent estimations, particularly for environmental analysis, where having a long time horizon is particularly crucial for correctly assessing the environmental problems.

[80] In an extreme situation, where a high level of tensions is introduced, the society may end up with civil war. For example, tensions between Muslims and Christians in Nigeria deepened social divisions and finally led to deadly attacks (Cox & Sisk, 2017).

Religious tensions ranks countries on a 6-point scale, where the score of 6 equates to "very low risk" (e.g., some minor inappropriate policies) and the score of 0 equates to "very high risk" (e.g., civil dissent and war). Higher ratings are given to countries where tensions are minimal (even though such differences may still exist) and lower ratings are given to countries where such fractionalisation is high since opposing groups are intolerant and unwilling to compromise.

To understand how informal institutions react in a different formal institutional context, it would be useful to include the interaction of formal and informal institutions in the regressions. To create the interactions, I have six variables for formal institutions, each of which should be multiplied by *religious tensions*. So, I will have six interactions. As including the interactive terms jointly with institutional variables may affect the magnitude of institutions' coefficients, I use the demeaned version of the interactions in the regressions. To create demeaned interaction, *(1)* a formal institutional variable, e.g., *political constraints* is initially averaged, then *(2)* its mean is subtracted from each of its own observations and, finally, *(3)* is multiplied by the demeaned *religious tensions*[81]. The created variable is the demeaned interaction.

Finally, in order to empirically solve the problems related to the endogenous nature of institutions, two further variables are used for instrumenting both types of institutions. They will be discussed in the next chapter.

3.4.3 Control Variables

The baseline regression model is augmented by the inclusion of eight control variables. Five of them are sourced from the category of broad settings: economic development *(S1);* demographic trends *(S2);* political stability *(S3);* media organisation *(S6);* and technology *(S7)*. The next two variables are chosen deliberately for the direct impacts they have on the storing-releasing process of the opted resource system. Specifically, the productivity of a resource system *(RS5)* is affected by forests and burning fossil fuels, hence, should be included. The last control variable is related to the quality of actors *(A7: knowledge of SES/ mental models)*.

Broad Social, Economic and Political Settings

It has been discussed that the social-ecological outcomes are affected by large external factors placed in the SES category of broad social, economic and political settings. It is important to

[81] The same procedure is done for the variable *religious tensions*.

take account of these variables because they give one an overall picture of a country's capacity in mitigating emissions. They also improve empirical assessment. In this study, five of the broad factors are controlled in the regression model.

The first variable is economic development *(S1)*. Since economic growth heavily relies on depleting natural resources, it is positively correlated with higher levels of pollution. In other words, the higher the economy outputs, the more pollution and waste there would be (scale effect). In fact, this variable is one of the main drivers of producing carbon emissions, which can be found in almost every theoretical and empirical model in the field of environment, (e.g., Q. Li and Reuveny (2006)).

For measuring *S1*, I draw on one of the widely-used World Development Indicators (WDI), *GDP per capita*, from the World Bank database. The GDP data are in constant 2010 U.S. dollars (divided by midyear population) and available for 217 countries. For statistical purposes I use the log-transformed version of it. In addition, as discussed before, to confirm the validity of the EKC relationship (income effect), the squared version of *Ln GDP per capita* will also be included in the GMM models.

The second essential variable is demographic trends *(S2)*. Almost a perfect correlation is found between global population growth and environmental degradation (Newell & Marcus, 1987). Therefore, consistent with other studies (Midlarsky, 1998; Wright, Sanchez-Azofeifa, Portillo-Quintero, & Davies, 2007), demographic dynamism must be included in the model. To that aim, I take the *population growth rate* from the WDI dataset for measuring *S2*. The annual *population growth rate* for year t is the exponential rate of growth of the midyear population[82] from year $t-1$ to t (in percentage).

The next important variable is political stability *(S3)*. As Midlarsky (1998) stated, a country with a stable political system produces relatively different outcomes than a newly found governance system (the maturation effects). This is because new governments tend to implement more state-building and economic-related policies, which are unfavourable to the environment, to satisfy the public interest. However, long-lasting governance systems have longer horizons, which enable them to make more environment-friendly decisions. Therefore, in politically stable (or durable) countries, regardless of their regime type, more environmental public goods are

[82] It is based on the de facto definition, which counts all residents regardless of legal status or citizenship.

expected to be provided. In this study, *government stability* from the ICRG dataset is taken for measuring *S3*. It evaluates the ability of the government to stay in office and carry out its declared programs. It varies on a 13-point scale $(0-12)$, in which countries assigned with higher scores possess better political stability, highlighting an inverse relationship with the dependent variable.

The fourth important settings variable is media organisation *(S6)*. Freedom of media is correlated with more public awareness by informing and engaging people in environmental issues (Östman, 2014). Therefore, it is crucial to consider such a factor that can improve citizens' everyday-life learning and proenvironmental behaviours adaptation. To capture cross-country variations within media freedom, I select the variable *freedom of the press* from the Freedom House dataset. It measures the degree of freedom in print, broadcast and digital media in three categories of legal, political and economic environments.[83] *Freedom of the press* ranges between $0-100$ based on which countries are ranked from the most free (0) to the least free (100). To avoid confusion in the interpretation of the results, the variable is rescaled so that higher scores indicate higher press freedom (i.e., the scores now vary between -100 and 0). Therefore, the higher the press score, the lower the carbon emissions will be (For further details on the methodology, see Appendix II).

Finally, the variable technology *(S7)* responds to the argument that economic growth relies heavily on depleting natural resources. The pressure on resources can be reduced if a country is technologically developed. Consistent with other studies (Carattini et al., 2020; Davino et al., 2019; Spencer et al., 2019), a lower level of air pollution is expected to be produced in technologically advanced economies. Therefore, it is vital to consider technological improvements in the analysis. Hence, the variable *total factor productivity (TFP) growth* from the Total Economy Database (TED) is employed. It considers variations in the level of outputs that are not directly caused by changes in the level of labour and capital inputs, i.e., *TFP growth* accounts for the effects of technological change, efficiency improvements, innovation and the contribution of all other inputs that cannot be directly measured to the level of carbon emissions.

[83] As media content and access to news and information are affected by the practised law and regulations, political pressures, and economic situation in a country.

Resource System

As said before, significant deforestation along with burning fossil fuels caused by anthropogenic factors, such as industrialisation and overpopulation, are substantially affecting the productivity of the resource system *(RS5)*, thus the ecological outcomes *(O2)*. These two parameters are theoretically considered in the construction of *carbon footprint per capita*. Now, they will also be controlled in the baseline model. The biological capacity of forests (Murdoch, Sandler, & Sargent, 1997) and the use of fossil fuels (Esty & Porter, 2005), specifically, affect the storing-releasing rate of carbon (or production-consumption rate of the oxygen) into the atmosphere. Hence, in this study, two proxy variables of *forest biocapacity per capita* and *energy use* are adopted from GFN and WDI datasets for reflecting their impacts on the dependent variable.

Biological capacity (or biocapacity) refers to the amount of biologically productive land areas (in hectares) available within the boundaries of a given country. Hence, *forest biocapacity per capita* measures the capacity of forestland to *(i)* regenerate biological materials (e.g., woods and timbers) consumed and *(ii)* absorb waste material (e.g., carbon) produced by people, given current management systems and extraction technologies. Since, *forest biocapacity* helps to store the *carbon footprint*, there is an inverse relationship between these two variables, meaning that the higher the biocapacity, the lower the carbon footprint will be in a country. As with *carbon footprint per capita*, *forest biocapacity* is reported as global hectares (gha) per person.

The world's carbon footprint has been increased 11-fold since 1960 (Lin et al., 2018). Fossil fuels consumption is one of the significant sources of carbon emissions; however, all forms of energy matters in this process. Hence, the variable *energy use*, which shows total energy consumption as the kilogram of oil equivalent per $1,000 (PPP GDP)[84], is controlled in the model. It measures the use of primary energy from combustible renewables and industrial and municipal waste[85] per unit of a country's GDP. Higher values show more energy consumption per unit of economic output, implying higher energy inefficiency and thus weaker environmental performance.

[84] PPP GDP is GDP converted to 2011 constant international dollars using purchasing power parity rates.

[85] It refers to all forms of energy (including solid, liquid and gas from biomass – any plant matter used directly as fuel or converted into fuel, heat or electricity – and animal products) before transformation into any other end-use fuels (equal to indigenous production plus imports and stock change, minus exports and fuels supplied to ships and aircraft engaged in international transport).

Actor

One of the most critical factors in conserving the environment is the level of knowledge that people possess. One the one hand, educated people can lower their emissions as they gain knowledge about the social costs of their current anti-environmental behaviours. On the other, they are likely to support environmental policies. Hence, there is an inverse relationship between the average educational level and emissions of a country. In the SES framework, it is depicted through the variable *A7* (knowledge of SES mental models). Also, it is recognised as one of the key elements of people's self-organisation. Therefore, it must be incorporated into the model. To do that, I take the variable *human capital index* from Penn World Table (PWT) dataset (version 9.0). In the construction of the index, PWT follows the approaches of Barro and Lee (2013) and Cohen and Leker (2014). The *human capital index* is based on the average years of schooling and an assumed rate of return to education for 150 countries. Out of 150 countries, the data for 95 countries are based primarily on Barro and Lee (2013), and for the other 55 countries, the data are based primarily on Cohen and Leker (2014).[86]

Further details on the construction of all the above-explained variables can be found in Appendix II. Also, they are briefly reviewed in Table 3.1:

Table 3.1. List of the quantitative variables

Variable	Unit	Source	Role	Expected Sign	
Carbon Footprint	gha per capita	GFN	DV	Higher values show higher emissions, i.e., larger numbers shows a larger amount of forestlands required for storing emissions.	
Forest Biocapacity	gha per capita	GFN	CV	Higher values indicate higher biocapacity, i.e., more biocapacity results in fewer emissions, showing an inverse relationship.	$-$
Political Constraints Index V	$0 - 1$	POL CON	IV	Higher values show higher constraints, i.e., better quality of formal institutions bring about fewer emissions, showing a negative correlation.	$-$
Combined Polity Score	$-10 - +10$	Polity IV	IV	Spectrum ranges on a 21-point scale, where -10 is a strong autocracy, and $+10$ is a strong democracy. Hence, higher values show stronger formal institutions, i.e., higher possibility of providing and implementing more environmental goods and policies.	$-$

[86] For further details on how the data is used for creating the index, see Feenstra, Inklaar, and Timmer (2015).

Level of Democracy	0 – 10	QoG	IV	Scale ranges from 0 – 10, where 0 shows the least, and 10 shows the most democratic countries. Hence, higher values show stronger democratic institutions, in which the provision and adoption of environmental goods and policies are more prevalent.	–
Law and Order	0 – 6	ICRG	IV	On a scale of 0 to 6, where higher numbers indicate lower risk level and better quality of the legal system. Thus, it is negatively correlated with carbon emissions.	–
Corruption	0 – 6	ICRG	IV	On a scale of 0 to 6, where higher numbers indicate lower risk level and better quality of the legal system. Thus, it is negatively correlated with carbon emissions.	–
Investment Profile	0 – 12	ICRG	IV	On a scale of 0 to 12, with higher scores indicating the lower risk associated with inward investment, i.e., it shows the better quality of economic institutions. Thus, it is negatively correlated with carbon emissions.	–
Religious Tensions	0 – 6	ICRG	IV	On a scale of 0 to 6, with higher scores showing a lower level of tensions, i.e., good quality of the informal institutions. Thus, it is negatively correlated with carbon emissions.	–
Government Stability	0 – 12	ICRG	CV	On a scale of 0 to 12, with higher scores indicating the lower risk associated with fall or overthrow of a government, i.e., it shows the stability of a country, hence, negatively correlated with carbon emissions.	–
Gross Domestic Product	per capita (constant 2010 US$)	WDI	CV	The log of GDP per capita is a proxy for economic development. The higher the economic activity, the higher the pollution. Hence, a positive correlation is expected.	+
Population Growth Rate	%	WDI	CV	Annual population growth rate reported as a percentage is highly correlated with environmental degradations. Hence, an increase in the demographic trend leads to an increase in air pollution.	+
Energy Use (kg of oil equivalent)	per $1,000 GDP (constant 2011 PPP)	WDI	CV	Energy use is representing fossil fuels consumption in the regression models. It is the major source of carbon emissions, therefore, positively linked to the DV.	+
Freedom of the Press	−100 – 0	FH	CV	In countries where the rescaled scores of press freedom are close to zero, there is more freedom of media. In a sense, people are more informed about the social costs of their polluting activities, thus releasing fewer pollutants.	–
Total Factor Productivity Growth	%	TED	CV	In order to consider the effects of technological change and innovation on carbon emissions, TFP growth is utilised. A negative relationship is expected.	–
Human Capital Index	1 – 4	PWT	CV	The combination of the average years of schooling and an assumed rate of return to education creates the human capital index, which is adversely correlated with emissions.	–

Notes: This table provides a list of quantitative variables representing selected second-tier variables from the SES.

3.5 Sample

To avoid sample selection bias and obtain accurate estimations of the institution-environment relationship, a panel dataset consisting of 217 countries[87] over 26 years from 1990 to 2015 is initially constructed. However, the important restriction of data coverage imposed by some of the selected variables described above led to a shrinking of the initial sample. For instance, all the variables that are adopted from the ICRG dataset,[88] particularly the one representing informal institutions, are only available for 140 countries. Moreover, the adopted dependent variable is only covered up to 2014, dictating that the studied period of this study be reduced by one year (1990-2014).

Although the above-defined variables were selected after looking across many possible databases and variables, the sample size is completely drawn from the availability of reliable data. Previous empirical analyses suffered from the trade-off that some authors did for the sake of including as many as countries possible in their sample (S. Dasgupta & De Cian, 2018). The main side effect directly affected their empirical approaches. Because of focusing on a large sample of countries and the limitations regarding the data availability, these analyses had to use cross-sectional regressions, which only provide a snapshot of the situation at a single point of time. Hence, their results are more likely to be biased, as their analyses are affected by endogeneity and omitted variable issues, as well.

This is, in fact, the most common issue in empirical analysis related to institutions and environment (Esty & Porter, 2005), especially in the case of poor countries (Q. Li & Reuveny, 2006), where the choice of empirical specification is dictated by data availability (Ward, 2008). Considering this, the sample size is shrunk to 140 countries covering the period 1990-2014. The list of the countries is classified into six politico-geographic regions based on the seminal work of Hadenius and Teorell (2007), which categorised countries built on two criteria of geographical proximity and democratisation. The categories are shown in Table 3.2.

[87] The list of countries is adopted from the World Bank database.

[88] They are: *law and order*, *corruption*, *investment profile*, *religious tensions* and *government stability*.

Table 3.2. The sample of countries

Countries and Regions				
Eastern Europe and post-Soviet Union				
Albania	Armenia	Azerbaijan	Belarus	Bulgaria
Croatia	Czech Rep.	Estonia	Hungary	Kazakhstan
Latvia	Lithuania	Moldova	Poland	Romania
Russian Federation	Serbia	Slovak Rep.	Slovenia	Ukraine
Latin America and The Caribbean				
Argentina	Bahamas	Bolivia	Brazil	Chile
Colombia	Costa Rica	Cuba	Dominican Rep.	Ecuador
El Salvador	Guatemala	Guyana	Haiti	Honduras
Jamaica	Mexico	Nicaragua	Panama	Paraguay
Peru	Suriname	Trinidad and Tobago	Uruguay	Venezuela RB
The Middle East and North Africa				
Algeria	Bahrain	Cyprus	Egypt	Iran Islamic Rep.
Iraq	Israel	Jordan	Kuwait	Lebanon
Libya	Morocco	Oman	Qatar	Saudi Arabia
Syrian Arab Rep.	Tunisia	Turkey	United Arab Emirates	Yemen
Sub-Saharan Africa				
Angola	Botswana	Burkina Faso	Cameroon	Congo Dem. Rep.
Congo Rep.	Cote d'Ivoire	Ethiopia	Gabon	Gambia
Ghana	Guinea	Guinea-Bissau	Kenya	Liberia
Madagascar	Malawi	Mali	Mozambique	Namibia
Niger	Nigeria	Senegal	Sierra Leone	Somalia
South Africa	Sudan	Tanzania	Togo	Uganda
Zambia	Zimbabwe			
Western Europe and North America				
Australia	Austria	Belgium	Canada	Denmark
Finland	France	Germany	Greece	Iceland
Ireland	Italy	Luxembourg	Malta	Netherlands
New Zealand	Norway	Portugal	Spain	Sweden
Switzerland	United Kingdom	United States		
South Asia, East Asia, and South-East Asia				
Bangladesh	Brunei Darussalam	China	Hong Kong	India
Indonesia	Japan	Korea Rep.	Malaysia	Mongolia
Myanmar	North Korea	Pakistan	Papua New Guinea	Philippines
Singapore	Sri Lanka	Taiwan	Thailand	Vietnam

Notes: This table shows the list of 140 countries grouped by six politico-geographic regions. They are categorised based on *(i)* geographical location (with the partial exception of Australia and New Zealand that are included in the category of Western Europe and North America), and *(ii)* a regional understanding of democratisation (see Hadenius and Teorell (2007)). Accordingly, the category of Eastern Europe and post-Soviet Union includes countries in Central Asia. Also, Dominican Rep. is now included in the category of Latin America and The Caribbean. Likewise, the Middle East and North Africa includes Israel and Turkey. Finally, countries listed separately in each of the three regions of South Asia, East Asia, and South-East Asia are merged into one category.

The sample of all countries will be further categorised into two divisions, based on the natural resource-dependency rate. They will be discussed entirely in Chapter 4 with their corresponding results. So far, the selected variables and the studied sample are clarified, now it would be useful to look at the descriptive statistics (Table 3.3).

Table 3.3. Descriptive statistics

Variables	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Carbon Footprint per capita	1905	2.34	2.51	.02	15.26
Forest Biocapacity per capita	1905	1.46	2.77	0	23.87
Political Constraints Index V	1896	.5	.32	0	.87
Combined Polity Score	1905	4.87	6.07	-10	10
Level of Democracy	1905	6.98	3.01	.42	10
Law & Order	1905	4.04	1.42	1	6
Corruption	1905	3.12	1.35	.5	6
Investment Profile	1905	7.97	2.47	1.5	12
Religious Tensions	1905	4.7	1.34	0	6
Government Stability	1905	7.99	1.85	2.67	11.13
Ln GDP per capita	1905	8.84	1.61	5.32	11.6
Population Growth	1905	1.44	1.39	-1.88	6.06
Energy Use	1905	152.78	103.9	47.6	736.16
Freedom of the Press	1710	-43.29	23.85	-100	-5
TFP Growth	1905	.53	3.63	-18.1	12
Human Capital Index	1905	2.55	.7	1.04	3.73

Notes: This table provides descriptive statistics for the reference sample of 140 countries (Table 3.2).

Further, to have a better sense of the content in Table 3.3, it is useful to check how the overall institutional qualities visually vary for sample countries over the studied period (1990-2015). As previously discussed, political institutions in this study are shown by the three variables of *political constraints*, *polity score* and *level of democracy*. The graph in Figure 3.1. illustrates that the overall quality of political institutions (averaged by year) is increasing. For instance, the level of constraints on executives increases by +0.2 unit, from 0.4 to 0.6 over 25 years. The same trend is also shown by *polity score* and *level of democracy,* with only one difference and, namely the slope, which is greater in the Polity IV measure of democracy (almost doubled).

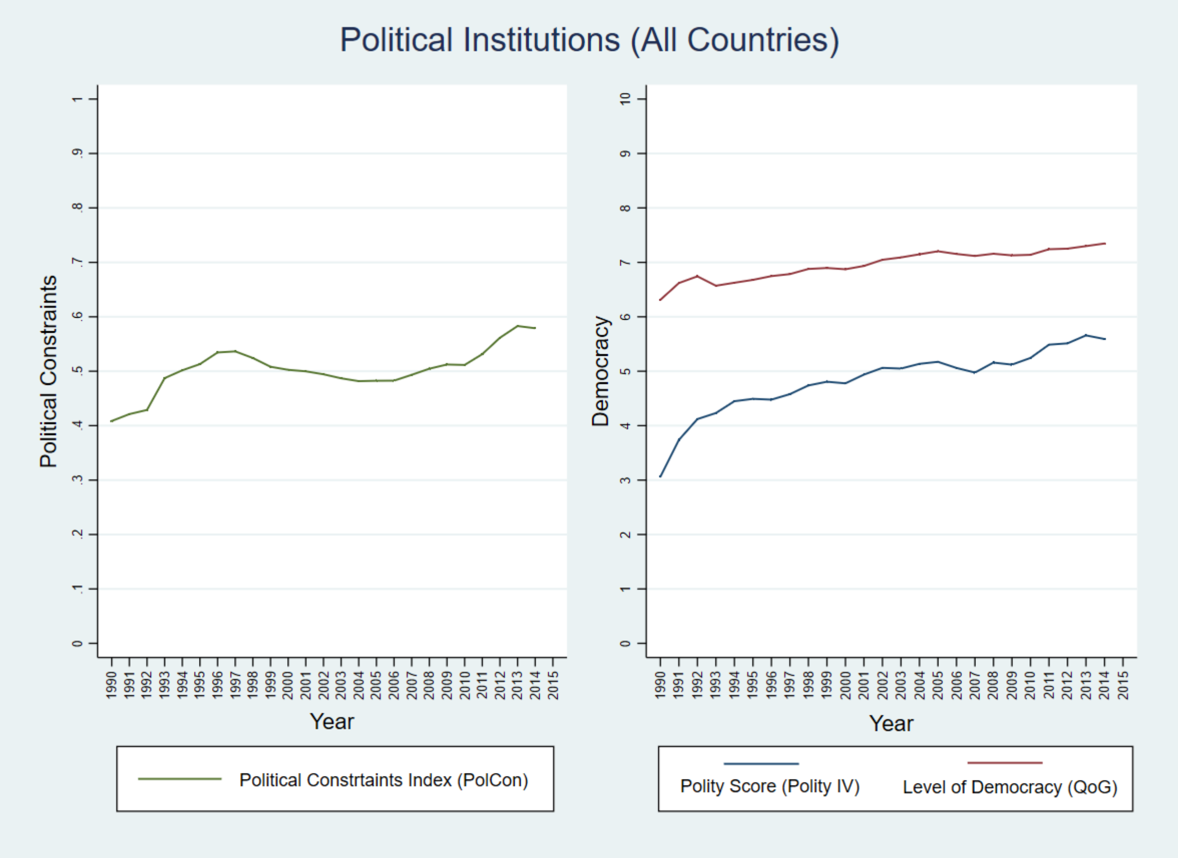

Figure 3.1. The comparative trends of the average quality of political institutions

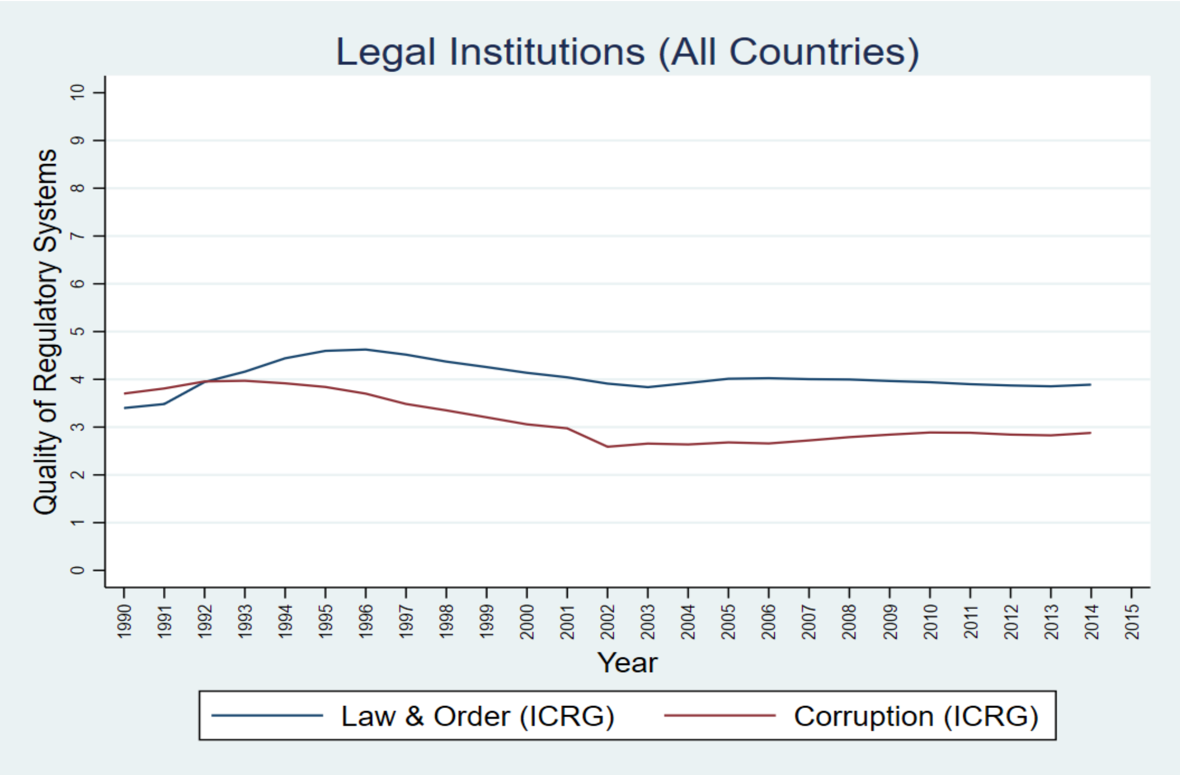

Figure 3.2. The comparative trends of the average quality of legal institutions

However, contradicting trends are shown by the variables on the quality of legal institutions. While the above line graphs (Figure 3.1) shows an upward trend for political institutions, the graph lines (Figure 3.2) behave differently. Despite the fluctuations, the measure of *law and order* depicts a slight increase in the studied period; however, *corruption* (higher values means less-corrupted countries) seems to be worsening (i.e., decreased by almost -1 unit). The quality of economic institutions is indicated in Figure 3.3., by the measure of *investment profile*. It shows an increase in the overall quality of economic institutions by more than 2.5 units (out of 10).

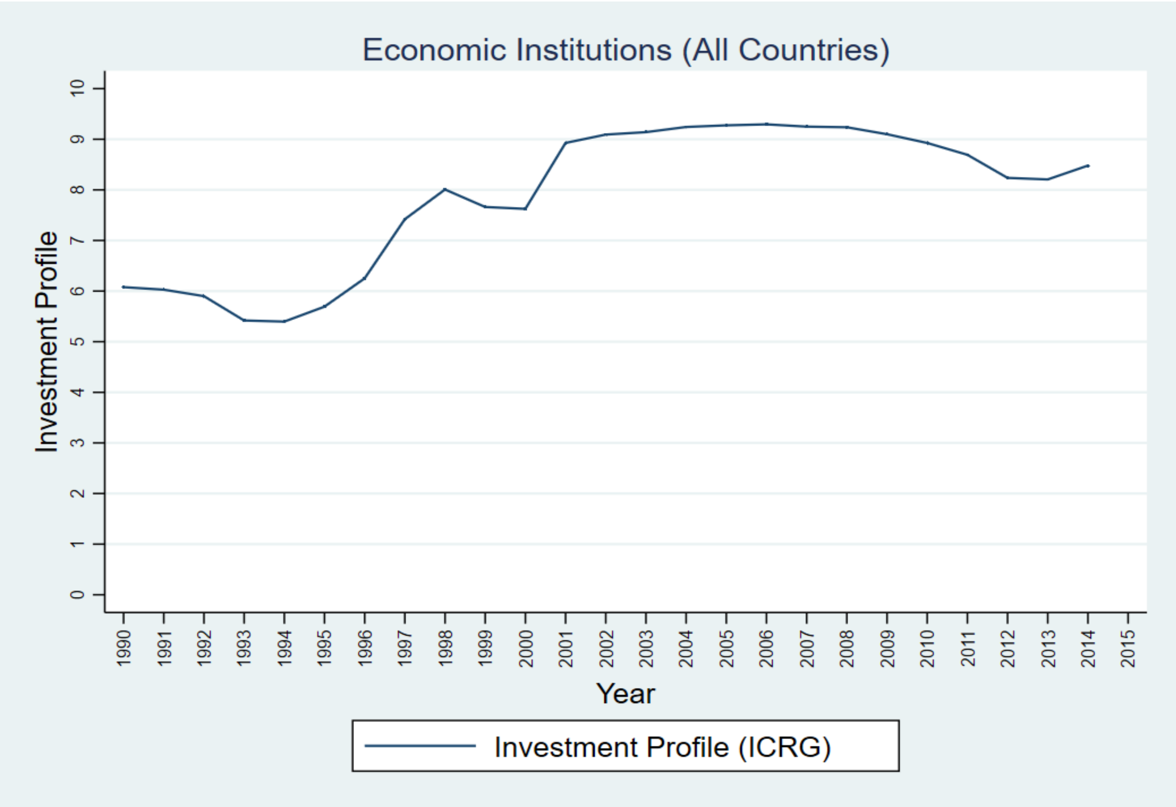

Figure 3.3. The average quality of economic institutions

One interesting point that can be observed from different measures of formal institutions is their fluctuations level. As can be seen, the average changes in legal and political institutions are relatively smaller than economic institutions. The other important point in their trends is a bump that happened approximately between the years 1992 and 1996, within which the quality of institutions increased with a steeper slope. It becomes more interesting when the same bump is also observed in the measure of trust during the same period. One possible reason for this spike is the political and social changes that occurred in the significant parts of Europe at that time, including the collapse of the former USSR and the reunification of East and West Germany, which happened in 1991/1992 (i.e., when the spike started).

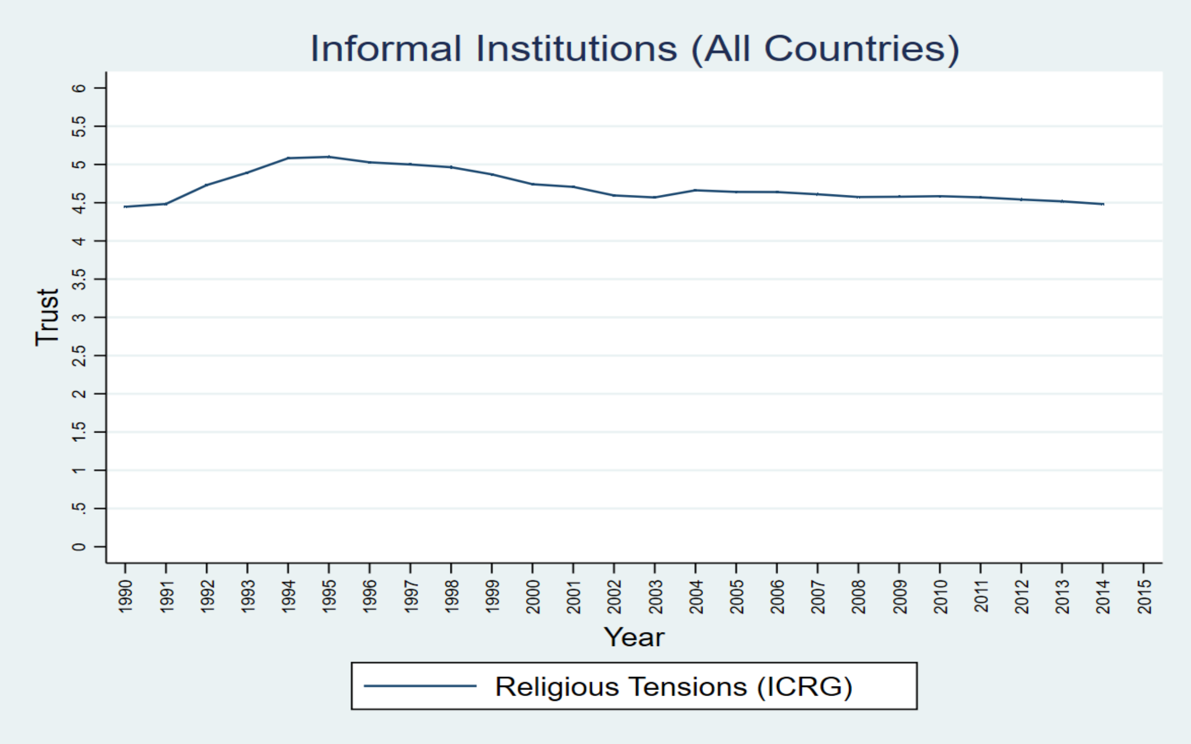

Figure 3.4. The average quality of informal institutions

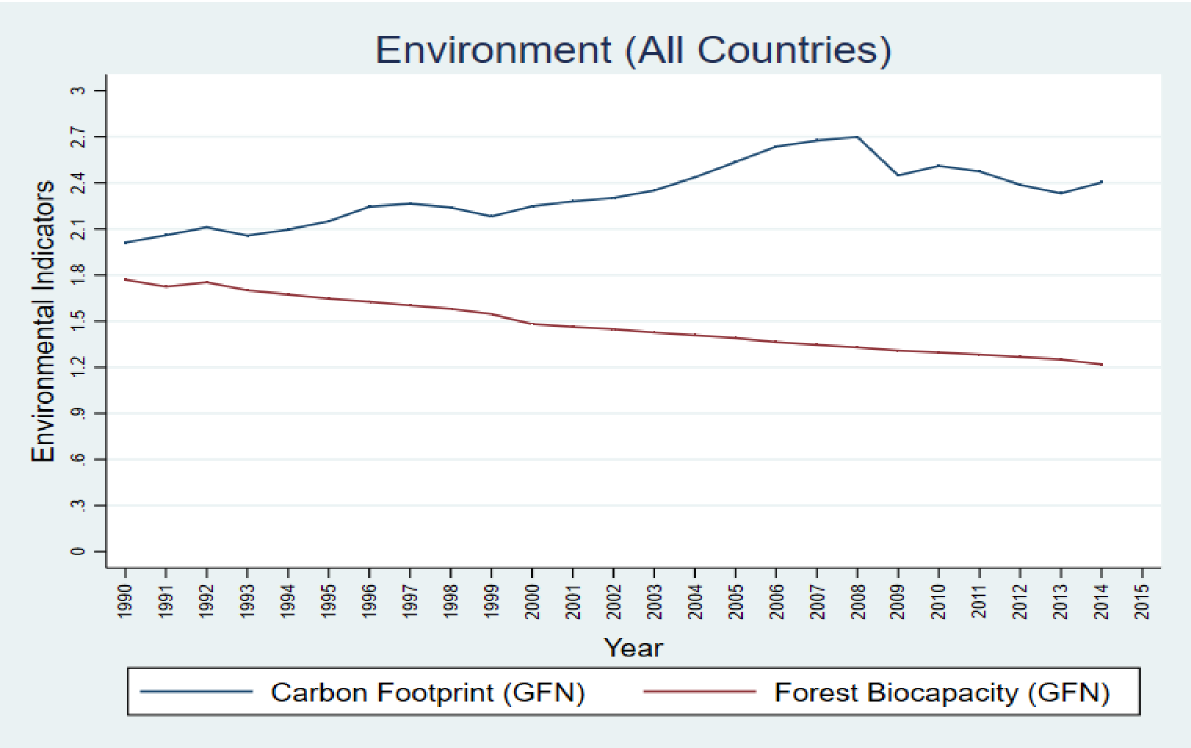

Figure 3.5. The average carbon footprints and forest biocapacity (per capita)

Moreover, the average quality of informal institutions for all countries per year is illustrated in the graph in Figure 3.4. Unlike different formal institutions, *religious tensions* remained almost the same over 25 years, showing higher persistence than formal ones. The last diagram (Figure 3.5) shows the overall condition of the environment across 25 years by plotting *carbon footprints per capita* against the average *forest biocapacity per capita* of countries. Accordingly, lower *biocapacity* is shown to be correlated with a higher *footprint*, indicating their divergence. It also highlights the significance of and urgency in mitigating emissions for avoiding the adverse effects of global warming.

Finally, considering the differences in the trends of both institutions and environment, I seek to confirm whether changes in the behaviour of the environmental data can be statistically explained by the variations within the quality of institutions across nations. To address this question, I subsequently need to design my empirical regression models appropriately.

3.6 Conclusion

The main goal of this chapter was to discuss suggested econometric approaches, describe the selected variables and build the regression models for carefully studying the impacts of the possession of high quality of institutions on the environmental performance of countries. Merging the datasets employed on the variables of interest, I constructed a cross-sectional time-series dataset with the maximum available number of countries and years, in which annual data from 1990 to 2014 is provided for 140 countries. To achieve the goal of this study, I will draw on the results of the FE-IV as the main estimation technique and check the robustness of the results with Sys-GMM.

In this process, one is required to deal with three main issues concerning the design of the empirical model: *(i)* unobserved cross-country heterogeneity; *(ii)* endogeneity; and *(iii)* dynamism of environmental systems. The issue of country-specific unobserved heterogeneity can be solved by the inclusion of the FE estimator in the regression model. It has been taken care of in the above-defined regression model. As discussed before, both formal and informal institutions are inherently endogenous since they are greatly affected by countries' socio-cultural (religion and ethnicity), historical (colonial or legal origins) and geographical preconditions (weather and rugged terrain).

In order to remove the endogeneity problem, the standard estimation method of IV can be used. It improves the estimations by introducing instruments for endogenous regressors. However, the addition of country fixed-effects in panel data models obliges one to employ time-variant instruments, which has always been very challenging for researchers. To my knowledge, due to the difficulty of finding appropriate instruments, the present study is the only research in the environmental economics literature so far that utilises FE-IV technique to explore into the institution-environment relationship. The use of the FE-IV estimator can appropriately capture the variations within the dependent variable and correctly estimate the magnitude of the effects of institutions on carbon footprints.

While the empirical analysis in the field of institutions mostly benefits from the IV estimation method, environmental analysis is focused on the moment conditions that are generated from the application of GMM models. Dynamic panel data models are useful for empirically indicating the effects of the accumulation of previous environmental outcomes on contemporary ones. This fact is also illustrated in the theoretical framework, in which the whole system in time $t+1$ will be affected by the ecological outcomes in time t. In this manner, the Sys-GMM estimator produces relatively more robust results than the Diff-GMM.

Moreover, for correctly testing the validity of the EKC hypothesis, GMM is preferred over the other empirical methods that have been used in previous literature. Finally, I use different panel data models like RE- and FE-OLS to shed more light on the hypothesis that defines environmental quality as a function of institutions. While the method of FE-IV is prioritised over the other empirical methods for estimating the institution-environment nexus, Sys-GMM is used for checking robustness. The results acquired by all of the four methods will be discussed in the next chapter.

Chapter 4

Results

4.1 Introduction

This chapter studies the determinants of environmental degradations by focusing on the role of institutions. By benefiting largely from the instrumental variable (IV) strategy, the impacts of formal and informal institutions on the carbon emission of countries are carefully estimated. To systematically discuss the findings, Chapter 4 is separated into four main studies. Each study is designed for presenting a specific part of the results and reviewing their main findings. For instance, the first study (Section 4.2) investigates the efficacy of formal institutions only, a question that has been normally discussed in environmental studies. Hence, the consistency of the outcomes of this study can be evaluated with the existing studies. The second study, however, tries to build a strong institutional foundation in the context of the environment. It extends current knowledge on environmental analyses by considering informal institutions through the original regression equation. Therefore, in Section 4.3, the effects of both formal and informal institutions are estimated on abating emissions.

In Study 3, the specified model is further augmented by the addition of the interaction of institutions. In effect, the completed form of the regression model is presented in this study (Section 4.4), wherein the focus is on testing the interdependency of formal and informal institutions across different estimations. The fourth study (Section 4.5) examines the robustness of Study 3's estimations in three sub-sections. In the first sub-section (Section 4.5.1), the completed form of the model is estimated with the (generalised method of moments) GMM technique. The studied sample is categorised, in the second sub-section, into two groups of countries based on the resource-dependency ratio. The IV analysis is then performed on these two sets of countries to further explore the heterogeneities in the institution-environment nexus. In the third sub-section (Section 4.5.3), different sources of emitting carbon dioxide — from fossil fuels and sectors— are analysed through different IV estimations. In the conclusion section, all the main estimations are holistically reviewed.

4.2 Study 1 Results and Discussion: Formal Institutions

To be consistent with the existing empirical studies, Study 1 is devoted completely to the role of formal institutions in managing carbon footprint of countries. As a result, the traditional collective action theory, in which the presence of formal external power is found to be essential in managing global commons, can also be examined. In this study, the efficacy of formal authority is tested empirically through introducing different variables for measuring the quality of formal institutions in regression models.

Formal institutions, as discussed in Chapter 3, are categorised into political, legal and economic institutions. In the SES framework, they are indicated by *regime type (GS4), rules-in-use (GS6)* and *property-rights system (GS7)*, each of which is used separately in the regression models. In the empirical literature, political institutions are examined more frequently than the other two types of institutions, indicating the importance of such factors in reducing environmental degradations. Thus, their respective results are going to be reported initially and separately from the other two types of institutions. Further, the results for legal and economic institutions can also be used for checking the robustness of the results for political institutions.

To estimate the effects of formal institutions, first I need to slightly change the general baseline regression model, which was presented in the previous chapter, to a model that is specifically aimed at addressing formal institutions only. To deal with the endogeneity problem, I then explain the utilised variables for instrumenting formal institutional variables. The theory for, and the construction of the instruments employed are explained in this section. Finally, I report and interpret the results I obtained on my models using three econometric techniques in panel data models: OLS, FE-OLS and FE-IV. This section excludes the effect of the quality of informal institutions *(GS8: repertoire of norms and strategies)*, to show what other researchers have done so far. Therefore, the following results can represent almost all the existing empirical literature in the institution-environment relationship.

4.2.1 Empirical Specification

In the previous chapter, I specified the general baseline regression model (3.8) as:

$$y_{it} = \alpha + \boldsymbol{\beta_1}\, \boldsymbol{X_{it}} + \boldsymbol{\beta_2}\, \boldsymbol{Z_{it}} + \gamma_i + \kappa_t + \varepsilon_{it} \qquad (4.\ 1)$$

Where y_{it} shows the dependent variable, *carbon footprint per capita*. Subscripts i and t denote *country* and *year*, respectively. α is the *constant term*, and $\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$ are *the vectors of unknown parameters.* In addition, $\boldsymbol{X_{it}}$ and $\boldsymbol{Z_{it}}$ are *the vectors of institutions* and *additional explanatory variables*, respectively. Finally, γ_i and κ_t represent *country-specific* and *year effects* and ε_{it} denotes *the error term.* In the above regression line, the vector of $\boldsymbol{X_{it}}$ includes both formal and informal institutions in accordance with their interaction term. Since the sole focus of this study is on formal institutions only, the new regression line takes account of the variables pertaining to formal institutions. Therefore (4.1) can be rewritten as:

$$y_{it} = \alpha + \beta_1\{formal\ institutions\}_{it} + \boldsymbol{\beta_2}\,\boldsymbol{Z_{it}} + \gamma_i + \kappa_t + \varepsilon_{it} \tag{4. 2}$$

The only difference between (4.1) and (4.2) is the substitution of $formal\ institutions$ with the vector of institutions ($\boldsymbol{X_{it}}$).[89] I first estimate regression (4.2) with the OLS model, ignoring any mismeasurement issue. I then add the fixed-effects estimator (γ_i) to protect against the potential risks of missing unobserved country-specific heterogeneity in the model. So, (4.1) is re-estimated with FE-OLS in the second stage. Finally, since $formal\ institutions$ is likely to be the function of other variables, equation (4.2) suffers from the potential endogeneity problem. Therefore, to deal with this issue, the FE-IV estimation technique will be used as the main econometric approach for estimating (4.2).[90]

In this study, estimating β_1 is of interest ($\beta_1 < 0$). However, before going through the estimation results, I will explain the variables I use for instrumenting $formal\ institutions$.

4.2.2 Instrumental Variables

As stated above, to solve endogeneity in (4.2) and to estimate the impacts of institutions successfully, one needs to introduce an exogenous source of variations in institutions, through which the endogenous regressor ($formal\ institutions$) is affected solely. The exclusion restriction implies that the instrument needs to be correlated with current institutions and should

[89] The indicator of *political constraints index* is used as the primary variable for $formal\ institutions$. The other indicators of political, legal and economic institutions can be simply replaced. In a sense, they can be considered as the robustness checks for the main variable.

[90] Measurement error and omitted variables bias are two main sources of endogeneity that I try to correct for by using the IV strategy.

affect the dependent variable only through the endogenous regressor. Also, the employed instrument should be uncorrelated with the error term (ε_{it}) in (4.2).

Therefore, in this study, following the works of Clague, Keefer, Knack, and Olson (1999) and Djankov and Reynal-Querol (2010), I use the variable *colonial origins* as an instrument for $formal\ institutions$.[91] It is a set of five dummy variables representing four main European colonisers and a group of countries never having been colonised by a Western colonial power (48 countries).[92] The four remaining colonial powers are British (24 countries), French (8 countries), Spanish (12 countries) and other powers including Portuguese, Belgian, Dutch, etc. (6 countries).[93] For example, the dummy variable for British power receives 1 for countries that have been former colonies of the British Empire, and 0 otherwise.[94] The same logic applies for other colonisers.

Colonial origins qualify as potentially exogenous determinants of contemporary formal institutional performance because the European powers that colonised large parts of the world left to their colonies the legacy of their key institutions, such as religion and law, which in turn influenced subsequent development of their institutions (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1998, 1999). For example, during his wars and colonial conquests, Napoleon exported the French legal system to Latin America, large parts of Europe, North and West Africa and parts of the Caribbean and Asia.[95] The quality of colonisers' implanted institutions is another important factor. For instance, the Belgians established extractive institutions in Dem. Rep. of Congo to transfer resources of the colony to themselves. On the other hand, in some countries, strong institutions were built by the coloniser with the emphasis on political

[91] This variable, which distinguishes *colonial origins* of countries since 1700, is constructed by Hadenius and Teorell (2007) and adopted from QoG database. The list of the countries included in the analysis is provided in Appendix III. See Table 4.A8.

[92] Western colonial power is defined as European powers that colonised territories outside of the Europe. This definition excludes European internal colonies (e.g., Russian, German) and cases where the colonial power was non-Western (e.g., Japan, the Ottoman Empire, etc.). See Bernhard, Reenock, and Nordstrom (2004).

[93] *Colonial origins* initially classifies former colonisers into 10 categories. However, following the approach of Nunn and Puga (2012), I have aggregated a number of smaller colonial powers into the category of "other powers."

[94] Also, following Bernhard et al. (2004), the British settler colonies (the US, Canada, Australia, Israel, and New Zealand) are excluded and categorised as countries that have never been colonised. Because, based on Hall and Jones (1999), life in these countries was modelled after the home country (the UK) and they satisfy two criteria of being sparsely populated (at the time of colonisation) and broadly similar in climate.

[95] La Porta et al. (1998, 1999) adopted *legal origins* for explaining institutional development. To check whether the results are robust to this alternative measure, I will use *legal origins*, as a further instrument for my main model.

and economic (property-rights) institutions.[96] Countries like Australia, New Zealand and Canada are cases in point.

Therefore, as theoretical and empirical literature on institutions predict, historically determined factors like colonial powers and the origins of the legal system, which were acquired centuries ago, are found to persist at present and shape the contemporary performance of institutions.[97] Hence, much of the variations in current institutions can be explained by such historical legacies (Tebaldi & Elmslie, 2013). In the following specification, the presence of the fixed-effect estimator (γ_i) implies that instruments must be time-variant. So, for the purpose of this study, each colonial power is interacted with a time trend to satisfy this requirement. By this transformation, I intend to show that the trajectory and developmental path of institutions, caused by having different *colonial origins*, are different over the years. Following this approach, the performance of current formal institutions is modelled as:

$$\{formal\ institutions\}_{it} = \alpha + \boldsymbol{\beta_1}\, \boldsymbol{W_{it}} + \boldsymbol{\beta_2}\, \boldsymbol{Z_{it}} + \gamma_i + \kappa_t + \eta_{it} \tag{4. 3}$$

Where $\boldsymbol{W_{it}}$ represents a vector of different colonial powers that determine the developmental path of current $formal\ institutions$ (not just their quality). Also, η_{it} shows the error term here. Equations (4.2) and (4.3) form a system of equations that links environmental pollution to institutions. The exclusion restriction implied by the above FE-IV regression is that, conditional on the variables I controlled in the regression; *colonial origins* (back to the 17th century) do not affect today's emissions, other than their effect through developing current $formal\ institutions$. Simultaneously, *colonial origins* are uncorrelated with the (4.2)'s error term (ε_{it}) and, therefore, uncorrelated with current carbon emissions.[98]

[96] Acemoglu et al. (2001) argued that European colonisers established good institutions that protect property rights, where they faced lower risk of dying from disease. Therefore, based on this argument, they have introduced a variable called *settler mortality rate* as an instrument for institutions. However, there are several data issues regarding the use of this instrument, as explained by Albouy (2012, pp. 3074-3075). He claimed that "any researchers who have used the AJR mortality series in their analyses may need to reconsider their conclusions."

[97] Institutions change slowly over time, and those early colonial institutional arrangements persisted over time. The transition experiences in several African and Latin American countries are cases in point. For instance, slavery persisted in Brazil until 1886, and forced labour lasted until 1945 in Guatemala. In several African countries, including Dem. Rep. of Congo, extractive institutions were even reintroduced (Acemoglu et al., 2001).

[98] It seems reasonable to accept that such historical legacies directly influence current institutions but have no direct effect on current emissions, on the grounds that the pairwise correlation between carbon emissions and British imperial power, as the largest Western coloniser, and the French legal system, as the most adopted law worldwide, is only 0.058 and -0.091, respectively.

In other words, the emissions effects from such historical legacies (i.e., colonial powers) are only felt through their impacts on the development of current institutions rather than directly influencing current emissions. Hence, the identifying assumption employed in this study is that different colonisers (as early institutions) shaped different developmental paths for current institutions, which in turn drives different environmental outcomes over the period of 1990 to 2014. Hereafter, this instrument is called *trend of colonial origins*.[99]

4.2.3 Estimation Results

Table 4.1 reports the empirical results of estimating the baseline regression equation (4.2) on the relationship between carbon emissions and the first set of institutional measures: *political constraints index, level of democracy* and *combined polity score*.

As can be seen, the table contains three main models, each of which represents the impacts of one of the above political indicators on *carbon footprint per capita*. Each model is estimated using three econometric approaches: random-effects OLS; fixed-effects OLS; and fixed-effects IV. As mentioned in Section 4.2.1, FE-IV is the main estimation technique in this study. So, only the results of this approach are of interest.[100] Further, all models are estimated with robust standard errors and year dummies to adequately address the risks of heteroscedasticity and serial correlation.

First, I use *political constraints index V* from POLCON dataset as the primary institutional variable in my baseline regression model. I draw on this factor as the main variable for formal political institutions because, on the one hand, it does not evaluate the quality of a political system by whether a country possesses either democratic or autocratic institutions only.[101] On the other hand, it measures democracy to some degree as stronger democracies are expected to impose higher constraints on the executives.[102]

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[99] To further test the validity of this IV, I ignore the time dimension and perform a cross-sectional analysis (IV-2SLS), using *colonial origins* as the instrument. See Appendix III (Table 4.A3), for more details.

[100] The results of the RE-/FE-OLS are reported for the first three models only so as to show the consistency of changes across the three estimations.

[101] The type of political regime per se is not directly linked to better or worse environmental performance, as mixed results are obtained by different scholars in this field. For the full discussion on the ambiguous effects of democracy and autocracy on the environment, see Chapter 2, Section 2.5.4.1.

[102] This index is a narrow measure of democracy, so cannot fully function as a proxy for democracy (Henisz, 2015).

Political constraints index measures the extent of constraints faced by politicians in changing a status quo policy in a country. It explains the extent to which the concentration of political power (in the hands of the head of the state) helps to reduce emissions. It is a continuous variable, which ranges from 0 (the least constrained - no checks and balances) to 1 (the most constrained – extensive checks and balances). Thus, higher values show higher constraints on executives and lower feasibility of overturning a government policy because of the change in any one political elite's preferences. Model (1) represents the results of this variable.[103]

As illustrated in Table 4.1, the OLS results show that countries with higher *political constraints* show lower levels of *carbon footprint*, indicating an inverse relationship between these two variables, as expected. At first glance, it may appear that OLS is appropriate for estimating the parameters. However, it is not, as it would generate biased and inconsistent estimates. In fact, the simple OLS results may just present a correlation. Therefore, the model is estimated again with fixed-effects OLS (the second column). In this specification, the sign for *political constraints* flips to positive when I control for the country-specific unobserved heterogeneity.[104] This unexpected effect of constraints on emissions in the fixed-effect analysis means that the higher the constraints, the higher the emissions would be in a country.

To obtain unbiased and consistent estimates, I appeal to the instrumental variable strategy. In the third column of Model (1), once I have estimated the model with FE-IV to eliminate the potential endogeneity problem that lies within the institutions, the sign for *political constraints index* flipped again. Now, it can be seen that in this specification, *political constraints index* is significant and negatively correlated with *carbon footprint per capita*. The FE-IV results show that a one-unit increase in the constraints on executives results in more than a one-unit decrease (-1.070) in per person carbon emissions at the 1% level. In other words, the lower the concentration of political power in the hands of the ruling elites (or the higher the number of legislative units with veto power),[105] the lower the emissions would be in a given country. This result is consistent with the study by Cole and Fredriksson (2009), in which the positive indirect

[103] The model predicts that the estimated coefficient for *political constraints index* should be negative.

[104] The unobserved factors are time-invariant and only use variations within each country to relate institutions to environmental performance.

[105] The presence of more effective branches of government (i.e., independent actors with veto power over policy change), including the executive, lower and upper houses in the legislative chambers, judiciary and sub-federal entities, leads to a greater level of constraints. The higher the constraints, the lower the emissions would be.

effect of *political constraints* is analysed by the FE-2SLS estimation on the environmental performance stringency.

In fact, the main reason for getting unreliable estimations in the RE- and FE-OLS, compared to the FE-IV estimation, is due to the presence of the endogeneity problem, which is adequately addressed in this study.[106] It is supported by a test of weak instruments (with the null hypothesis of the equation weakly identified), according to which the values of Cragg-Donald's (1993) F statistic is compared to Stock-Yogo's (2005) critical values. In my model, the value of the CD-F statistic meets the SY 5% maximal IV relative bias and 15% maximal IV size thresholds, showing that my exclusion restriction condition is valid (i.e., the model is strongly identified).[107] The results on the other covariates are as follows:

Settings (S): for economic development *(S1)*, if *log GDP per capita* is increased by 1%, *carbon footprint* is expected to increase by 0.017 unit (global hectare per capita), confirming a significant positive correlation between these two variables. Therefore, a rise in income per capita causes more emissions (Q. Li & Reuveny, 2006). The same correlation is also obtained for the variable pertaining to demographic trends *(S2)*; a one-unit change in *population growth* increases the amount of pollution by almost 0.08%. Hence, the theory which posits that the pressure of population growth threatens global environmental quality through, for example, increasing toxic gases emissions (Q. Li & Reuveny, 2006) and deforestation (Ehrhardt-Martinez et al., 2002), is statistically confirmed.[108]

Further, the variables of *government stability* and *the freedom of the press*, which are employed for measuring political stability *(S3)* and media organisation *(S5)* respectively, highlight a negative correlation with the dependent variable, though it is not statistically significant. The finding related to *S3* is consistent with the work of Midlarsky (1998), in which the effect of political stability and maturation was found to be negatively associated with various environmental degradation indicators, including emissions. Moreover, Ollerton, Walsh, and

[106] As stated, I have used a set of five variables on *the trend of colonial origins* as instruments for the institutions.

[107] Stock and Yogo's (2005) critical values for $K1 = 1$ (number of endogenous regressor) and $L1 = 4$ (number of excluded instruments) are 16.85 and 24.58, which correspond to the maximal IV relative bias of 5% and size of 10%, respectively. A value of the Cragg-Donald F-statistic $= 17.24$ implies that the null hypothesis of weak instruments is not rejected in a case in which the maximum IV size is no more than 15%, corresponding to a maximum size distortion of 5%. See Appendix III for more details on the first-stage results (Table 4.A1).

[108] To estimate the effects of demographic changes on the environment, I have also used another variable, *percentage of the population aged over 65*, which signifies demographic structure of a country. The obtained results on this variable further confirm the initial estimations, using *population growth*.

Sullivan (2019, October 3) found a direct relationship between world press freedom and environmental performance indices[109] across 167 countries in 2017. They concluded that countries that suppress freedom of media perform worse in terms of preserving the environment.

The last factor within the core of settings *(S)* concerns the level of technology *(S7)*. This variable, which is measured by *TFP growth*, shows a positive association (0.008) with *carbon footprint*, suggesting that the more the technologies are developed, the more pollution there will be. One reason for this unexpected result may be because TFP is often considered as the primary contributor to GDP, so it may produce higher pollution levels through increasing industrial outputs. For instance, Kalaitzidakis, Mamuneas, and Stengos (2018) found a monotonically increasing relationship between TFP growth and emissions.

Actors (A): the variable *A7 (knowledge of SES mental models)* is an important factor in the SES framework, as it can directly affect people's self-organisation abilities. It is indicated by *human capital index* in the quantitative models, which is a proxy for country-level formal education. As can be seen in Table 4.1, a one-unit rise in the *human capital index* brings about -0.37 drop in the level of *carbon footprint*. This result is consistent with the literature in which the positive influence of human capital on emissions reduction has been studied. It has been shown that gaining formal education helps to reduce the degradations by causing people to behave in a sustainably environmental-friendly manner (Sarkodie, Adams, Owusu, Leirvik, & Ozturk, 2020) and increase their adoption of cleaner technologies (Sapkota & Bastola, 2017).

Resource System (RS): *forests biocapacity* and *energy use*[110] are two variables that are selected to represent the storing-releasing rate of carbon into the atmosphere. These two opposite driving forces determine the productivity of the resource system *(RS5)*. As anticipated, the results in column three of Table 4.1 illustrate that *forest biocapacity* (-0.065) is negatively and *energy use* $(+0.45)$ is positively influencing *carbon footprint,* at the 1% significance level. In other words, the larger the forest stock (energy consumption), the lower (higher) the level of emissions.[111]

[109] Both indices are developed jointly by Yale and Columbia universities and the World Economic Forum.

[110] This variable is standardised so that its coefficient value can reflect its actual effects on the dependent variable.

[111] See Zhang and Cheng (2009) for the effects of energy use on carbon emissions and Murdoch et al. (1997) for the effects of forests in reducing sulphur and NO_2.

Overall, the outcomes produced by the model estimated with FE-IV are mainly consistent with the hypotheses and theoretical basis of this study.[112]

As previously discussed, the most tested hypothesis in the institution-environment literature concerns the role of the political regime (democracy vs autocracy) in mitigating carbon emissions (S. Dasgupta & De Cian, 2018).[113] So far, the findings on this relationship are inconclusive; hence, further investigation is still needed to clarify this link. To be consistent with previous empirical works, extend the literature and delve deeper into this ambiguous nexus, I, therefore, examine the role of democracy as one of the formal political institutions in reducing carbon emissions. The findings are discussed in Model (2) and (3) of Table 4.1.

For measuring the quality of democratic institutions, I take the two most widely used variables in the literature. The first one is the *polity score* from Polity IV dataset, which is the most closely scrutinised data series on political issues. It is a combination of two variables, *democracy* and *autocracy*,[114] which captures the spectrum of a regime authority on a 21-point scale, ranging between -10 (strongly autocratic) and $+10$ (strongly democratic). The higher score a polity receives, the more democratic it is.

The second measure of democracy used in this study is *level of democracy*. It is the enhanced version of *polity score*, in which the two variables of *political rights* and *civil liberties* from Freedom House dataset are first averaged and then added to the first measure. So, *level of democracy* is based on three variables of *polity score*, *political rights* and *civil liberties*.[115] It is an 11-point indicator $(0-10)$, where 0 shows the least, and 10 shows the most democratic countries. Hence, higher values show stronger democratic institutions. Both indicators of democracy are expected to be negatively correlated with the dependent variable.

As illustrated in Table 4.1, the RE- and FE-OLS results in both models indicate the same correlations as shown in Model (1). That is countries with lower carbon emissions are the ones

[112] The sensitivity of Model (1) estimations is also tested by the inclusion of *legal origins* as an instrument for formal variables. See Appendix III for more details on the first-stage results (Table 4.A2).

[113] This is because mixed results have been obtained by different scholars in this field.

[114] It is derived simply by subtracting the *autocracy* value from the *democracy* value, each of which is an additive 11-point indicator $(0-10)$.

[115] The addition of these two variables to the *polity score* made the *level of democracy* a better measure in terms of both reliability and validity than its three components. It is adopted from QoG database.

with better democratic institutions, highlighting an inverse relationship between these two variables in the simple OLS estimation.[116] While, in the fixed-effect analysis, the sign for both variables, *level of democracy* and *polity score*, flip to positive, showing that better democracies produce higher emissions.[117] The results are consistent with the first two columns of Model (1).

Finally, in the FE-IV estimations, where *the trend of colonial origins* is used for instrumenting democracy, both variables become insignificant, denoting that political system per se is not effective enough in the carbon mitigation process. The results are robust to alternative democratic variables. Now, the FE-IV column in both Models (2) and (3) shows that *the level of democracy* remains positive, while *polity score*'s sign changes to negative. However, both variables are statistically insignificant, hence, unable to establish meaningful relationships with *carbon footprint*.

[116] See Barrett and Graddy (2000), who found that higher FH political rights and civil liberties improves air quality.

[117] See, for example, Midlarsky (1998), who found that better democracies, measured by polity III, strongly increase carbon emissions per capita. In this study, democracy is measured by three indicators: 1) Polity III: I use updated version of this index (Polity IV) in my regression models. (2) Political rights measured by free elections. (3) A composite index of liberal democracy, which is based on the freedom of election, free political opposition and an effective legislative body.

Table 4.1. Political institutions (IV estimations)

	Model (1)			Model (2)			Model (3)		
	OLS	FE-OLS	FE-IV	OLS	FE-OLS	FE-IV	OLS	FE-OLS	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Political Constraints Index V	-0.803***	0.191**	-1.070***						
	(0.152)	(0.089)	(0.340)						
Level of Democracy				-0.271***	0.039*	0.042			
				(0.030)	(0.020)	(0.045)			
Combined Polity Score							-0.115***	0.016**	-0.009
							(0.011)	(0.008)	(0.019)
GDP per capita	1.460***	1.853***	1.663***	1.380***	1.831***	1.831***	1.349***	1.845***	1.823***
	(0.056)	(0.366)	(0.116)	(0.051)	(0.358)	(0.104)	(0.049)	(0.362)	(0.104)
Population Growth	0.627***	0.040	0.078***	0.564***	0.047	0.047**	0.544***	0.048	0.048**
	(0.045)	(0.030)	(0.026)	(0.043)	(0.031)	(0.022)	(0.042)	(0.031)	(0.022)
Government Stability	0.133***	-0.006	-0.006	0.100***	-0.007	-0.007	0.088***	-0.007	-0.009
	(0.025)	(0.017)	(0.008)	(0.025)	(0.016)	(0.007)	(0.026)	(0.016)	(0.008)
Press Score	-0.017***	-0.006**	-0.001	0.006*	-0.008**	-0.009**	-0.000	-0.008**	-0.004
	(0.002)	(0.003)	(0.002)	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)
TFP Growth	0.012	0.002	0.008**	0.011	0.002	0.002	0.013	0.002	0.003
	(0.011)	(0.004)	(0.004)	(0.011)	(0.004)	(0.003)	(0.011)	(0.004)	(0.003)

Human Capital Index	0.707***	-0.406	-0.374**	0.771***	-0.439	-0.441***	0.735***	-0.423	-0.405***
	(0.102)	(0.348)	(0.166)	(0.101)	(0.345)	(0.148)	(0.099)	(0.341)	(0.147)
Forest Biocapacity	-0.026**	-0.060	-0.065***	-0.026***	-0.058	-0.058***	-0.019*	-0.059	-0.058***
	(0.010)	(0.042)	(0.017)	(0.010)	(0.042)	(0.015)	(0.010)	(0.043)	(0.015)
Energy Use	0.764***	0.599***	0.453***	0.724***	0.571***	0.570***	0.714***	0.572***	0.586***
	(0.046)	(0.176)	(0.076)	(0.042)	(0.177)	(0.058)	(0.042)	(0.177)	(0.057)
cons	-14.889***	-13.875***		-11.556***	-13.872***		-12.384***	-13.800***	
	(0.519)	(3.093)		(0.537)	(3.101)		(0.449)	(3.073)	
Obs.	1745	1745	1730	1754	1754	1739	1732	1732	1717
R-squared	0.744	0.382	0.176	0.755	0.381	0.381	0.759	0.382	0.368
No of Countries		98	83		98	83		97	82
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(9)). Independent variables representing formal political institutions are *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$. Higher values (in parenthesis) indicate stronger formal institutions. Model (1)-(3) reports estimations of the dependent variable against each of the institutional variables. All of the three models is estimated with simple OLS regressions (shown in column (1)/(4)/(7)), fixed-effects OLS regressions (shown in column (2)/(5)/(8)), and fixed-effects IV regressions (shown in column (3)/(6)/(9)). In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. All regressions are performed on the sample of all countries. The number of countries is reduced by 15 in IV regressions as *xtivreg2* drops singletons in Stata. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01, *** ** *p<0.05, ** * *p<0.1*.

These findings are in line with the current literature. In the study on the effects of democracy on a wide range of environmental indicators, Midlarsky (1998) concluded that democracy is unable to improve environmental quality. Using cross-sectional OLS regression for up to 100 countries in around 1990, he found, for instance, no significant effects of democracy on soil erosion (by chemicals) and freshwater availability. On the contrary, he further found that democracy even worsens carbon emissions, deforestation and soil erosion (by water).[118] This seminal work represented a starting point from which to re-examine the assumption that democracy is always considered as a benign political influence on the environment. In fact, democracy's effects on the quality of the environment are multidimensional.

Likewise, several more studies have been unable to find evidence for the positive effects of democracy on improving environmental quality, especially mitigating emissions (see, for example, Carlsson and Lundström (2003) and Scruggs and Rivera (2008)). Further, Scruggs and Rivera (2008) found almost no evidence in support of democratic countries, especially long-established ones, performing better with respect to national and global environmental indicators,[119] using OLS estimation with Huber-White standard errors for 169 countries between 1990 and 2000. On a panel of 75 countries between 1975 and 1995, Carlsson and Lundström (2003) also confirmed that political freedom, as measured by the average of political rights and civil liberties (Freedom House), has no effect on reducing levels of carbon emissions.[120]

Using the same measure of democracy as Carlsson and Lundström (2003), Shandra (2007) also documented that political freedom is unable to reduce deforestation rates. Employing another measure of democracy (Polity II),[121] Ehrhardt-Martinez et al. (2002) concluded that weak democratic states allow for forest exploitation, and thus are unable to reduce deforestation; that is, only democratic states with strong state capacity can improve forestation. Further, Murdoch,

[118] He could only find a positive effect of democracy on protected land.

[119] The authors relied on FH civil liberties and political rights for measuring democracy. They also used eight indicators spanning three different aspects of the environment. Four indicators are related to air pollution, two of which measure local air pollutants of sulphur dioxide (SO2) and nitrogen oxides (NO), while carbon dioxide (CO2) and methane (CH4) represent global pollution levels. Further, land conservation is measured by two indicators: protected areas and forest areas. Finally, water pollution is measured by carbon monoxide (CO) and biochemical oxygen demand (BOD), both of which jeopardise human health.

[120] In a similar vein, Jorgenson (2006) did not find any significant association between democratisation index (i.e., political competition and popular participation) and methane emissions in 1995. On the contrary, Congleton (1992) showed that democracies are in favour of methane emissions reduction.

[121] Polity II is the previous version of *polity score* (polity IV); its effects on a sample of 55-74 LDCs 1980-1995 are estimated using OLS with Huber-White heteroscedasticity correction estimation.

Sandler, and Vijverberg (2003) and Pellegrini and Gerlagh (2006) found no direct effects of democracy on environmental protocol ratification and the adoption of a stringent environmental policy, respectively.

As can be seen, democracy is not always effective in protecting the environment, especially in the process of carbon emissions mitigation, where the failure of democracies is documented the most. Therefore, the findings of the present research, in which no evidence of democracies in improving air quality is shown, are supported. However, as previously discussed, the findings on *political constraints index* are preferred over the ones on democracy, as they better explain the quality of political institutions.[122] This index signifies the extent to which the concentration of political power helps to reduce emissions (Acemoglu et al., 2003).[123] In fact, the important concept of constraints on human behaviour is a key feature of institutions defined by Douglas North (Acemoglu & Robinson, 2010).

The results of the three models illustrated in Table 4.1 reveal that it is, in effect, the extent of power concentration in the hands of the rulers that matters the most for mitigating emissions (not democracy or autocracy per se). In decentralised countries where the extent of constraints on the executive (i.e., head of the state) are high, lower carbon emissions and better air quality (or environmental performance in general) are expected. This result is also consistent with that which Ostrom and Cox (2010) discussed. They argued that decentralised systems are a rather suitable institutional structure for handling collective environmental problems.[124] While the empirical findings of the present research confirm the above argument, the evidence is less robust and consistent in democracies.

Further, the results for the other covariates in Models (2) and (3) are almost the same as those I discussed in relation to Model (1).[125] Only the magnitude of coefficients is slightly different. For instance, a one-unit change in *population growth rate* increases the amount of *carbon*

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[122] Democratic indices are mainly used for checking the robustness of the results on the principal political measure.

[123] These researchers argued that the proxy of constraints on executive determines the extent of power concentrated in the hands of the rulers.

[124] This is empirically tested in the present research, where the findings show that the higher the extent of constraints, the higher the degree of decentralisation, and thus the higher the likelihood of decreasing emissions.

[125] There are some improvements regarding two of the control variables: *press score* and *TFP growth*. Similar to Model (1), *the freedom of the press* in both Models (2) and (3) indicate a negative correlation with the dependent variable. Unlike Model (1), *press score* is significant and negatively correlated with *carbon footprint* ($\cong -0.01$) in Model (2). While *TFP growth* showed a positive correlation with the dependent variable in Model (1), it becomes insignificant in the next two models.

footprint per capita by almost 0.03%, compared to Model (1). Overall, all the results produced by the three models estimated with FE-IV are consistent with the literature.

While the first panel of the results (see Table 4.1) contains the political aspect of institutions, the second panel, which is reported in Table 4.2, is assigned to the efficacy of legal and economic aspects of institutions in the emissions mitigation process. In fact, Table 4.2 reports the results of the baseline regression equation (4.2) on the relationship between the second set of institutional measures, *law & order*, *corruption* and *investment profile* and *carbon footprint*.[126] The results achieved on the following legal and economic indicators enable me to build a clear and robust relationship between institutions and CO_2 emissions.

I first use *law & order*, which measures the strength and impartiality of the legal system alongside the popular observance of the law. This variable ranges from 0 to 6, with higher scores showing a better quality legal system (i.e., the higher the value, the lower the risk). For the second measure of legal institutions, I use *corruption*, which measures the level of corruption within the realm of politics on a 6-point scale ($0 - 6$). Higher scores indicate less risk of corruption; hence, the higher the value, the less corrupt a country is. Finally, I focus on the inclusive measure of economic institutions, *investment profile*. It includes three elements of expropriation risks (or contract viability),[127] profits repatriation and payment delays. *Investment profile* ranges between 0 and 12, where higher scores indicate lesser risks associated with the inward investment and higher quality of economic institutions.

Therefore, Table 4.2 contains three models, each of which is estimated with the instrumental variable technique to statistically investigate the impacts of the quality of the regulatory system and property-rights protection on carbon emissions.[128] Further, to properly address the risks of heteroscedasticity, serial correlation and unobserved heterogeneity, all models are estimated with robust standard errors, year dummies and the country fixed-effects estimator. In addition, similar to the political indicators, a set of five dummies on *trend of colonial origins* are used as instruments for solving the endogeneity issue in the estimations for institutions. Models (4)

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[126] All the institutional variables are sourced from the ICRG provided by the Political Risk Services (PRS) group.

[127] The expropriation risk is a proxy for property-rights protection. It used to be defined as a separate variable, and has been extensively used by different scholars, including Acemoglu et al. (2003), Besley and Reynal-Querol (2014) and Knack and Keefer (1995). However, since 1997, it has become one of the three sub-components of the *investment profile*, meaning that it constructs one third of the total score by getting values between 0 and 4.

[128] As the FE-IV estimation is of interest in this study, only the results drawn from this technique are reported, i.e., the results of the RE- and FE-OLS are excluded for this set of institutions.

and (5) in Table 4.2 represent the results of the two variables concerning the quality of the regulatory system.

It can be observed from the FE-IV estimation that both legal indicators are significant and negatively correlated with *carbon footprint per capita* at the 1% significance level. Table 4.2 reports that a one-unit increase in the quality of the legal system, measured by *law & order*, results in -0.45 decrease in the unit of *carbon footprint*. If *corruption* is also changed by one, it is expected that *carbon footprint* changes by -0.65. Therefore, as the results show, the impacts of having fewer corrupt public officials on the emissions abatements are relatively larger than those emanating from a good regulatory system (by 0.2 unit).

These results are robust to alternative legal indicators as well as consistent with the literature on institutions and emissions. For instance, Ivanova (2011), by focusing on a sample of 30 countries in the EU region (1999-2003), concluded that sulphur emissions are likely to be lower in countries with effective regulations, measured by the ICRG *law & order* and *corruption* variables (a fall in *corruption* and rise in *law & order)*, compared to the corrupt ones. Further, Castiglione et al. (2015) estimated the effects of the rule of law on carbon emissions in the sample of 33 high-income countries (1996-2010), using the panel-VAR approach. They found a negative relationship, indicating that the enforcement of rules matters for controlling emissions. In the same vein, Cole (2007) demonstrated that corruption (ICRG) increases carbon emissions across 94 countries (1987-2000), using the random-effects IV approach.[129]

The findings of the present research further support the literature on the effects of legal institutions on implementing different national and global policies, which can directly affect the level of emissions. Using the cross-sectional OLS approach Fredriksson and his co-authors demonstrated the positive effects of low corruption (measured by ICRG and WGI indices) on the stringency of climate change policy (2016), environmental (2003) and energy regulations (2004), and better compliance with international environmental agreements (2003). These results are also supported by Pellegrini and Gerlagh (2006). They found that countries that have less stringent environmental policies are more corrupt; however, there was no evidence as to whether these countries are less democratic.[130]

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[129] Welsch (2004) found that this relationship is particularly strong in the low-income countries.

[130] Koyuncu and Yilmaz (2009) and Meyer, Van Kooten, and Wang (2003) also argued that deforestation rates are likely to be higher in corrupt countries.

Table 4.2. Legal and economic institutions (IV estimations)

	Model (4)	Model (5)[131]	Model (6)
	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)
Law & Order	-0.454***		
	(0.125)		
Corruption		-0.649***	
		(0.239)	
Investment Profile			0.044*
			(0.026)
GDP per capita	1.810***	1.724***	1.799***
	(0.111)	(0.115)	(0.105)
Population Growth	0.045**	0.019	0.036
	(0.023)	(0.025)	(0.023)
Government Stability	0.005	0.045**	-0.015*
	(0.009)	(0.021)	(0.009)
Press Score	-0.001	0.001	-0.006***
	(0.002)	(0.003)	(0.001)
TFP Growth	0.007*	0.004	0.003
	(0.004)	(0.004)	(0.003)
Human Capital Index	-0.762***	-0.506***	-0.285*
	(0.181)	(0.175)	(0.163)
Forest Biocapacity	-0.112***	-0.099***	-0.076***
	(0.022)	(0.028)	(0.018)
Energy Use	0.529***	0.653***	0.582***
	(0.065)	(0.080)	(0.056)
Obs.	1739	1739	1739
R-squared	0.092	-0.373	0.355
No of Countries	83	83	83
Year Dummies	Yes	Yes	Yes
Country FE	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(3)). Independent variables representing formal legal and economic institutions are *law and order* $(0-6)$, *corruption* $(0-6)$, and *investment profile* $(0-12)$. Higher values (in parenthesis) indicate stronger formal institutions. Model (4)-(6) reports estimations of the dependent variable against each of the institutional variables. All three models

[131] A negative R-squared is obtained in this model, which is not problematic; it is quite common in IV specification. For further details, see Sribney, Wiggins, and Drukker (2003).

are estimated with fixed-effects IV regressions (column (1)-(3)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: **** p<0.01, ** p<0.05, * p<0.1*.

The last column of the table above depicts the results on *investment profile*. In contrast with previous results on the institutional factors, a significant positive coefficient is found for the proxy of economic institutions, indicating that in countries with strong economic institutions, the level of emissions gets worsen. Although it is not consistent with what I have initially hypothesised, such result is somewhat predictable, as the positive effects of strong economic institutions on increasing the levels of CO_2 emissions have been statistically documented in previous studies. For example, Carlsson and Lundström (2003) showed that enforcing contracts as a large part of economic freedom increases emissions in high-income countries.[132]

The same results were also obtained by Joshi and Beck (2018) in the sets of OECD and non-OECD countries. They argued that higher economic freedom leads to a larger scale of economic activity, which in turn increases the level of emissions because good economic institutions mean that contracts are enforced and property-rights are protected.[133] This further means that the state's control over the economy declines; as a result, the state cannot act as a positive factor in protecting the environment. Therefore, economic institutions negatively affect the quality of the environment.

The results obtained on additional explanatory regressors are consistent across Models (4), (5) and (6) and the ones presented in Table 4.1.[134] Only *government stability* shows contradictory results in Models (5) and (6), where both positive and negative reliable estimations can be observed. Initially, I hypothesised that political stability is in favour of the environment. As in countries with mature governance systems, regardless of the type of regime, more environmental-friendly policies are adopted (maturation effect) (Midlarsky, 1998). So, the result of Model (6) is in line with this hypothesis. On the other hand, stable countries are more prone to attract foreign investment, which in turn increases physical and human capital accumulation

[132] The opposite result is found in the low-income countries, which is also supported by Wood and Herzog (2014, April).

[133] The positive effects of strong economic institutions on GDP per capita is well established in several empirical studies, including Acemoglu et al. (2001).

[134] Similar to the first three models presented in Table 4.1, the *population growth* is positively correlated with *carbon footprint per capita*, though it is only significant in Model (4). Moreover, like Model (2), *freedom of the press* indicates a significant negative correlation with the dependent variable in Model (6). Finally, the positive effects of *TFP growth* in Model (4) is indicated above, which is broadly discussed before.

and leads to higher economic growth (Aisen & Veiga, 2013). As *GDP per capita* is one of the main contributors of environmental degradations, *government stability* results in more emissions. Therefore, the result of Model (5), though unexpected, is reasonably explained.

Finally, the results of legal institutions are consistent with the main political institutions. As illustrated in Tables 4.1 and 4.2, the empirical findings of the present research seem to confirm the efficacy of formal institutions, particularly political and legal ones, in mitigating carbon emissions. This denotes that the higher the quality of formal institutions, the lower the level of carbon emissions would be across countries. Overall, it can be concluded that all the IV estimation results across the presented six models are mainly consistent with the conceptual framework of this study and existing literature.

4.3 Study 2 Results and Discussion: The Inclusion of Informal Institutions

Study 2 is assigned to empirically test the validity of the updated collective action theory, in which cooperation is proposed to be the key to solving collective problems. It is suggested that the dilemma of removing the risks of free riding embedded in the global commons can be solved by the presence of social capital within society. In this process, interpersonal trust as the main component of the social capital seems to be the key for sustaining cooperation and reciprocal behaviours among a large portion of the population. Therefore, to thoroughly consider the role of institutions, particularly the significant effects of informal institutions in governing the commons, the variable of trust will be included in the regression model.

As discussed in Chapter 3, informal institutions are better indicated by *GS8 (repertoire of norms and strategies)* in the SES framework.[135] Hence, *GS8* is used alongside each individual variable of formal institutions *(GS4: regime type*, *GS6: rules-in-use* and *GS7: property-rights system)* in quantitative equations. Therefore, building on the first study, I first need to re-specify regression equation (4.2) to take account of the informal institutional variables as well as the formal ones. I will then explain the reasons why I did not use the conventional measure of

[135] In the theoretical framework, two variables of *GS8* and *A6 (norms, trust-reciprocity/social capital)* show the importance of norms and trust in managing the global commons. *GS8* is a better variable for representing informal institutions because it refers to a broad term that includes all norms, beliefs, culture and traditions, while *A6* is a narrow concept that can be treated as referring to the qualities and attributes of an actor.

informal institutions (i.e., trust). In addition, I am going to demonstrate that the new indicator (i.e., tensions) is reliable enough for being used as a proxy for informal institutions.

As in the first study, to carefully estimate the institution-environment nexus, I have utilised three panel data specifications: RE-OLS, FE-OLS and FE-IV. However, to deal with the endogeneity issue, I primarily rely on the FE-IV estimations, in which exogenous instruments are required to be introduced for institutions. Accordingly, I have constructed a new variable for instrumenting informal institutions in the FE-IV estimation, called *distance to conflict zones*. I will explain the construction and theory of my instrument in the third sub-section (Section 4.3.3). Finally, this study ends with the presentation of and discussion on the estimation results.

Study 2, in fact, contains one of the significant contributions of this study to the current literature. To the best of my knowledge, this study is among the very first studies that examine the effects of both formal and informal institutions on mitigating emissions. In addition, the empirical analysis is carried out by the fixed-effects instrumental variable strategy. As far as I know, researchers are reluctant to use FE-IV specification for studying the institution-environment nexus, mainly because they are required to specify time-variant instruments for the endogenous institutions. It is a difficult task; however, I have overcome this obstacle by constructing a new instrument for the employed measure of informal institutions. Overall, I use a novel approach to validate collective action theory and the efficacy of cooperation in lessening the free-riding risks in data.

4.3.1 Empirical Specification

Since the focus of this study is on the impacts of both types of institutions, the new regression line should also take account of the informal institutions. Thus, (4.2) can be rewritten as:

$$y_{it} = \alpha + \beta_1\{formal\ institutions\}_{it} + \beta_1^{'}\{informal\ institutions\}_{it} + \boldsymbol{\beta_2}\,\boldsymbol{Z_{it}} + \gamma_i + \kappa_t + \varepsilon_{it} \tag{4. 4}$$

Where y_{it} shows the dependent variable, *carbon footprint per capita*. Subscripts i and t denote *country* and *year*, respectively. α is the *constant term*. γ_i and κ_t represent *country-specific* and *year effects*, and ε_{it} denotes *the error term*. In addition, $\boldsymbol{Z_{it}}$ is *the vector of additional explanatory variables* and $\boldsymbol{\beta_2}$ is *the vector of unknown parameters*.

In this study, the estimation of β_1 and β_1' are of interest ($\beta_1 < 0,\ \beta_1' < 0$). They are *the unknown parameters* of $formal\ institutions$ and $informal\ institutions$. Equation (4.4) has only one difference with (4.2), and that is the addition of $informal\ institutions$. It is measured by *religious tensions* as the primary variable. The reasons for choosing such variable are reviewed below (Section 4.3.2). Subsequently, before going directly to the estimation results, I explain the variables I use for instrumenting $informal\ institutions$ in Section 4.3.3.

Here, I use the same procedure I followed in study 1, so I will first estimate regression (4.4) with the OLS model, ignoring any misspecification issues. I will then re-estimate (4.4) with FE-OLS to address the potential risks of missing unobserved heterogeneity in the model. Since both $formal\ institutions$ and $informal\ institutions$ are likely to be endogenous, equation (4.4) will be finally estimated with the FE-IV method. This strategy is considered as the main econometric approach for estimating (4.4).

4.3.2 Trust and Tensions

One of the most common variables used in the economic literature for quantifying informal institutions is the World Values Survey (WVS) measure of "trust." There is a well-established literature on the strong positive effects of *WVS trust* on economic growth and development.[136] However, institutional studies in the context of the environment have failed to include trust and, more broadly, informal institutions in their analysis.[137] This research is one of the very first studies to focus on this aspect of institutional analysis.

In this study, however, I use the indicator of *religious tensions* (sourced from the ICRG) as the main proxy for measuring the quality of informal institutions across countries and over time. It measures the degree of tensions arising from a situation where a single religious group dominates a country. It ranges between 0 and 6, where the higher number shows lower tensions.[138] The present research is unique, in a sense, because it aims at measuring the effects of informal institutions on the level of emissions without using the conventional measure of informal institutions (i.e., *ICRG religious tensions* replaces *WVS trust* in my regressions).

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[136] See for example Knack and Keefer (1997) and Zak and Knack (2001).

[137] There are only two empirical studies that have included informal institutions (using *WVS trust*) in mitigating emissions. See Carattini and Jo (2018) and Carattini et al. (2015).

[138] The maximum score of 6 equates to "very low risk" (e.g., some minor inappropriate policies), and the score of 0 equates to "very high risk" (e.g., civil dissent and war).

Two sample-related problems arising from using *WVS trust* can be alleviated by using *ICRG religious tensions*. First, by using *religious tensions* as the primary indicator of informal institutions, the empirical analysis largely benefits from better data coverage due to comprehensive annual observations which have been provided for a sample of 140 countries since the 1990s. One of the main problems with *WVS trust* is that it does not cover a sufficient number of years and countries.[139] The first wave of WVS was published in 1985 (1981-1984) and the most recent one (sixth wave) produced in 2015, though the latest available data is for 2010-2014. As a result of publishing a wave every five years, the number of observations has substantially decreased.

The second problem is related to the first because the latter may produce further biased and unreliable estimations. To assess the effects of environmental problems correctly, having a lengthy time horizon is particularly crucial since ecological challenges develop over a long period. To reflect this aspect of the environment in empirical analysis in this research, I tried to construct a cross-sectional time-series dataset with the maximum available number of years: annual data from 1990 to 2014 is provided for all countries.[140] While *ICRG religious tensions* enables one to build such a large dataset and improve the estimations, *WVS trust* results in losing many more observations. Consequently, *WVS trust* is not useful for this research.

Moreover, it seems that the required settings for developing interpersonal trust and social capital are less likely to be built in heterogonous societies. This tells one that cooperative behaviours are less likely to be adopted in such diverse communities. Hence, using a proxy for measuring tensions arising from ethnic and religious fractionalisation is relatively more important for assessing the probability of cooperation and reciprocation. While *WVS trust* subjectively measures the degree of interpersonal trust within a country,[141] it does not tell one anything about whether the society is ethnoreligiously heterogeneous. By using *ICRG religious tensions*, one is able to take into account the degree of heterogeneity within a society. Therefore, the data on this variable gives a more realistic sense of the feasibility of occurring cooperation.

[139] The maximum number of observations for all countries in the WVS dataset is 308, which is far less than the ICRG on *religious tensions* (3549).

[140] As stated in Chapter 3, the adopted dependent variable is only covered up to 2014, dictating that the studied period of this study be reduced by one year (1990-2014).

[141] By asking this question from participants: “Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?”

What I have argued so far is that tensions and trust can be theoretically correlated, but I need to further uncover their linkages to show their correlation. As mentioned, cooperation and reciprocation can be fostered more easily in homogenous societies (Esfahani & Ramírez, 2003). because it is easier for people to connect with and predict the behaviours of those who have the same religious and ethnic identifications as they have, rather than those who are different (Field, 2003).[142] This argument is especially relevant to this study because it implies that trust is relatively lower in terms of ethnic or religious composition in less homogeneous countries,[143] a point also advanced by Field (2003). He stated that strong intra-group networking lessens inter-group interactions, as people are less likely to adopt trust-based behaviours when they are dealing with members of another group. This, in turn, promotes social tensions and inequality.[144]

While ethnic and religious fractionalisation increases the level of social tension, it decreases social interactions, which, in turn, hinders social cohesion (Rohner, 2011). Society comprises several dis-/less-connected groups.[145] Social fragmentation increases the likelihood of violence and conflicts among different groups of people, and it is detrimental to the creation of the trust (Rohner et al., 2013). When the radius of trust is limited to the members of a specific group, the trust itself is no longer able to facilitate cooperation and reciprocation in the society (beyond the group's members) for achieving collective goals (Field, 2003, p. 73).[146] Therefore, tensions and trust are correlated and, simply put, the higher the tensions, the lower the trust will be.

Table 4.3. Correlation between WVS trust and ICRG tensions

Wave	W2	W3	W4	W5	W6
Year	(1990-94)	(1995-98)	(1999-2004)	(2005-09)	(2010-14)
Coefficient	0.49**	0.48*	0.34*	0.75**	0.42*

*Notes: *** p<0.01, ** p<0.05, * p<0.1.*

[142] The tendency for connection and interaction is notably stronger among religious groups, as different religions may have different attitudes toward social interactions (Alesina & La Ferrara, 2002).

[143] Ethnic homogeneity is said to be one of the main reasons that the level of trust is high in Scandinavian countries (Delhey & Newton, 2005; Zak & Knack, 2001).

[144] A key determinant of lower trust in a society is being part of a minority group that has been historically discriminated against. See Alesina and La Ferrara (2002).

[145] Within a society, therefore, each homogeneous group keeps to itself and does not interact with other homogeneous groups.

[146] This will also damage the level of trust between people and government, lowering public goods provision (Esfahani & Ramírez, 2003).

Now, I am going to test the possibility of having a correlation between trust and tensions in the data. To show the degree to which *ICRG religious tensions* and *WVS trust* are related to each other, I ran a pairwise correlation test. The results are provided in Table 4.3. As can be seen, the top row shows the number of the wave recorded in the World Values Survey, which ranges between 2 and 6. Since the first wave was published before 1990, it is excluded from this table. The middle row shows the period during which the corresponding wave of data collection was conducted across the sample of countries. For example, the second wave (W2) data collection took five years between 1990 and 1994.[147] The bottom row shows the correlation coefficient, which reveals that the variable has around a 50% correlation; this indicates their relevancy to each other.

Table 4.4. The highest- and lowest-ranked countries in WVS trust and ICRG tensions

	Indicator	**Country**				
Top 5%	WVS Trust	Norway (0.70)	**Denmark** (0.67)	**Sweden** (0.65)	**Finland** (0.59)	China (0.57)
	ICRG Tensions	New Zealand (6.0)	**Denmark** (6.0)	**Sweden** (6.0)	**Finland** (6.0)	Australia (6.0)
Bottom 10%	WVS Trust	Philippines (0.05)	Uganda (0.07)	Malaysia (0.08)	Turkey (0.10)	**Lebanon** (0.10)
	ICRG Tensions	Pakistan (1.1)	Algeria (1.5)	Nigeria (1.8)	Israel (2.4)	**Lebanon** (2.5)

Notes: Numbers in parentheses shows values of *WVS trust* (0 - 1) and *ICRG tensions* (0 - 6) for the listed countries.

To confirm the close correlation of *WVS trust* and *ICRG tensions* and have a better sense of how they are related to each other, I dig deeper into the data by comparing the top- and bottom-ranked countries in both variables. Table 4.4 compares the average trust and tensions in countries placed in the top 5% and bottom 10% of both variables. The table is divided into two main parts: the top- and bottom-ranked countries in both WVS *trust* and *ICRG religious tensions* variables. The mean of trust for the top 5% of countries in the WVS dataset is more than 0.55,[148] and in the ICRG it is 6. In the WVS dataset, trust is calculated every five years, so each country has a maximum of 5 observations in total. Hence, to have a better interpretation, average trust is calculated only for countries that have at least 3 observations.

[147] In the WVS dataset, the second-wave data were recorded in different years within the period (1990-1994). For instance, Argentina's W2 data was recorded in 1990, while the same data for Austria was recorded in 1991. It is the same for all other waves.

[148] The maximum of average trust for a country is 0.70. Thus, the top countries range between 0.55 and 0.70.

As can be seen from Table 4.4, at the top of the list, three out of the five countries are the same: Denmark, Sweden and Finland (in bold). In the WVS dataset, two countries - New Zealand (0.52) and Australia (0.46) - are among the top 10% of countries with the highest mean of generalised trust. In addition, the average values of Norway and China fall between 5 and 6 in the ICRG dataset (top 25%). The mean of trust for the bottom 10% of countries in the WVS and ICRG datasets is less than 0.10 and 3, respectively. As illustrated, in the bottom-ranked countries, Lebanon is the only one common to both lists of bottom-ranked countries. In the WVS dataset, the average level of *trust* for Pakistan, Algeria, Nigeria and Israel is valued between 0.15 and 0.25. Further, the mean of *tensions* for four countries - the Philippines, Uganda, Malaysia and Turkey - is between 3 and 4 (the bottom 25%).

Overall, the theoretical and statistical correlation between the *WVS trust* and *ICRG religious tensions* confirms that these two variables are closely linked. Given that *religious tensions* can further improve the studied sample and reliability of estimations, I substitute the conventional measure of *trust* with *religious tensions*. From now on, *religious tensions* is used as an indicator of trust in this research.

4.3.3 Instrumental Variable

As discussed in Section 4.3, institutions are endogenous, and thus I would need to find appropriate instruments to use in my IV estimations. However, finding a time-variant instrument for informal institutions is inherently a challenging task (Fredström, Peltonen, & Wincent, 2020; Williamson & Kerekes, 2011).

Robbins (2012) used countries' current monarchical status as an instrument for the generalised level of trust in countries, arguing that monarchs represent countries' national identities and serve as role models unifying nations against social and political distress. Williamson and Kerekes (2011) considered countries' geography as an instrument for informal institutions on the basis that geography affects the cultural progress of a country such that "groups that live in isolation because of geographic conditions do not advance as much culturally as do other societies in which the costs of interacting are much lower" (p. 557). Such instruments are, however, generally static in nature and cannot add much value to my panel data model.

This study constructs a variable called *distance to conflict zones*, to quantify each country's risk levels in terms of its distance to countries involved in internal conflicts, external conflicts or both. Conflict zones have been identified using the data provided by ICRG's rating system

(Howell, 2015). *Internal conflict* assesses the level of political violence in a given country. The risk level is based on civil war/coup threats, terrorism/political violence and civil disorders. *External conflict* evaluates the level of foreign pressures upon an incumbent government. The risk level is determined based on violent (e.g., wars and cross-border conflicts) and non-violent (e.g., diplomatic pressure) foreign actions. For both variables, the risk score ranges between 0 and 12, indicating that countries with a higher score are less likely to experience the threat of violence.[149]

In order to have one single value for a given country in each year, I have sum totalled the *internal* and *external conflicts* scores. This creates an index measuring the total likelihood of inter- and intra-state conflicts in each country $(0 - 24)$. I then divided the score by 24 and multiplied it by -1, for rescaling so that the violent (peaceful) countries receive higher (lower) values $(-1 - 0)$. In other words, the lower the total score, hereafter $Conflict\ Score$, the lower the overall conflict score, and thus, the lower the overall risk would be in a country. Now that I have a variable that measures the total risk of the conflict/violence in a country, the next step is to estimate *distance to conflict zones*. To do so, I first estimate the pairwise distance between two countries (in kilometres) using their geographical coordinates (i.e., latitude and longitude). Countries' geographical information has been collected from the GeoDist database provided by CEPII institute (Mayer & Zignago, 2011, January 31). The resulting variable is named $Distance$.[150] I then calculate, *total risk factor* for each country using the below formula:

$$Risk\ Factor_i = \frac{\sum_{i,j=1}^{n}(\frac{1}{Distance_{ij}} \times Conflict\ Score_j)}{\sum_{i,j=1}^{n}(\frac{1}{Distance_{ij}})}, \qquad i \neq j \tag{4. 5}$$

Where $Distance$ is the distance between country i and country j; and $Conflict\ Score$ is the total conflict score of country j. In other words, country i's risk factor is that country's total conflict weighted by the inverse distance. Therefore, this formula would provide me with a new variable called *distance to conflict zones*, which evaluates a country's level of risk based on its *(i)* possibility of experiencing conflict and *(ii)* geographical distance to other countries that are in/out of the conflict-prone zones. *Distance to conflict zones* is a continuous variable

[149] For further details on the components of these two variables, see Appendix III.

[150] This variable is inverted in (4.5), as countries that are further away should have less weight in the function.

measuring a country's risk factor on a one-point scale $(-1-0)$. To be closer to -1 (lower risk factor), countries should satisfy two criteria of having longer distances to the conflict zones and being less prone to possible conflicts. In order for the instrument to be a valid measure, I need to ensure that it does not directly influence the measure of the environment.

One needs to be cautious when drawing any conclusions about the impacts of warfare on the environment as several other factors can also alter this relationship (Reuveny, Mihalache-O'Keef, & Li, 2010). First, different types of environmental degradation may be more or less sensitive to varying forms of conflicts, i.e., depending on the type and intensity of the conflicts, they will have different effects on the destruction of ecosystems, deforestation or air pollution. For instance, armed conflicts in the home country and abroad are expected to have harmful effects on the environment both directly (e.g., by destroying lands, oil fields and mines) and indirectly (e.g., army movements and arms production pollution). Second, history shows one that less developed countries are more likely to become involved in armed conflicts. Therefore, not all types of warfare degrade the environment in the same way.

Furthermore, in constructing the instrument, I am using the probability of conflict in each country weighted by the inverse geographical distance, not the conflict measure itself. This additional weighting makes this instrument exogenous.[151] For example, if I only use country i's total conflict score, then one may argue that wars might have a direct effect on the environmental quality both in the home country and abroad.[152] While it should not directly affect the dependent variable (i.e., it should only affect it through the measure of informal institutions). Hence, I cannot use only country i's conflict measure in the construction of this specific instrument, as the exclusion restriction assumption may be violated.[153]

The idea that makes *distance to conflict zones* qualify as a potentially exogenous instrument for *religious tensions* is that being physically close to conflict-prone zones (i.e., the ones with

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[151] That is the whole idea behind using this IV. In fact, the further away I can go, the better, as the instrument becomes more exogenous.

[152] Although $Conflict\ Score$ measures the potentiality for a country to be involved in conflict, to some degree it is a rough indicator of war as two of its sub-indices (civil and cross-border wars) can be related to armed conflict and, therefore, may play a role in carbon emissions. However, it is important to consider that $Conflict\ Score$ does not necessarily measure that a given country is *actually* involved with any inter-/intra-state war, because most of its sub-indices involve non-armed conflicts, such as low-tech conflicts, surgical air strikes and border confrontations, which have minimal or no effects on emissions.

[153] I also cannot use a country's own conflict (i.e., *internal conflict*) here, as it may directly affect the emissions of carbon dioxide. It may violate the exclusion restriction assumption as it is self-driven and endogenous.

higher risk factors) makes a country more vulnerable to social tensions that arise from higher migration flows, which in turn bring about ethnic and religious heterogeneities. This will have adverse effects on the current level of within-nation trust, which in turn influences the current environmental performance of countries, negatively. In other words, vulnerable countries (i.e., the ones with higher risk factors) are highly likely to be influenced by ethnoreligious tensions (high correlation) that are arisen from migration flows.[154] This gradually shapes the level of interpersonal trust that drives the environmental outcome. Therefore, much of the variations in current informal institutions can be explained by ethnoreligious fractionalisation. Following this approach, the current performance of informal institutions is modelled as follows:

$$\{informal\ institutions\}_{it} = \alpha + \beta_1^{'}\ \{distance\ to\ conflict\ zones\}_{it} + \boldsymbol{\beta_2}\ \boldsymbol{Z_{it}} + \gamma_i + \ \kappa_t + \nu_{it} \tag{4. 6}$$

Where the quality of $informal\ institutions$ is a function of $distance\ to\ conflict\ zones$, and ν_{it} is an error term. Equations (4.4) and (4.6) form a system of equations that links environmental degradations to informal institutions. The exclusion restriction implied by the above FE-IV regression (equation 4.6) is that, conditional on the variables I controlled in the regression; the geographical distance between a single country and other regions with/without having conflict has no effect on carbon emissions, other than their effect through hindering current $informal\ institutions$. In other words, the emissions effects from conflict-prone geographical territories are only felt through their impacts on informal institutions rather than directly influencing emissions. It implies that the employed instrument should be uncorrelated with the error term (ε_{it}) in (4.4).

4.3.4 Estimation Results

Table 4.5 reports the empirical results of the regression equation (4.4). In this equation, the relationship between formal and informal institutions and carbon emissions are examined. As for Study 1, I first present and discuss the results of the political institutions.[155]

[154] Based on the pairwise correlation test, the average *risk factor* of countries is more than 25% correlated with *religious tensions*; hence, it seems reasonable to accept that a country's *total risk factor (distance to conflict zones)* is a direct determinant of current level of trust.

[155] As discussed in Section 4.2, legal and economic institutions are used for testing the sensitivity of the results on political institutions and mostly in terms of *political constraints*.

As can be seen, Table 4.5 contains three main models, each of which represents the impacts of one of the above political indicators (namely *political constraints index*, *level of democracy*, and *polity score)* jointly with *religious tensions* on *carbon footprint*. Along with the results of the main specification (FE-IV), I also provide the random- and fixed-effects OLS estimations only for the three models (Models (1), (2) and (3)) on political indicators to show the consistency of the results.[156] With respect to the instruments in the IV strategy, *colonial origins* and *distance to conflict zones* are used as instruments for formal and informal institutions, respectively.

First, I report the results of the most important model (M1). In this model, *political constraints index* is accompanied by *religious tensions* as the core institutional variables. As illustrated in Table 4.5, the OLS results show that countries with lower emissions are the ones with higher levels of trust and constraints, demonstrating a significant negative correlation with the dependent variable.[157] However, in the fixed-effect analysis, the sign for both of the institutional indicators flip to positive, though *religious tensions* are not significant. Once the issue of endogeneity is addressed in the FE-IV estimation, the signs for both *religious tensions* and *political constraints index* flipped back to negative. Now both variables establish statistically meaningful relationships with *carbon footprint*. [158]

The FE-IV results show that a one-unit increase in the level of trust results in the 0.383 unit decrease in pollution across countries, ceteris paribus;[159] that is, the lower the social tensions, the lower the emissions would be in a given country. Moreover, if the variable related to the executive constraints is changed by one, ceteris paribus, it is expected that the levels of emitted carbon change by -1.6, approximately.[160] In other words, the results indicate that the lower the concentration of political power (in the hands of the head of the state), the lower the emissions would be in a given country.

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[156] All models are robust to the presence of heteroscedasticity and serial correlation.

[157] However, the OLS results may not be reliable.

[158] To check the predictive strength of the constructed instrument for *religious tensions,* see the first-stage results in Appendix III (Table 4.A1).

[159] If the level of trust increases by one standard deviation, emissions is expected to decrease by 0.2035 across countries. The magnitude of the effect related to trust seems substantial for a variable that was neglected in the environmental analysis, particularly when it exceeds the effects of executive constraints. See the footnote below.

[160] If the level of executive constraints is changed by one standard deviation, it is expected that the levels of emitted carbon change by -0.1938.

Table 4.5. Political institutions and informal institutions (IV estimations)

	Model (1)			Model (2)			Model (3)		
	OLS	FE-OLS	FE-IV	OLS	FE-OLS	FE-IV	OLS	FE-OLS	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Religious Tensions	-0.144***	0.018	-0.383***	-0.120***	0.021	-0.312***	-0.131***	0.019	-0.327***
	(0.024)	(0.022)	(0.102)	(0.023)	(0.023)	(0.080)	(0.023)	(0.022)	(0.078)
Political Constraints Index V	-0.827***	0.192**	-1.556***						
	(0.150)	(0.089)	(0.441)						
Level of Democracy				-0.263***	0.040*	0.064			
				(0.029)	(0.021)	(0.055)			
Combined Polity Score							-0.114***	0.017**	-0.016
							(0.011)	(0.008)	(0.024)
GDP per capita	1.483***	1.859***	1.466***	1.402***	1.838***	1.724***	1.371***	1.851***	1.707***
	(0.056)	(0.365)	(0.139)	(0.051)	(0.357)	(0.110)	(0.048)	(0.361)	(0.113)
Population Growth	0.593***	0.038	0.142***	0.538***	0.044	0.086***	0.514***	0.046	0.089***
	(0.046)	(0.031)	(0.033)	(0.044)	(0.033)	(0.025)	(0.043)	(0.033)	(0.025)
Government Stability	0.150***	-0.006	-0.005	0.116***	-0.007	-0.005	0.106***	-0.007	-0.007
	(0.025)	(0.017)	(0.010)	(0.025)	(0.016)	(0.008)	(0.026)	(0.016)	(0.009)
Press Score	-0.015***	-0.006**	0.000	0.006*	-0.009**	-0.010**	0.000	-0.008**	-0.003
	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.004)

TFP Growth	0.011	0.002	0.009*	0.010	0.002	0.001	0.012	0.002	0.003
	(0.011)	(0.004)	(0.005)	(0.011)	(0.004)	(0.004)	(0.011)	(0.004)	(0.004)
Human Capital Index	0.736***	-0.408	-0.322	0.789***	-0.443	-0.417**	0.757***	-0.425	-0.363**
	(0.100)	(0.346)	(0.204)	(0.100)	(0.343)	(0.168)	(0.098)	(0.340)	(0.167)
Forest Biocapacity	-0.011	-0.058	-0.124***	-0.013	-0.055	-0.103***	-0.005	-0.056	-0.107***
	(0.010)	(0.041)	(0.030)	(0.010)	(0.041)	(0.023)	(0.010)	(0.042)	(0.023)
Energy Use	0.812***	0.605***	0.266***	0.765***	0.578***	0.456***	0.758***	0.578***	0.476***
	(0.047)	(0.179)	(0.094)	(0.043)	(0.180)	(0.059)	(0.042)	(0.181)	(0.058)
_cons	-14.533***	-14.004***		-11.401***	-14.036***		-12.045***	-13.944***	
	(0.518)	(3.062)		(0.540)	(3.080)		(0.456)	(3.048)	
Obs.	1745	1745	1730	1754	1754	1739	1732	1732	1717
R-squared	0.748	0.383	-0.397	0.757	0.382	0.113	0.762	0.383	0.088
No of Countries		98	83		98	83		97	82
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(9)). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal political institutions are *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$. Higher values (in parenthesis) indicate stronger formal institutions. Model (1)-(3) reports estimations of the dependent variable against each of the institutional variables. All of the three models is estimated with simple OLS regressions (shown in column (1)/(4)/(7)), fixed-effects OLS regressions (shown in column (2)/(5)/(8)), and fixed-effects IV regressions (shown in column (3)/(6)/(9)). In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. All regressions are performed on the sample of all countries. The number of countries is reduced by 15 in IV regressions as *xtivreg2* drops singletons in Stata. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01*, ** *p<0.05*, * *p<0.1*.

The finding related to trust is consistent with two studies that have focused on the effects of informal institutions (measured by WVS trust) in emissions reduction analysis. In the first study, Carattini et al. (2015) analysed the effects of trust on mitigating GHG emissions in a sample of 29 European countries (1990-2007). Benefiting from the fixed effect OLS, their results supported the descriptive evidence collected by Elinor Ostrom (2010a) on the positive effects of social and moral norms on adopting environment-friendly behaviours and reducing pollution. Later, Carattini and Jo (2018) drew the same conclusion. Following the approach of Algan and Cahuc (2010), they analysed the causal effects of the inherited trust of immigrants' descendants to the United States[161] (which show the level of trust in their countries of origin) on CO_2 emissions across 26 countries between the years 1950 and 2010. Using the same estimation method, they found that carbon emissions are substantially less in trustworthy countries than low-trust ones during this period.

Comparatively, the present research adds much more to the existing literature, in terms of both theoretical and empirical analysis. For instance, Carattini et al. (2015) and Carattini and Jo (2018) have claimed that their studies provide empirical analysis in support of collective action theory, through considering the measure of trust in their estimations. However, the first main drawback of these studies relates to the exclusion of formal institutions from their empirical analysis, without which collective action theory is inefficiently tested.[162] While I have thoroughly analysed the effects of formal institutions in the first study, previous studies have neglected this facet of institutions.[163]

Next, they have ignored the possibility of endogeneity in their specifications and simply used fixed-effects analysis to estimate the relationship. Institutions are inherently endogenous and failure to address this problem yields unreliable estimations. This misspecification problem is illustrated in the above estimations (Table 4.5), where inconsistent results are reported in the FE-OLS columns. In fact, the main reason for obtaining opposite results by the fixed-effect OLS implies this common specification problem; otherwise, such a positive link does not seem to be correct. As can be seen, I tried to overcome the endogeneity issue by using an IV strategy and instrumenting the institutional variables.[164]

[161] For example, they estimated the differences in trust between France and Germany by comparing Americans whose ancestors came to the US from France and Germany in different periods - 1920s, 1950s and 1980s.

[162] Formal power has been recognised as the main pillar of collective action theory.

[163] Only Carattini and Jo (2018) controlled for political institutions (Polity IV) in a supplementary regression.

[164] *Colonial origins* and *distance to conflict zones* are used as instruments for formal and informal institutions.

Third, estimations provided in those two studies might be further biased as their analyses are based on a very small sample of countries and years. For instance, the maximum number of observations they used in both studies are less than 100. This resulted from using the WVS measure of trust, which does not enable annual observations. However, to avoid losing observations and obtaining biased and unreliable estimations, I drew on ICRG measure of tensions, which enabled me to compile a yearly dataset for 140 countries over 25 years (1990-2014), leading up to 3500 data points. Overall, the results presented in this study seem to be reliable and consistent with collective action theory, as the positive effects of formal and informal institutions in mitigating emissions are empirically documented.[165]

Similar to Table 4.1, I then report the effects of the other two political indicators on air pollutants in Model (2) and (3).[166] The provided results in Table 4.5 extend the existing empirical literature related to the controversial democracy-emissions relationship. Moreover, considering informal institutions further signifies the contribution of this study.

As illustrated in Table 4.5, the simple OLS estimation in both models reveals a significant negative relationship between *religious tensions* and the dependent variable. However, a meaningless positive relationship is found in the next analysis (FE). Finally, the IV strategy demonstrates a statistically negative and meaningful association with *carbon footprint per capita*, meaning that the higher the level of trust, the lower the level of emissions would be across all countries, as anticipated. The outputs in both M(2) and M(3) are identical in terms of sign and significance level with Model (1), showing that the findings are quite consistent across all three models and estimations.

In addition, the results on the formal institutions are also consistent across two models. In the second model (first column), the simple OLS results illustrate that countries with lower carbon emissions are the ones with stronger democracy. In the fixed-effect OLS, the sign for the *level of democracy* flips to positive, showing that stronger democratic systems produce higher

[165] The reliability of estimations on informal institutions, which is initially instrumented by *distance to conflict zones* is further tested by creating two more instruments for informal institutions. New results are quite consistent with the ones presented in Table 4.5. For further details, see Appendix III, Table 4.A4 and 4.A5.

[166] As mentioned before, the employed indicators for measuring the quality of democratic institutions are the two most scrutinised variables in the literature, *polity score* $(-10 - +10)$ and *level of democracy* $(0 - +10)$. *Polity score* measures the quality of a regime authority solely, while the inclusive measure of *level of democracy* is a proxy for not only the *polity score* but also the quality of *political rights* and *civil liberties*. For both variables, the higher the numbers, the more democratic a country is.

emissions (at the 10% significance level). However, in the FE-IV specification, the political factors become insignificant; denoting that those democratic institutions are not relevant to the process of carbon mitigation. The results are robust to an alternative measure of democracy *(polity score)*.[167] Overall, the results acquired on the three models in Table 4.5, confirm that:

(1) If the level of tensions (trust) decreases (increases) in a country, then the likelihood of adopting cooperative and reciprocal behaviours by community members increases, and thus, the level of CO_2 emissions is expected to decrease. This is consistent with the prediction of the updated collective action theory. In fact, the present findings support the efficacy of cooperation sustained by trust in promoting pro-environmental behaviours toward curbing emissions.

(2) Consistent with previous findings (of Study 1), political institutions matters for reducing emissions, in particular the extent of constraints on power concentration. However, being either a democratic or an autocratic country is not relevant to emissions abatement efforts. These findings on political institutions are consistent with Ostrom's argument on the importance of decentralisation in managing the environment.

The results on the additional control variables demonstrate consistency across all three models (M(1), M(2) and M(3)). For instance, similar to M1, *press score* in (M2) and (M3) indicates a negative correlation with the dependent variable, though it is only significant in M2. Further, *human capital* is significant and negatively affect *carbon footprint* in M2 and M3. Besides, the results also seem to be consistent with the theoretical basis of this study. For instance, *log GDP per capita*, *population growth* and *energy use* confirm significant positive correlations with *carbon footprint per capita* (Carattini et al., 2015; Joshi & Beck, 2018).

Table 4.6. Legal and economic institutions and informal institutions (IV estimations)

	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)
Religious Tensions	-0.467***	-0.363***	-0.331***
	(0.151)	(0.098)	(0.079)
Law & Order	-0.700***		
	(0.251)		

[167] While, *level of democracy* remains positive in the FE-IV, *polity score*'s sign changes to negative. Since both variables are statistically insignificant, they are unable to establish meaningful relationships with *carbon footprint*.

Corruption		-0.167	
		(0.163)	
Investment Profile			-0.019
			(0.028)
GDP per capita	1.639***	1.677***	1.728***
	(0.155)	(0.121)	(0.113)
Population Growth	0.104***	0.085***	0.093***
	(0.033)	(0.024)	(0.026)
Government Stability	0.014	0.007	-0.003
	(0.014)	(0.016)	(0.010)
Press Score	0.002	-0.004*	-0.005***
	(0.004)	(0.002)	(0.001)
TFP Growth	0.008	0.002	0.001
	(0.006)	(0.004)	(0.003)
Human Capital Index	-0.891***	-0.390**	-0.424**
	(0.266)	(0.165)	(0.184)
Forest Biocapacity	-0.209***	-0.122***	-0.100***
	(0.053)	(0.030)	(0.025)
_cons	0.339***	0.476***	0.469***
	(0.104)	(0.058)	(0.057)
Obs.	1739	1739	1739
R-squared	-1.092	-0.008	0.076
No of Countries	83	83	83
Year Dummies	Yes	Yes	Yes
Country FE	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(3)). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal legal and economic institutions are *law and order* $(0-6)$, *corruption* $(0-6)$, and *investment profile* $(0-12)$. Higher values (in parenthesis) indicate stronger formal institutions. Model (4)-(6) reports estimations of the dependent variable against each of the institutional variables. All three models are estimated with fixed-effects IV regressions (column (1)-(3)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01, ** p<0.05, * p<0.1*.

The second panel of the results is shown in Table 4.6. In order to build a clear and robust relationship between institutions and emissions, the baseline regression equation (4.4) is estimated using the measures of the quality of the regulatory system *(law & order* and *corruption)* and property-rights protection *(investment profile)*. Models (4) and (5) represent the results of the legal system, and Model (6) shows the effects of the economic institutions on carbon emissions. Table 4.6 also includes the results of *religious tensions*. Since the instrumental variable strategy is of interest in this study, the table contains the FE-IV estimations only. Likewise, dummies on *the trend of colonial origins* and *distance to conflict zones* are used for instrumenting both types of institutions. Further, all three models are robust to the issues of heteroscedasticity, serial correlation and unobserved heterogeneity.

Based on the FE-IV estimations, *religious tensions* establishes a significant negative relationship with *carbon footprint* across the three models, confirming the robust positive effects of trust on reducing emissions. The results reported in Tables 4.5 and 4.6 show strong consistency across all six models. Regarding formal institutions, all three variables indicate a negative correlation with the dependent variables, though only one of the legal indicators significantly influences emissions. At the 1% significance level, if *law & order* increases by one unit, *carbon footprint per capita* would be expected to decrease by -0.7.

The results on other covariates in Table 4.6 are almost the same as those I have previously discussed. For instance, like Model (2) in Table 4.5, *press score* is significant and negatively linked to the emissions (see (M5) and (6)). This indicates that in countries where media can operate freely and independently, the likelihood of disseminating information regarding the environmental problems are higher. This, in turn, increases awareness in people to decrease their environmentally unfavourable behaviours, for example, changing their personal transport pattern from using private vehicles to public transportation. As a result, it is expected that the environment is better protected. This is consistent with the literature, where the positive effects of the freedom of media are documented empirically (Ollerton et al., 2019, October 3).

In conclusion, the consistent results across all the FE-IV models presented in Table 4.5 and 4.6 strongly demonstrate the positive effects of trust on carbon reduction. It also confirms the possibility of reducing the risks of free riding by adopting cooperation and reciprocation sustained by social capital. Moreover, in almost all models, the proxies for political, legal and economic institutions consistently reported an inverse correlation with the CO_2 emissions. For instance, *political constraints index* and *law & order* demonstrated their influential positive effects on reducing emissions in this study and the first one. Further, democratic institutions remain insignificant across two studies, showing that democracies are irrelevant to the context of lowering pollution. The estimations on *corruption* and *investments profile* turned out to be insignificant here, though in the first study both were consistent with the literature.

4.4 Study 3 Results and Discussion: The Addition of Interactions

As discussed in Chapter 2 (Section 2.5.4.2), it is useful to understand how informal institutions react in a different formal institutional context, and vice versa. For example, when people are not happy with their government's efficiency (i.e., weak formal institutions), cooperative societies may either make up for their inefficiency (substitutionary effects) or exert extra pressures by protesting and refusing to comply with the rules (complementary effect). This dynamic effect can be captured by incorporating the interaction of formal and informal institutions into the regression model. Therefore, Study 3 is assigned to explaining this dynamic effect. This study can also be considered as an extension to Study 2.

Since the focus of this study is on the impacts of the interactions of formal and informal institutions, the new regression line should take account of both types of institutions and their interactions. Therefore (4.4) can be rewritten as:

$$y_{it} = \alpha + \beta_1\{formal\ institutions\}_{it} + \beta_1^{'}\{informal\ institutions\}_{it} + \beta_1^{''}\{interaction\ of\ institutions\}_{it} + \boldsymbol{\beta_2}\, \boldsymbol{Z_{it}} + \gamma_i + \kappa_t + \varepsilon_{it} \tag{4.7}$$

Where y_{it} shows the dependent variable, *carbon footprint per capita*. Subscripts i and t denote *country* and *year*, respectively. α is the *constant term*. γ_i and κ_t represent *country-specific* and *year effects*, and ε_{it} denotes *the error term*. In addition, $\boldsymbol{Z_{it}}$ is *the vector of additional explanatory variables* and $\boldsymbol{\beta_2}$ is *the vector of unknown parameters*.

In this study, the estimations of $\beta_1, \beta_1^{'}$ and $\beta_1^{''}$ are of interest. Based on the hypotheses, they are all assumed to be negative ($\beta_1 < 0,\ \beta_1^{'} < 0,\ \beta_1^{''} < 0$). Following the work of Knowles and Owen (2010), I define the complementary effect between formal and informal institutions, meaning that the positive effects of formal institutions on reducing emissions will be enhanced by proper informal institutional quality. To create interactions, each of the six indicators of formal institutions is multiplied by *religious tensions*, generating six interactive terms. For instrumenting the generated interactions, I use the product of the instruments used for formal and informal institutions *(distance to conflict zones*trend of colonial origins)*.

Here, I will use the same procedures that I followed in the previous studies. I will first estimate (4.7) with the RE- and FE-OLS models, ignoring the common problem of endogeneity. I will then use the main method of this study (FE-IV) for estimating the effects of institutions.

4.4.1 Estimation Results

Table 4.7 reports the empirical results of equation (4.7). In this regression, the relationship between formal and informal institutions and their interactions on reducing carbon emissions are evaluated. As for studies 1 and 2, I first present and discuss the findings of the political indicators, and then the legal and economic ones. The results are presented below.

As can be seen, Table 4.7 contains three models (M(1), (2) and (3)), each of which shows the entire impacts of institutions, including formal and informal institutions and their interactions, on carbon emissions, using the RE-/FE-OLS, and FE-IV estimations.[168] As observed in Model (1), the institutional variables of *political constraints* and *religious tensions* are significant and negatively correlated with *carbon footprint per capita* in the first and the third columns. The estimations indicate that countries with better formal and informal institutions positively affect the environment (i.e., curb their share of emissions).[169] In other words, the lower the social tensions and concentration of political power, the lower the emissions would be in a country. Such results are consistent with the previous studies' findings (see Tables (4.1) and (4.5)).

Moreover, the interaction of *political constraints* and *religious tensions (PolCon*TnsRelig)* is statistically meaningful but positive in the IV models, which highlights the presence of substitutionary effect between formal and informal institutions (i.e., opposite to what I initially hypothesised). This finding is consistent with the findings of Knowles and Owen (2010) with respect to explaining life expectancy. The positive interaction highlights that *political constraints* and *religious tensions* are substitutes in the context of decreasing *carbon footprint*, that is, the negative impact of weak formal institutions (i.e., lower constraints on the executive) on air pollution is mitigated by high quality of informal institution (i.e., low level of social tensions). As well as contributing to the literature by taking account of the informal institutions, I extend the existing empirical research further by considering their interactive effects.

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[168] All models are robust to the presence of heteroscedasticity and serial correlation.

[169] However, RE-OLS may not be reliable, despite its consistency with the theory (it is just shown for the purpose of ensuring consistency across studies). Further, in the FE-OLS, sign for both of the institutional indicators are flipped to positive. It further implies a model misspecification. Once the institutions are instrumented in the FE-IV, the sign for both *religious tensions* and *political constraints index* flipped to negative again.

Next, as with the results reported in Tables 4.1 and 4.5, Models (2) and (3) in Table 4.7 show the results of the democratic institutions on reducing air pollutants. Analogous to the results presented in the aforementioned tables, such political factors are statistically insignificant in the FE-IV columns of this table, denoting that being either democratic or autocratic country per se is not relevant to curbing pollution.[170] However, the significant positive interaction *(Democ*TnsRelig)* shows that democracy can affect air quality through the level of trust. In countries with weak democratic institutions, carbon emissions are expected to be higher; however, this negative effect is mitigated when the level of within-nation trust is high. Therefore, trustworthy societies are expected to make up for the inefficiency of governments. The result of the interactive term is robust to the alternative measure of democracy *(polity score)* and its corresponding interaction with trust (*Polity*TnsRelig)* in the third model.

Also, the results on *religious tensions* depict that the higher the trust, the lower the emissions would be within a country, as depicted in Table 4.5 of Study 2. The outputs with respect to sign and significance level of the measure of trust indicate that the above finding is robust across all three models and estimations.[171] Finally, the results on the other covariates in Models (1), (2) and (3) are robust to and consistent with previous models in Study 1 and 2. For instance, while *forest biocapacity* indicates a meaningful positive effect on reducing *carbon footprint* across countries, *energy use* establishes a significant negative impact on the level of pollution. These two variables affect the extent of pollution through the storing-releasing rate of carbon emissions into the atmosphere, as the theoretical framework of this research suggested.[172]

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[170] The simple OLS results in both Models (2) and (3) illustrate that countries with lower carbon emissions are the ones with stronger democracy. However, quite the opposite relationship is shown in the fixed-effect OLS, as the signs for the *level of democracy* and *polity score* flip to positive, showing that stronger democracies produce higher emissions.

[171] The simple OLS estimation in both models show a significant inverse relationship with carbon emissions. However, a meaningless positive effect is found on this variable in the fixed effects analysis. Finally, once the *religious tensions* is instrumented by *distance to conflict zones* in the FE-IV strategy, a statistically meaningful and indirect relationship is established with *carbon footprint* in Models (2) and (3).

[172] One might argue that these two variables can be channels through which institutions affect emissions; and, by controlling for their direct effects in the model, I have ignored their indirect effects on emissions (i.e., in a different institutional quality context). To address this concern, I base my answer on two factors. First, the process of selecting all the influential variables is totally based on the theoretical foundation (the SES framework) of this study, as discussed in Chapter 2. Second, according to the WDI, *energy use* captures total energy consumption sourced from both types of renewables and non-renewables. Therefore, following the works of Carattini et al. (2015) and Joshi and Beck (2018), I simply controlled for the effects of consuming any type of energy on CO_2 pollution. However, in the case of *forest biocapacity*, I have estimated the same regressions without this variable. All the results remain consistent with previous estimations.

Table 4.7. Political institutions and informal institutions with interactions (IV estimations)

	Model (1)			Model (2)			Model (3)		
	OLS	FE-OLS	FE-IV	OLS	FE-OLS	FE-IV	OLS	FE-OLS	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Religious Tensions	-0.142***	0.019	-0.287***	-0.120***	0.022	-0.305***	-0.131***	0.020	-0.411***
	(0.025)	(0.022)	(0.083)	(0.024)	(0.022)	(0.087)	(0.024)	(0.022)	(0.110)
Political Constraints Index V	-0.787***	0.198**	-0.669**						
	(0.152)	(0.094)	(0.263)						
PolCon*TnsRelig	0.112	0.018	0.596***						
	(0.074)	(0.039)	(0.229)						
Level of Democracy				-0.262***	0.041*	-0.000			
				(0.030)	(0.021)	(0.060)			
Democ*TnsRelig				0.001	0.001	0.082***			
				(0.008)	(0.005)	(0.024)			
Combined Polity Score							-0.113***	0.017**	-0.018
							(0.011)	(0.008)	(0.028)
Polity*TnsRelig							0.002	0.001	0.046***
							(0.004)	(0.003)	(0.014)
GDP per capita	1.472***	1.858***	1.539***	1.401***	1.835***	1.490***	1.368***	1.847***	1.435***
	(0.057)	(0.365)	(0.135)	(0.051)	(0.360)	(0.152)	(0.049)	(0.361)	(0.173)
Population Growth	0.597***	0.039	0.142***	0.539***	0.045	0.133***	0.515***	0.047	0.159***
	(0.046)	(0.031)	(0.032)	(0.044)	(0.033)	(0.033)	(0.043)	(0.034)	(0.041)
Government Stability	0.151***	-0.007	-0.010	0.116***	-0.007	-0.014	0.107***	-0.007	-0.019
	(0.025)	(0.017)	(0.009)	(0.025)	(0.016)	(0.010)	(0.026)	(0.016)	(0.011)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Press Score	-0.016***	-0.006**	-0.002	0.006*	-0.009**	-0.005	0.000	-0.008**	-0.002
	(0.002)	(0.003)	(0.002)	(0.003)	(0.004)	(0.005)	(0.002)	(0.003)	(0.004)
TFP Growth	0.012	0.002	0.006	0.010	0.002	0.004	0.013	0.002	0.006
	(0.011)	(0.004)	(0.004)	(0.011)	(0.004)	(0.004)	(0.011)	(0.004)	(0.005)
Human Capital Index	0.742***	-0.414	-0.579***	0.791***	-0.446	-0.554***	0.760***	-0.431	-0.586***
	(0.100)	(0.348)	(0.198)	(0.099)	(0.345)	(0.188)	(0.097)	(0.342)	(0.204)
Forest Biocapacity	-0.013	-0.058	-0.122***	-0.013	-0.055	-0.109***	-0.006	-0.056	-0.121***
	(0.011)	(0.041)	(0.025)	(0.010)	(0.041)	(0.024)	(0.010)	(0.042)	(0.027)
Energy Use	0.808***	0.606***	0.387***	0.765***	0.577***	0.424***	0.757***	0.578***	0.419***
	(0.047)	(0.179)	(0.065)	(0.043)	(0.181)	(0.057)	(0.042)	(0.181)	(0.062)
_cons	-14.528***	-13.976***		-11.410***	-14.013***		-12.042***	-13.907***	
	(0.518)	(3.066)		(0.539)	(3.100)		(0.457)	(3.054)	
Obs.	1745	1745	1730	1754	1754	1739	1732	1732	1717
R-squared	0.748	0.383	-0.156	0.757	0.382	-0.182	0.762	0.383	-0.504
No of Countries		98	83		98	83		97	82
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(9)). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal political institutions are *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$. Higher values (in parenthesis) indicate stronger formal institutions. Three interactive terms of *PolCon*TnsRelig, Democ*TnsRelig*, and *Polity*TnsRelig* represent the interaction of each variable on formal political institutions with *religious tensions*. Model (1)-(3) reports estimations of the dependent variable against each of the institutional variables. All of the three models is estimated with simple OLS regressions (shown in column (1)/(4)/(7)), fixed-effects OLS regressions (shown in column (2)/(5)/(8)), and fixed-effects IV regressions (shown in column (3)/(6)/(9)). In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting interactive terms. All regressions are performed on the sample of all countries. The number of countries is reduced by 15 in IV regressions as *xtivreg2* drops singletons in Stata. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The regression equation (4.7) is subsequently estimated for legal and economic indicators using the FE-IV method. In this specification, the issues of heteroscedasticity, serial correlation, unobserved heterogeneity and endogeneity are addressed effectively in all models. Likewise, *colonial origins* and *distance to conflict zones* are used for instrumenting formal and informal institutions. In addition, the product of the instruments is also used for instrumenting the interaction of institutions. The results are reported in Table 4.8.

Table 4.8. Legal and economic institutions and informal institutions with interactions (IV estimations)

	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)
Religious Tensions	-0.287***	-0.316***	-0.153**
	(0.103)	(0.075)	(0.061)
Law & Order	-0.546***		
	(0.130)		
LawOrd*TnsRelig	0.059		
	(0.046)		
Corruption		-0.070	
		(0.094)	
Corr*TnsRelig		0.101***	
		(0.032)	
Investment Profile			-0.045**
			(0.020)
InvPro*TnsRelig			0.061***
			(0.015)
GDP per capita	1.672***	1.635***	1.761***
	(0.128)	(0.120)	(0.107)
Population Growth	0.077***	0.085***	0.030
	(0.028)	(0.024)	(0.026)
Government Stability	0.008	-0.006	0.000
	(0.011)	(0.011)	(0.009)
Press Score	0.000	-0.004**	-0.004***
	(0.002)	(0.002)	(0.001)
TFP Growth	0.006	0.000	0.004
	(0.005)	(0.004)	(0.003)
Human Capital Index	-0.827***	-0.516***	-0.408**
	(0.203)	(0.176)	(0.162)

Forest Biocapacity	-0.167***	-0.123***	-0.067***
	(0.033)	(0.024)	(0.020)
Energy Use	0.390***	0.445***	0.547***
	(0.073)	(0.053)	(0.054)
Obs.	1739	1739	1739
R-squared	-0.395	0.023	0.159
No of Countries	83	83	83
Year Dummies	Yes	Yes	Yes
Country FE	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(3)). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal legal and economic institutions are *law and order* $(0-6)$, *corruption* $(0-6)$, and *investment profile* $(0-12)$. Higher values (in parenthesis) indicate stronger formal institutions. Three interactive terms of *LawOrd*TnsRelig, Corr*TnsRelig,* and *InvPro*TnsRelig* represent the interaction of each variable on formal legal and economic institutions with *religious tensions.* Model (4)-(6) reports estimations of the dependent variable against each of the institutional variables. All three models are estimated with fixed-effects IV regressions (column (1)-(3)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01*, ** *p<0.05*, * *p<0.1*.

Consistently across three models, *religious tensions* establish a significant negative relationship with *carbon footprint per capita*, meaning that in countries with a lower level of social tensions, better air quality is expected. These findings are consistent with previous estimations presented in Tables 4.2 and 4.6.

In addition, as anticipated, legal and economic indicators are all pointing to a negative association with the dependent variable. For example, if *law & order* increases by one unit, emissions are expected to be cut by -0.55. *Corruption* is also negative, though it remains insignificant. However, it can affect emissions through the channel of informal institutions. That is, in less corrupt countries, the negative effects of social tensions on air pollution would be smaller in comparison with more corrupt countries. However, another interactive term implies that the effects of *law & order* and *religious tensions* on *carbon footprint per capita* are independent of each other.

Regarding economic institutions, contradictory results are obtained on *investment profile* across the three studies, albeit the calculations in Table 4.8 are preferred over the ones presented in the first study. This is because they are: *(i)* consistent with the research hypothesis;

and *(ii)* acquired from the completed regression model (equation (4.7)). Reviewing the results of the three studies shows that the proxy of property-rights protection (or contract viability) has little (Studies 1 and 3) or no (Study 2) systematic impact on reducing emissions, compared to the indicators of formal political and legal institutions. For example, it can be observed from the first and third studies that if *investment profile* increases by one unit, emissions are expected to fall or rise by ± 0.05. These results are consistent with the findings of Scruggs and Rivera (2008), which revealed variations in estimations related to the variables of economic institutions and the environment. In addition, the positive interaction highlights that the effects of trust on reducing air pollution will be less positive if the quality of economic institutions increases.

The results on the other covariates in the table above are almost the same as previous tables in the first two studies (Tables 4.1-4.2 and 4.5-4.6).[173] For instance, *press score* is significant and negatively linked to emissions. As with Models (5) and (6) in Table 4.6, *press score* is significant and negatively linked to the emissions, indicating that the concentration of atmospheric pollution in a country will be lower if media organisations work autonomously.

Overall, based on the findings of Studies 1, 2 and 3, it can be concluded that:[174]

1. A higher level of trust decreases emissions. This is shown by the variable of *religious tensions*, through which a statistically significant and negative relationship is confirmed across all IV models. The acquired results are robust to the use of alternative formal institutions.
2. Better formal institutions mainly lead to better environmental performance in terms of decreasing air pollution across countries. Among all indicators of formal institutions, *political constraints index* and *law & order* strongly support the hypothesis that they have a negative correlation with *carbon footprint*.

[173] One may argue that the regressions in this research all suffer from the classic bad control problem; a situation where control variables are supposed to be the outcomes of the variable of interest (i.e. institutions). To address this issue, I have first estimated a mis-specified model, in which control variables are all excluded from the specification. Such a model would be susceptible to omitted variable bias. Hence, additionally, I have tried to mitigate this issue by estimating a model with lagged control variables. The results of both models confirm the empirical findings of this research. Additionally, they clarify the exogeneity concerns in the institutional measures. For further details, see Appendix III, Table 4.A6-4.A7.

[174] The robustness of the results presented and discussed in the first three studies, is further tested by *(i)* excluding former USSR countries from the studied sample, and *(ii)* including lagged institutions for studying persistency. In both cases, the results were quite consistent with the ones presented in Table 4.1-4.2 and 4.5-4.8, therefore, further confirm the current research's empirical findings.

3. The total impacts of formal and informal institutions on carbon emissions are dependent on each other. The positive effects of strong formal institutions on reducing carbon emissions can be mitigated by a low level of informal institutions, and vice versa. This substitutionary effect is indicated by significant positive interactive terms. These results are consistent across all models.
4. Democracy affects emissions through the level of trust. Otherwise, being a democratic country, measured by the *level of democracy* and *polity score*, does not necessarily mean better air quality. The positive effects of increasing trust on improving the air quality will be relatively larger in democratic countries than non-democratic ones.
5. The same conclusion can also be drawn for *corruption*. The positive effects of increasing trust on improving the air quality will be relatively larger in less corrupt countries than more corrupt ones.
6. The effects of economic institutions, that is, property-rights protection and enforceability of contracts, on air pollution cannot be regarded as absolute. It can increase pollution slightly through increasing the scale of economic activity. It can also decrease emissions a little via developing a stronger market orientation throughout an economy, which leads to the efficient allocation of environmental resources.

4.5 Study 4 Results and Discussion: Robustness Tests

So far, I have tried to estimate the effects of both types of institutions with their interactions on per capita emissions of carbon dioxide in the sample of all countries between the years 1990 and 2014, using static panel data models of OLS and IV.

In this study, however, I try to explore the heterogeneities that reside in the institution-environment relationship. To check the robustness of the estimated models in the first three studies, Study 4 is divided into three sections. In the first section (4.5.1), the full regression model presented in Study 3 is estimated with a dynamic panel data model of the generalised method of moments (GMM). In this way, the new specification is required to transform the static panel data model into a dynamic one. The obtained results will be compared with the ones estimated with regression equation (4.7) in Study 3, Tables (4.7) and (4.8).

Next, in Section 4.5.2, the studied sample of countries is further categorised into two groups of countries based on the ratio of the resource-dependency. In this section, I am interested in testing whether the institutional deficiency of resource-dependent countries, compared to the opposing group (i.e., non-resource-dependent countries), influences the extent of emissions. The findings are then compared with the benchmark estimations presented in Tables 4.7 and 4.8 in Study 3. Notably, this section extends the current institution-environment literature, as there are no studies on assessing the aforementioned relationship focusing on this particular sample of countries.

Study 4 is finally completed by Section 4.5.3, in which the robustness of the main results are checked in relation to different sectors and sources of producing carbon emissions. In this study, the environmental performance of countries is mainly evaluated through the extent of air pollution, particularly CO_2 emissions. In this section, I look at the institution-emissions nexus from a different angle, by swapping the left-hand-side variable. So far, total carbon emissions have been checked through the use of *carbon footprint per capita* as the primary dependent variable. However, in this section, equation (4.7) will be tested using different CO_2 emissions stemming from different types of fossil fuels and sectors.

Overall, Study 4 is assigned to explaining the differences in the inclusive effects of institutions on mitigating carbon dioxide emissions across different samples, sectors, sources and estimations.

4.5.1 Different Estimation Technique: Generalised Method of Moments (GMM)

One of the important characteristics of the environment that has been mistakenly ignored in empirical analyses is the dynamic nature of ecological units (Ostrom, 2012b). The quality of ecosystems is constantly and cumulatively changing such that previous global and local biophysical damages may affect current ecological outcomes (historical dependency). Hence, environmental outcomes are likely to be correlated with each other over time (T. Li et al., 2016). Due to the slow-moving nature of changes, such dynamism is not immediately apparent (Q. Li & Reuveny). However, the evolutionary character of environmental resources can affect the whole system gradually and link the outcomes to the relevant factors through the feedback paths over time (Tavoni & Levin, 2014).[175] Therefore, sophisticated dynamic approaches need to be adopted to reflect the dynamism in the empirical analysis.

[175] The dynamism of ecological systems is also illustrated in the SES framework (see Figure 2.1) through the dashed lines that originate from the focal action situation (FAS) and run to each of the core subsystems. This means that the whole system at time $t + 1$ will be affected by the generated feedback from the outcomes at time t.

To that aim, the focus of this section is on developing a dynamic panel data model as an alternative econometric approach for estimating the impacts of institutions on carbon emissions. The new regression model is specified such that the lags of the dependent variable are added as additional explanatory variables to the right-hand-side of the equation. This transformation allows for the evolutionary character of environmental outcomes to be included in the model (Tamazian & Rao, 2010). Therefore, equation (4.7) can be rewritten as:

$$y_{it} = \alpha + \lambda\, y_{it-1} + \beta_1 \{formal\ institutions\}_{it} + \beta_1^{'} \{informal\ institutions\}_{it} + \beta_1^{''} \{interaction\ of\ institutions\}_{it} + \boldsymbol{\beta_2}\, \boldsymbol{Z_{it}} + \beta_3^{'}\, log\ GDP_{it} + \beta_3^{''}\, log\ GDP\ Squared_{it} + \gamma_i + \kappa_t + \varepsilon_{it} \tag{4.8}$$

Where y_{it} is the *dependent variable* measuring *carbon footprint per capita*. Subscripts i and t denote *country* and *year*, respectively. α is the *constant term*, and y_{it-1} indicates *the first lag of the dependent variable*,[176] and λ is *its unknown parameter* that needs to be estimated. Due to the dynamic nature of air pollution, λ is expected to be positive ($\lambda > 0$). In this study, the estimations of $\beta_1, \beta_1^{'}$ and $\beta_1^{''}$ are all assumed to be negative ($\beta_1 < 0,\ \beta_1^{'} < 0,\ \beta_1^{''} < 0$). Also, $\boldsymbol{Z}$ is *the vector of additional explanatory variables*, which now also includes *income per capita squared* to account for the presence of the Kuznets-type income-emissions relationship in the model. Therefore, out of the explanatory variables, I will report the results related to the *log-transformed of GDP per capita* and *GDP per capita squared* in the table below (Table 4.9). $\boldsymbol{\beta_2}$ is also the *vector of unknown parameters*. To confirm the presence of the EKC, $\beta_3^{'}$ is needed to be positive, while $\beta_3^{''}$ is required to be found negative ($\beta_3^{'} > 0, \beta_3^{'} < 0$). Finally, γ_i and κ_t represent *country-specific* and *year effects* and ε_{it} denotes the error term.

Two common approaches for estimating the above dynamic panel data model are difference- and system-GMM. In difference-GMM, which was first introduced by Arellano and Bond (1991), lagged-levels of the explanatory variables are used as instruments for the corresponding variables in the first-differenced equation. To avoid the problem of weak instrumental variable in difference-GMM, Arellano and Bover (1995) and Blundell and Bond (1998) further proposed system-GMM estimator. Within this estimation technique, the transformed equation (in difference) is coupled with the original equation (in level). Therefore, in addition to the moment conditions formed by the lags of the level of regressors as instruments for difference

[176] The possibility of including higher order lags are predicted in GMM.

equation (Arellano-Bond estimator); system-GMM uses lags of the first differences of the regressor as instruments for the level equation (Arellano-Bover/Blundell-Bond estimator). The lagged-difference of the variables are added as additional instruments for endogenous regressors to increase the efficiency of the system-GMM models.[177]

The system GMM also enables one to estimate the relationship between institutions and environmental quality while simultaneously accounting for past values of environmental quality and time-invariant unobservable heterogeneity. Hence, the system-GMM estimation is expected to give more reliable, accurate and consistent estimations compared to what difference-GMM estimators offer. The inclusion of several instruments for explanatory variables makes GMM dynamic panel data models robust to the potential endogeneity problems, especially where explanatory variables are determined by their own past or present values (Drukker, 2008).[178] GMM models can also eliminate the unobservable country-specific heterogeneity through first-differencing all variables. Further, the estimations are robust to the presence of heteroscedasticity. Simply put, GMM is a form of an IV estimation technique that can achieve consistency and accuracy (Halkos, 2003) by relaxing the assumptions of serial correlation and heteroscedasticity (Ito, 2017).

The system-GMM models can also be estimated with one- and two-step estimators. Since the two-step estimator uses an optimal weighting matrix, it produces more efficient results in the presence of heteroscedasticity (Kripfganz, 2019); thus, it is preferred over the one-step estimator in this study. To avoid biased standard errors, the GMM model is estimated with Windmeijer (2005) bias-corrected (WC) robust standard errors.[179] Furthermore, to control for possible serial correlation, time effects are included to capture general trends observed during the sample period. The inclusion of the lagged dependent variable also allows time trend to capture the temporal dynamics in panel data. However, its inclusion makes it even harder to obtain statistically significant results because it absorbs the variations in the dependent variable that could be explained by other explanatory variables (Q. Li & Reuveny).

[177] These additional moment conditions are orthogonal to the levels of disturbances (ε_{it}).

[178] Compared to the conventional panel OLS estimations, the dynamic panel GMM model can perform better in the presence of misspecification problems like endogeneity.

[179] The use of the two-step non-robust estimation is not recommended because the standard errors tend to be biased downward. It can be corrected by the WC robust VCE. See, for example, Drukker (2008).

Considering the number of years ($T = 25$) and countries ($N = 83$) in the employed sample, the number of lags, should be restricted to avoid the over-fitting problem;[180] however, the predictive power of higher-order lags can be lost (Kripfganz, 2019). Therefore, it is crucial to balance out these issues by including sufficient lags of the regressors. However, the existing environmental economics studies that have been using GMM estimation lack such foundation. Therefore, to find the optimal lag length, I follow a combination of theory and the sequential model selection processing, which was introduced and developed by Kiviet (2020) and Kripfganz (2019).[181]

First, one must consider the omission of relevant variables. If relevant variables are omitted due to, for example, statistical insignificancy, this can produce a correlation between instruments and error term, hence should be avoided. Therefore, in addition to the variables applied in previous estimations, I include the *GDP squared* for testing the dynamic income-emissions relationship. The process of selecting influential variables entirely relies on the theoretical framework of this research. The next step considers the classification of regressors. The covariates are required to be correctly classified as endogenous or strictly exogenous in the model. Based on the theory, I define my institutional indicators as endogenous as they are inherently endogenous, while other additional independent variables are assumed to be exogenous. The third step is the inclusion of sufficient lags. To prevent serial correlation and increase the efficiency of the model, higher-order lags of dependent and independent variables are included in the model, if required.

Following the theory, the number of lags of the endogenous variable is restricted to $lag\ (1\ 4)$ in the first-differenced equation. In all six models, I include the first through to the fourth lags of the level of the institutional variables for the first-differenced equation. Since institutions are persistent to a high degree, higher-order lags are selected to overcome such persistency in their data. Further, due to the predictive power of the instruments of the dependent variable, higher-order lags of the difference of the dependent variable are included to increase the efficiency of the model in level. Hence, the first six lag terms of the difference of the dependent variable are introduced. These instruments are further accompanied by the

[180] If the total number of moment conditions exceeds the number of cross-sections, the model becomes strongly over-identified; hence, severe problems, including obtaining biased coefficient, become inevitable.

[181] It is difficult to find studies that explain the procedures they followed to obtain their optimal GMM estimations. For example, Esty and Porter (2005) mentioned the application of GMM as their empirical approach in the footnote without explaining it.

first two lags of the difference of the endogenous institutional variables for the level model. Finally, as control variables are considered as being exogenous in the model, up to two lags of the variables are used as instruments for both differenced and level equations.

During this process, the model is constantly tested by the proposed specification tests, such as serial correlation (up to the second order) and overall over-identification tests. If the model cannot satisfy the post-estimation tests, then it needs to be modified. The specified lag-length discussed above is not absolutely fixed from the beginning. It is gone through this process several times until optimal estimations are achieved. Consequently, the employed two-step estimator with the Windmeijer bias-corrected robust standard errors produces the following output that is robust to heteroscedasticity. The specified model is estimated with *xtdpdgmm* in Stata, which was recently developed by Kripfganz (2019).[182] It produces more efficient estimations than the conventional *xtabond2*.[183]

Table 4.9. GMM estimations (formal and informal institutions with interactions)

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM	Sys-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
L1.Carbon Footprint	0.955***	0.954***	0.956***	0.959***	0.953***	0.950***
	(0.015)	(0.016)	(0.016)	(0.022)	(0.017)	(0.019)
GDP per capita	0.441**	0.402**	0.403**	0.350*	0.372*	0.401**
	(0.172)	(0.190)	(0.185)	(0.180)	(0.205)	(0.163)
GDP Squared	-0.023**	-0.020**	-0.020**	-0.017*	-0.018*	-0.020**
	(0.009)	(0.010)	(0.009)	(0.009)	(0.010)	(0.008)
Religious Tensions	-0.025**	-0.030**	-0.029**	-0.026*	-0.030*	-0.044**
	(0.012)	(0.015)	(0.014)	(0.013)	(0.017)	(0.018)
Political Constraints Index	0.051					
	(0.044)					
PolCon*TnsRelig	0.049					
	(0.038)					

[182] In addition, to further decrease the number of instruments and avoid the problem of over identification, all models are estimated with the *collapse* option. Further *vce(robust)* is used for computing panel-robust standard errors when the error term is heteroskedastic. Following the *twostep* estimation, it computes the conventional estimator with the Windmeijer correction. Finally, *tffects* is included to capture time trend and prevent serial correlation.

[183] For example, *xtabond2* makes the reported p-value of the over-identification tests invalid by reporting higher number of instruments. See Kripfganz (2019) for more discussion on inefficiencies of *xtabond2*.

Level of Democracy		0.000				
		(0.017)				
Democ*TnsRelig		0.001				
		(0.006)				
Combined Polity Score			0.000			
			(0.006)			
Polity*TnsRelig			0.000			
			(0.003)			
Law & Order				-0.014		
				(0.027)		
LawOrd*TnsRelig				0.002		
				(0.010)		
Corruption					-0.007	
					(0.026)	
Corr*TnsRelig					-0.001	
					(0.011)	
Investment Profile						0.011
						(0.015)
InvPro*TnsRelig						-0.008
						(0.009)
_cons	-2.599***	-2.243**	-2.252***	-2.106**	-2.046**	-2.293***
	(0.844)	(0.886)	(0.846)	(0.955)	(0.993)	(0.822)
Obs.	1725	1734	1712	1734	1734	1734
No of Countries	83	83	83	83	83	83
No of Instruments	83	79	79	81	81	77
AR (1)	-3.979***	-3.983***	-3.902***	-4.066***	-4.018***	-3.974***
AR (2)	-0.779	-0.576	-0.875	-0.700	-0.658	-0.691
Sargan-Hansen	44.66	44.54	43.50	56.33	51.83	42.53
Control	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(6)). *L1.Carbon Footprint* shows the lagged dependent variable. *GDP squared* is the squared version of Ln *GDP per capita* (2010 constant USD) and tests for the validity of the EKC hypothesis. Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions.* Control variables are included in all models. Model (1)-(6) report estimations of the dependent variable against each of the institutional variables, using a new estimation technique. All six models are estimated with the two-step system GMM regressions (column (1)-

(6)), using command *xtdpdgmm* in Stata. All regressions are performed on the sample of all countries. To restrict the number of instruments, all models are specified with *collapse* option. *AR(1)* and *AR(2)* test for the first- and second-order autocorrelation. *Sargan-Hansen* tests for overidentifying restrictions. Windmeijer-corrected (WC) robust standard errors are in parenthesis. Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4.9 presents the results of equation (4.8), which is estimated with two-step system-GMM. The results include three main findings. The first supports the evolutionary character of environmental pollution. It is indicated by the first lag of the dependent variable *(L1.carbon footprint per capita)* in the model, which is positively correlated with the dependent variable. This confirms that the current level of pollution is highly affected by the previous year's pollution. The estimations are strongly consistent with alternative measures of institutions across all models. Second, the inverted U-shaped EKC relationship between income per capita and emissions is supported. It is shown by the positive sign on the *GDP per capita* and negative sign for the *GDP squared*. The associated results are consistent across all models and the literature (Acheampong, 2018; Apergis & Ozturk, 2015; T. Li et al., 2016).

While the presence of the Kuznets-type relationship is successfully indicated in the above dynamic panel data models, it was rejected in previously specified static models. In order to check the sensitivity of the results, I utilised FE-IV approach to test the presence of the environmental Kuznets curve in static models. The results were unable to confirm the non-linearity existing in the income and emissions relationship. Such inconsistency in the GMM and IV results can be attributed to the dynamic nature of the EKC relationship, which might not be appropriately captured by static models. A similar argument was also offered by Halkos (2003), who claimed that the complex interaction between carbon emissions and economic development is dynamic rather than linear; hence, the use of common estimation techniques such as OLS by previous scholars cannot be reliable. The above studies that have studied the EKC relationship benefitted from GMM estimations.

Finally, among all the formal and informal institutional measures, as indicated, only trust is consistently correlated with *carbon footprint*. The significant negative association between these two variables shows that if nations suffer from a lower level of social tensions, then they are expected to largely benefit from a lower level of carbon emissions. This finding further confirms the idea of Elinor Ostrom on the importance of social and moral norms in fostering cooperation and reciprocal attitudes among people for mitigating emissions as a global collective good. Unlike formal institutions, trust is consistently found to be a driving factor of environmental development across countries. While its defining role has been largely ignored in previous research, it is empirically tested across different estimations in this study.[184]

The results are further tested with the inclusion of Ahn and Schmidt (1995) non-linear instruments.[185] The findings remain consistent with Table 4.9. As an additional robustness check, the annual data points are then reduced to a five-year interval data, starting from 1990, 1995… 2010, and 2014. Since institutions are persistent to a high degree, especially informal ones, I increased the gap between each data point to benefit from better variations. However, institutional effects did not change considerably, in terms of sign and significance, to the analysis related to the annual sample. Finally, the robustness of the estimations reported in the first two studies are also examined using GMM models. The results remain consistent with the ones presented in the table above. Therefore, the results on the efficacy of informal institutions are confirmed.

4.5.2 Different Sample: Resource-Dependent Countries

The natural resources of different countries have become a subject of controversy. During the past two decades, experimental results illustrate that most countries with significant natural resources have not performed well in terms of economic development (i.e., the natural resource curse hypothesis), whereas a considerable number of countries that have achieved sustainable growth and development possess few resources (Auty, 1993; Barbier, 2007; Gylfason, 2001). The resource-dependent economies of Africa, Latin America and the Middle East, on the one hand, and Japan, Singapore and South East Asia on the other are cases in point.[186]

Previous empirical research has identified the lack of proper institutions as the leading cause of underdevelopment of those with abundant natural resources (Acemoglu et al., 2001; Acemoglu et al., 2003; Acemoglu et al., 2005; Acemoglu & Robinson, 2010). While growth and development must be both inclusive and environmentally sound to reduce poverty and build prosperity for current and future generations, resource-dependent countries often have failed in this regard because of their major institutional and governance failures (Bottero et al.,

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[184] However, formal institutions are indicated to be irrelevant to this relationship. However, using GMM approach, Hassan et al. (2020) found that institutions are contributing to the level of carbon emissions.

[185] The option of *nl(no)* is further added to the model to consider non-linear instruments.

[186] The problem varies in severity: some countries like Norway, Botswana, and Australia, which are comparable in terms of natural resources, have shown different records of economic progress over the past decades.

2012). Evidence for this can be found in Worldwide Governance Indicators (WGI) for 1996-2014,[187] according to which resource-rich countries are often ranked lower in terms of formal institutional quality compared to their non-resource-dependent (resource-poor) ones with the same level of GDP per capita.[188]

While a large body of the existing empirical literature has documented the positive impacts of institutions on growth and development, there is a lack of sound institutional analysis in the empirical studies within the context of the environment (Hassan et al., 2020), especially in resource-rich countries where major governance deficits are frequently observed (Van der Ploeg, 2011). Further, these countries are more vulnerable to environmental degradations because: *(i)* their economic activities depend heavily on depleting natural resources; and *(ii)* they have to exploit more to achieve higher economic growth and development due to their lower level of technology. Hence, resource destruction is observed more in these countries where not many environmental-friendly policies have been adopted to reduce pollution (Ostrom, 2010a, 2016). Therefore, without having effective institutions to limit users (harvesters), natural resources will be over-harvested (Douai & Montalban, 2012).

Since possessing natural resources, or lack thereof, potentially make significant changes in the economic performance of countries, mainly due to the quality of their institutions, it would be interesting to classify countries based on the resource-dependency ratio and check whether there is any statistical difference in the institution-environment relationship across these two different categories of countries. In fact, conducting a comparative study on the impacts of institutions on air pollution would be highly beneficial. To that aim, the International Monetary Fund (2012) criteria, based on which at least 20% of a country's total exports or fiscal revenue are comprised of fossil fuel exports or revenue, are used as a basis for splitting the countries into two categories.[189]

As a result, the employed sample of the present research is categorised into countries that are: *(i)* dependent on natural resources including oil, gas and minerals; and *(ii)* not dependent on resources.[190] Since resource-dependent countries (RDC) tend to suffer from major institutional

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[187] See the methodology developed by Kraay, Kaufmann, and Mastruzzi (2010), for further details on WGI.

[188] IMF staff calculations. See International Monetary Fund (2015, October) for further details.

[189] For the full list of 61 resource-rich countries, see the appendix of International Monetary Fund (2012, August 24) or Venables (2016).

[190] The list of the resource-dependent countries included in the analysis is provided in Appendix III, Table 4.A9.

deficits, it is expected that minor improvements in the quality of their institutions would result in relatively larger changes in their environmental outcomes, compared to the non-resource-dependent countries (NRDC). In contrast, the size of changes in the sample of NRDC (resource-poor countries), where the institutions perform effectively, are not expected to be as large as the RDC (resource-rich countries). Hence, the magnitude of coefficients on institutional variables in the RDC group is likely to be larger than the ones in the NRDC.

Table 4.10. The average quality of formal institutions across RDC and NRDC (t-test)

	Obs.		**Mean**		**Diff.**	**Std. Err.**	**t-value**
Sample	NRDC	RDC	NRDC	RDC			
Political Constraints Index V $(0-1)$	1249	647	.62	.28	.34	.01	25.65***
Level of Democracy $(0-10)$	1249	656	8.05	4.95	3.1	.13	24.45***
Combined Polity Score (± 10)	1249	656	6.9	1.01	5.89	.26	22.7***
Law & Order $(0-6)$	1249	656	4.49	3.19	1.3	.06	21.15***
Corruption $(0-6)$	1249	656	3.46	2.46	1.01	.06	16.6***
Investment Profile $(0-6)$	1249	656	8.35	7.24	1.11	.12	9.55***

*Notes: *** p<0.01, ** p<0.05, * p<0.1.*

As shown in Table 4.10, the average quality of different types of formal institutions in the resource-rich countries is considerably lower than their resource-poor ones.[191] In particular, this difference seems to be substantial on political institutions (top three variables) compared to the legal and economic ones (the bottom three). Hence, the significance of such sample classification seems to be crucial for a deep understanding of the studied relationship. Also, the present research is the first empirical study in the field of environment to assess the institution-environment relationship across resource-rich/-poor countries. As a basis for dividing their studied samples, the existing studies have concentrated on the advanced economies such as those in the OECD (Fredriksson et al., 2004; Joshi & Beck, 2018; Neumayer, 2003), income ranges such as high-income countries (Castiglione et al., 2015; Cole, 2007), and locations, including Asia, Africa and Latin America (Culas, 2007) and Europe (Murdoch et al., 2003).

[191] The t-test results indicate that the mean-difference across all six measures are significant at 1%. This means that the null hypothesis, which shows the mean-difference across two samples is zero ($H_0: mean = 0$), can be rejected.

Table 4.11. Resource-dependent and non-resource-dependent countries (IV estimations)

	Panel A: Resource-Dependent Countries (RDC)						**Panel B: Non-Resource-Dependent Countries (NRDC)**					
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Religious Tensions	-0.142***	-0.193***	-0.238***	0.037	-0.040	0.009	-0.134*	-0.154*	-0.230***	-0.154**	-0.037	-0.112*
	(0.046)	(0.042)	(0.047)	(0.102)	(0.052)	(0.046)	(0.074)	(0.080)	(0.083)	(0.062)	(0.061)	(0.062)
Political Constraints	-0.959***						-0.348					
	(0.281)						(0.278)					
PolCon*TnsRelig	-0.240						0.541***					
	(0.205)						(0.180)					
Level of Democracy		-0.149**						-0.076				
		(0.060)						(0.066)				
Democ*TnsRelig		0.003						0.131***				
		(0.018)						(0.032)				
Combined Polity			-0.110***						-0.045			
			(0.032)						(0.031)			
Polity*TnsRelig			0.008						0.061***			
			(0.010)						(0.016)			
Law & Order				-0.465***						-0.200***		
				(0.083)						(0.054)		
LawOrd*TnsRelig				0.100						0.086**		
				(0.079)						(0.041)		

Corruption					-0.387***						0.159**	
					(0.136)						(0.069)	
Corr*TnsRelig					0.088						0.095***	
					(0.062)						(0.031)	
Investment Profile						-0.109***						-0.024
						(0.028)						(0.020)
InvPro*TnsRelig						0.068***						0.021
						(0.016)						(0.016)
Obs.	577	586	586	586	586	586	1153	1153	11131	1153	1153	1153
R-squared	0.350	0.388	0.167	0.395	0.287	0.299	0.103	-0.359	-0.624	0.136	0.196	0.297
No of Countries	28	28	28	28	28	28	55	55	54	55	55	55
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(12)). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig,* represent the interaction of each variable on formal institutions with *religious tensions.* Control variables are included in all models. Panel A reports estimations of model (1)-(6) for the sample of resource-dependent countries (RDC). Panel B reports estimations of model (1)-(6) for the sample of non-resource-dependent countries (NRDC). All six models in each panel are estimated with fixed-effects IV regressions (column (1)-(12)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Splitting the base sample into two categories of resource-dependent countries (RDC) and non-resource-dependent countries (NRDC) enables one to conduct a comparative study on differences between these two sets of countries. To that aim, the regression equation (4.7), which was provided in the third study, is used for these two sets of countries. The results for all six models, which were reported in two separate tables for the first three studies, are here combined and presented in one nested table. From now on, only the results of the FE-IV specification will be reported.[192] A comparison of Panels (A) and (B) in Table 4.11 indicates:

Formal institutions seem to matter more for reducing carbon emissions in the RDC sample, relative to the NRDC one. As can be seen, all six indicators representing the quality of formal political, legal and economic institutions are statistically significant and negatively correlated with carbon emissions across the RDC sample. Even democracies that were shown to be unrelated to this process in the reference sample (all countries) now demonstrate reliable negative estimations in the RDC sample. However, on the other hand, none of the political indicators in the NRDC sample is significantly correlated with the dependent variable.

One plausible explanation for obtaining such results on political institutions across the two samples (RDC and NRDC) can be related to the nature of the political system in resource-dependent countries. These countries tend to be more autocratic (Robinson, Torvik, & Verdier, 2006; Wantchekon, 2002); hence, fostering democracy, political rights, and civil liberties in these countries could make significant positive changes to the environment. In contrast, non-resource-dependent countries are mostly democratic (Auty, 2001), therefore, further improvements could not produce any positive environmental outcomes.[193]

Moreover, the coefficients magnitude related to the indicators of formal institutions further highlights the importance of formal institutions in decreasing emissions in the RDC sample. It is shown that, in almost all cases, the coefficients on formal institutions in the RDCs are substantially larger than their corresponding ones in the reference sample.[194] As anticipated, the size of the effects of the formal indicators in the NRDC sample is significantly smaller than

[192] The employed instruments are as follows: *(i) trend of colonial origins* for instrumenting political, legal and economic institutions; and *(ii) distance to conflict zones* for instrumenting informal institutions. The product of these instruments is used for instrumenting the interaction of formal and informal institutions. Moreover, all models are robust to the heteroscedasticity, serial correlation and unobserved heterogeneity.

[193] Based on the dichotomous measure of democracy/dictatorship developed by Cheibub, Gandhi, and Vreeland (2010), 15 out of 28 resource-dependent countries in the sample are autocratic, while only nine (out of 55 non-resource-dependent countries) are not democratic.

[194] See Table 4.7 for the full details on the results.

the ones in the sample of all countries. For instance, the coefficient size of the variable *political constraints index* is -0.96 in the RDC sample, while it is -0.67 and -0.18 in the reference and NRDC samples, respectively. Therefore, it seems that the presented results in Table 4.11 can confirm the hypothesis: a minor improvement in the institutional quality of the resource-dependent countries is more effective in curbing emissions than the same improvement in non-resource-dependent countries.

One might still argue that the other types of formal institutions are effective in the NRDC sample. This can be true, but considering their coefficients size, their impacts are minimal. Moreover, when the analysis is further filtered to include only upper-middle and high-income NRDC countries (i.e., low and lower-middle income ones are excluded from NRDC), it is observed that none of the indicators on formal institutions, including legal and economic ones, is statistically reliable.[195] Therefore, contrary to the RDC sample, a small change in wealthy resource-poor countries' institutions cannot actually improve the air quality, meaning that the quality of formal institutions is already good enough for decreasing emissions. This further confirms the argument.

While formal institutions matter more for decreasing carbon dioxide emissions across resource-dependent countries, it seems that trust is the key to achieving sustainability in resource-poor countries. As can be seen in Table 4.11, *religious tensions* in all models of Panel (B),[196] is significantly negative, meaning that the lower the levels of social tensions, the lower the levels of emissions will be across this set of countries. However, the proxy of trust is only significant in the first three models of Panel (A). Given the current quality of formal institutions in resource-poor countries, it can be concluded that decreasing emissions can be achieved mainly through improving informal institutions.

The above discussions on the differences in institutional quality between the RDC and NRDC groups can also be validated by the included interactions. As shown, almost, none of the interactive terms in Panel A's models (columns 1-6) is significant, showing that the effects of both types of institutions on *carbon footprint* are independent of each other. In other words, no

[195] See Appendix III, Table 4.A10 (Panel (B1)).

[196] Except column (11) of Table 4.11. However, when the low-income countries are excluded from the analysis of the NRDC sample of countries, it is found that all six models now become statistically reliable. Furthermore, the coefficients magnitude are significantly higher in Panel (B1) (Table 4.A10) relative to Panel (B), highlighting that this set of countries should mainly focus on decreasing (increasing) the level of social tensions (trust) in order to make significant progress in reducing emissions.

matter how high or low trust can get, it does not alter the effects of formal institutions on the dependent variable. This indicates that if formal institutions lower the level of emissions, its effect is separate from the effects of trust. This may also be a rough indicator of dishonesty or a confidence gap between people and the state government in these countries, showing that people are not confident in the governmental actions.

On the other hand, all the interactions in Panel B (columns 7-12) are statistically significant and positive. Similar to Tables 4.7 and 4.8, the positive interactions show the substitutionary effect of formal and informal institutions, meaning that if the quality of either political or legal institution increases, the negative effect of tensions on reducing the air quality will be mitigated. These meaningful positive interactions also imply that the reason for obtaining meaningless results on formal political indicators in the NRDC group, as said, is not related to the fact that these countries' formal institutions are not good enough for making changes in the level of emissions. The converse is true: the indication is that they are sufficiently mature. Hence, no further improvements can alter emissions, given the prevailing technology. If the institutions were irrelevant, then their interactions with *religious tensions* would be insignificant.

Overall, it can be drawn from the estimations that while improving formal institutions should be the priority for resource-dependent countries, in wealthy non-resource-dependent ones, it is the quality of informal institutions that should be developed further for mitigating emissions.

4.5.3 Different Sources: Solid, Liquid and Gas Fuels

So far, I have concentrated on the right-hand-side of the equation (4.7) by drawing on different institutional indicators and estimating their significant impacts on total carbon emissions. However, in this section, the focus is on the left-hand-side variable, *carbon footprint per capita*. Here, I am interested in checking the sensitivity of the results obtained in Studies 1, 2 and 3 to using different dependent variables. However, the choice of different left-hand-side variables is, to some extent, restricted by the SES framework, meaning that not all environmental problems can be studied with the same set of control variables.[197]

[197] In this study, the set of control variables is specifically selected for studying air pollution (that is mainly resulted from the emissions of carbon dioxide). To that aim, for instance, two variables of *forests biocapacity* and *fossil fuels consumption* that are directly related to the environmental outcome of interest, are deliberately controlled in the model. They should be dropped out from the regression models, if the new dependent variable does not measure the quality of the selected resource system. For example, if this variable considers another type of environmental problem, something out of the scope of this study like biodiversity or water quality, then the right-hand-side of the equation should be altered in favour of the selected environmental indicator.

Therefore, the choice of the dependent variables in this study must be within the area of air pollution or carbon emissions.[198] To remain consistent with the previous three studies, the data on total CO_2 emissions is initially broken down into five types of fuel sources, including gas, liquid (oil), solid (coal), and flaring and cement production. Then, the usual dependent variable is substituted with different measures of CO_2 emissions stemming from fossil fuels.[199] Figure 4.1 shows the annual tonnes of carbon emissions from each type of fossil fuel:

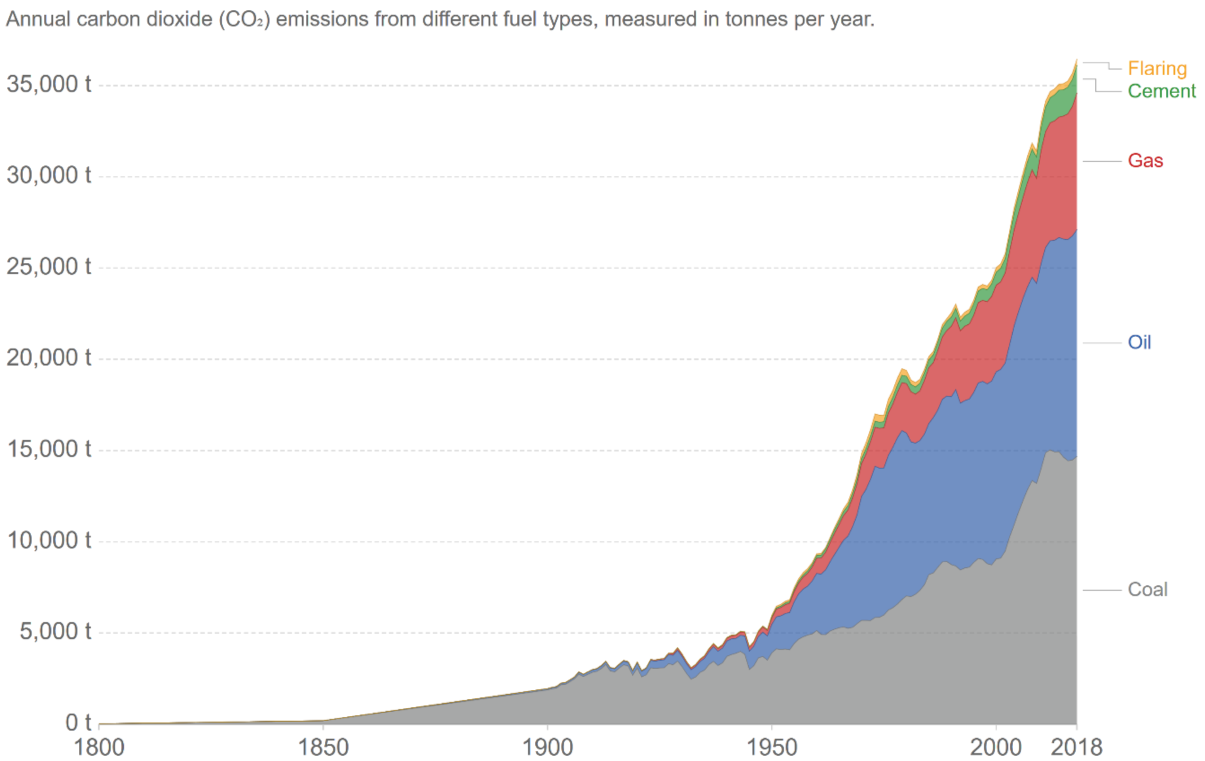

Figure 4.1. Global CO2 emissions by fossil fuel type (1800-2018)

Source: Ritchie and Roser (2020)

As illustrated, the contribution of each of these fossil fuels has changed remarkably in the last two centuries. From the industrial revolution to around 1950, the use of solid fuel or coal at the industrial scale has dominated global carbon emissions. However, in the present day, coal and oil, as solid and liquid fuels, account for around 40% and 35% of global carbon emissions per year, respectively. The emissions produced by gas is also significant at present. This fuel type

[198] However, to provide further robustness on the results acquired on carbon emissions, two more environmental indicators of greenhouse gas and methane emissions that lie within the area of air pollution are selected as new dependent variables. The results are provided in Appendix III, Table 4.A13 and 4.A14.

[199] The alternate variables measure CO_2 emissions sourced from fossil fuels that are associated with energy and industrial production.

has been steadily increasing since the beginning of the 19th century, and now around 20% of emissions stem from its consumption in the energy and industrial sectors.

In order to explore the effects of institutions on carbon emissions stemming from different types of fossil fuels, I take account of the three largest CO_2-emitting sources that collectively make up for 95% of the world's total emissions.[200] The results of the three major polluting sectors are reported in Table 4.12, Panel A; Table 4.13, Panel B; and Table 4.14, Panel C.

Table 4.12. Carbon emitted from solid fuels (IV estimations)

Panel A: Solid Fuel Consumption						
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-0.005	-0.029	-0.203	0.396***	-0.085	-0.278***
	(0.148)	(0.109)	(0.139)	(0.152)	(0.099)	(0.095)
Political Constraints	-0.012					
	(0.484)					
PolCon*TnsRelig	2.522***					
	(0.532)					
Level of Democracy		0.406***				
		(0.093)				
Democ*TnsRelig		0.158***				
		(0.043)				
Combined Polity Score			0.148***			
			(0.041)			
Polity*TnsRelig			0.078***			
			(0.022)			
Law & Order				-0.279*		
				(0.150)		
LawOrd*TnsRelig				0.433***		
				(0.094)		
Corruption					0.232	
					(0.166)	
Corr*TnsRelig					0.421***	
					(0.082)	

200 The three major polluting sources are coal, oil and gas fuels Less than 5% of total emissions come from cement and gas flaring so they are excluded from the analysis.

Investment Profile						-0.172***
						(0.034)
InvPro*TnsRelig						-0.063***
						(0.018)
Obs.	1730	1739	1717	1739	1739	1739
R-squared	-1.102	-0.269	-0.323	-0.547	-0.428	-0.208
No of Countries	83	83	82	83	83	83
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon emissions per capita* sourced from solid fuel (coal). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions.* Control variables are included in all models. Panel A reports estimations of the new dependent variable against each of the institutional variables. All six models in Panel A are estimated with fixed-effects IV regressions (column (1)-(6)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01, ** p<0.05, * p<0.1*.

The share of CO_2 emissions from solid fuels are presented in Table 4.12 (Panel A). As can be seen, the results seem to be different from those found in all previous studies. For instance, trust is no longer an effective factor in reducing pollution. Although it is negative in almost all models, it establishes a reliable negative estimation in only one model (M6).[201] Hence, the efficacy of trust in this sector is likely to be weak. One plausible reason for explaining the irrelevancy of informal institutions to decreasing the coal-type emissions can be related to the application of this type of fuel. Solid fuels are mainly used in the industrial sectors of an economy, and it is the preferred choice for most industrialised countries and their industrialising followers for supplying energy (Goodman, Marshall, & Pearse, 2016). On the other hand, solid-type is not a fuel that people directly rely on in everyday life. Therefore, any change in the level of trust does not directly affect the amount of released emissions from coal.

[201] Except Model (4), in which a significant positive coefficient is observed.

Despite discussing the efficacy of trust first, the most interesting results in Table 4.12 are related to formal institutions, particularly democracy. I showed previously (in the reference sample) that democracy is not relevant to the emissions abatement process. I argued that the political system per se is not as efficient as *political constraints* for reducing emissions. However, in this table's results, there is a positive coefficient on the indicators of democracy *(level of democracy* and *combined polity score)*, suggesting that democracy is not only inefficient but also hurts the quality of the environment by increasing the emissions from dirty fuels like coal. This is broadly consistent with the theory, which proposes that democracy is linked to economic prosperity and, thus, is damaging for the environment.

The following points can be used in support of the above argument. On the one hand, democracies are market-based economies, so the exclusive focus is on encouraging economic growth and development (Acemoglu et al., 2019). Additionally, democracies are biased toward protecting the interests of large profit-oriented industries, which are reluctant to make sacrifices for the interests of society, resulting in environmental policy inaction (Q. Li & Reuveny, 2006).[202] On the other hand, as mentioned above, solid fuels such as coal have been mostly used in industries across countries. Thus, emissions from coal, to a large extent, show emissions from the manufacturing industries. As democratic countries are mainly industrialised; hence, more emissions are expected to be generated in that countries. Therefore, a higher *level of democracy* is positively associated with higher amount of emissions.

To further examine this argument, I also examine the role of democracy in industrial carbon dioxide emissions. The statistical results seem to confirm that democracies are in favour of growth. As indicated in Table 4.A11 (Appendix III), democracy is shown to be a contributing factor to the level of emissions that are largely sourced from manufacturing industries and construction. Instead, the other two types of institutions demonstrate a significant negative relationship with both types of emission sources. The results in both Tables (4.12) and (4.A11) reveal that, while democracy increases pollution, improving law and contract enforcements as the proxies of legal and economic institutions decreases emissions stemming from the consumption of solid fuels in the industrial sector. Consequently, democracies worsen emissions through fostering industrialisation.[203]

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[202] While the stringency of environmental policy is not promoted by democratic institutions (Pellegrini & Gerlagh, 2006), industry lobbying is stimulated by democracies (Fredriksson & Neumayer, 2013).

[203] The positive interactions further imply that the effects of formal institutions on the emitted carbon will be bigger in high-trusted countries.

Table 4.13. Carbon emitted from liquid fuels (IV estimations)

Panel B: Liquid Fuel Consumption						
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-0.631**	-0.649**	-0.645**	-0.825**	-0.627**	-0.264*
	(0.267)	(0.264)	(0.265)	(0.391)	(0.269)	(0.153)
Political Constraints	-1.483**					
	(0.621)					
PolCon*TnsRelig	-0.828					
	(0.630)					
Level of Democracy		-0.063				
		(0.140)				
Democ*TnsRelig		-0.016				
		(0.037)				
Combined Polity Score			-0.039			
			(0.059)			
Polity*TnsRelig			-0.001			
			(0.019)			
Law & Order				-0.898**		
				(0.352)		
LawOrd*TnsRelig				-0.104		
				(0.126)		
Corruption					-0.932***	
					(0.306)	
Corr*TnsRelig					-0.051	
					(0.095)	
Investment Profile						0.025
						(0.054)
InvPro*TnsRelig						0.135**
						(0.054)
Obs.	1730	1739	1717	1739	1739	1739
R-squared	-0.052	-0.022	-0.028	-0.318	-0.165	-0.001
No of Countries	83	83	82	83	83	83
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon emissions per capita* sourced from liquid fuel (oil). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions*. Control variables are included in all models. Panel B reports estimations of the new dependent variable against each of the institutional variables. All six models in Panel B are estimated with fixed-effects IV regressions (column (1)-(6)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The second panel of estimations (Panel B) is assigned to the effects of institutions on CO_2 emissions stemming from liquid fuels such as oil. As can be seen from Table 4.13, all estimations are consistent with previous results, showing that better institutions are equated with lower air pollution from consuming oil. Similar to the results on *carbon footprint*, the proxy of trust confirms a statistically negative and meaningful association with carbon emitted from using petroleum-derived fuels. Also, higher *political constraints*, along with a better quality regulatory system, positively influence emission reductions from this source. Moreover, consistent with previous results, indicators of democracy turned out to be insignificant. Finally, almost all the interactions reject the co-dependency of institutions.

Table 4.14. Carbon emitted from gas fuels (IV estimations)

Panel C: Gas Fuel Consumption						
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-0.602***	-0.593***	-0.657***	-0.916***	-0.568***	-0.075
	(0.187)	(0.188)	(0.192)	(0.267)	(0.177)	(0.131)
Political Constraints	-0.182					
	(0.485)					
PolCon*TnsRelig	-1.052**					
	(0.505)					
Level of Democracy		-0.478***				
		(0.110)				
Democ*TnsRelig		0.036				
		(0.036)				

	(1)	(2)	(3)	(4)	(5)	(6)
Combined Polity Score			-0.192***			
			(0.048)			
Polity*TnsRelig			0.023			
			(0.020)			
Law & Order				-0.538**		
				(0.269)		
LawOrd*TnsRelig				-0.274***		
				(0.097)		
Corruption					0.318	
					(0.207)	
Corr*TnsRelig					-0.224***	
					(0.064)	
Investment Profile						0.118***
						(0.041)
InvPro*TnsRelig						0.169 ***
						(0.035)
Obs.	1730	1739	1717	1739	1739	1739
R-squared	-0.262	-0.263	-0.376	-0.685	-0.162	-0.200
No of Countries	83	83	82	83	83	83
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon emissions per capita* sourced from gas fuel (gas) consumption. Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions.* Control variables are included in all models. Panel C reports estimations of the new dependent variable against each of the institutional variables. All six models in Panel C are estimated with fixed-effects IV regressions (column (1)-(6)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Finally, the results for the emissions sourced from gas fuels consumption are reported in Table 4.14 (Panel C). Similar to the results for liquid fuels, institutional indicators are mainly consistent with the principal models' estimations.[204] For instance, trust confirms a statistically

[204] The models presented in the first three studies. See for example Tables 4.7 and 4.8.

negative and meaningful relationship with emitted carbon from consuming gas fuels. A similar direction is also found on formal indices. However, unlike solid fuels, where democracy is shown to have an adverse effect on air quality, here, stronger democratic institutions lead to lower emissions. One plausible reason for this effect can be related to the application of gas fuels in the energy sector, and energy-related policies in democratic countries.

On the one hand, natural gas is mainly exploited for producing electricity and heat;[205] the most polluting sector that accounted for half of the global CO_2 emissions in 2014 (Ritchie & Roser, 2020). On the other hand, democracies' tend to increase the residential sector's share of electric power consumption and decrease the industries' through implementing redistribution policies (Brown & Mobarak, 2009).[206] As CO_2 emissions from gas fuels (Panel C) measures the emissions resulting from the contribution of natural gas to energy and other industries, increasing the quality of democracy is associated with decreasing the use of gas fuels in the industrial sector (e.g., due to cross-subsidisation) and, therefore, decreasing carbon emissions from this type of fuel. Consequently, a negative relationship between democratic indicators and gas-related carbon emissions is shown in Table 4.14.

To further examine whether the effects of the redistribution policies are reflected in this study, I also delve into the role of democratic institutions in reducing the extent of carbon dioxide emissions stemming from electricity and heat production. As indicated in Table 4.A12 (Appendix III), the above argument on redistribution policies seems to be valid in this sector as well. In estimations that are outlined in Table 4.A12, one of the proxies of democracy *(polity score)* determines a significant negative effect on the extent of industrial emissions, meaning that in democratic countries, the extent of pollution caused by the production of heat and electric power is relatively lower than autocratic ones.[207] In addition, other institutional

[205] In 2015, about 35% of the world's total electric power sector was sourced from gas (Ritchie & Roser, 2017), this is more than any other sectors such as industrial and residential in the US in 2018 (EIA, 2019, November).

[206] In fact, politicians influence the prevailing pattern of electricity consumption by subsidising the residential sector (at the expense of the industrial) to increase the provision of public goods. This type of energy redistribution, which is more prevalent in developing countries, contributes to emissions reduction as well because residential utilisations emit less pollution than burning such fossil fuels in the process of industrial production.

[207] I even dig deeper into the effects of redistributional policies in democratic countries by checking emissions from residential buildings. The results show that as democracy gets better, pollution from this sector worsen, indicating a positive association with the dependent variable. In contrast, all other formal institutional indicators are linked negatively with this type of emissions. Hence, by considering the results on the emissions stemming from gas fuels and electricity and heat production, and comparing with the type of sectoral emissions, one can confirm the effects of the cross-subsidisation policy.

indicators also demonstrate a statistically meaningful and negative relationship with this type of carbon emissions. Consequently, democracy encourages mitigating gas-type emissions through the implementation of redistribution policies.[208]

The results of this section help one to have a better grasp of the effects of institutions, particularly democracy, on the extent of emissions reduction across different sources and sectors. More specifically, it is possible to extend one's knowledge of the specific role of institutions in mitigating emissions. Based on the results outlined above, I found that better formal and informal institutions mainly improve the air quality across countries, regardless of the types of fossil fuels their economies rely upon. However, among formal institutions, the effect of democracy on emission abatement is not absolute. Depending on the type of fossil fuels, democracies respond differently, affecting emissions both positively and negatively. While carbon dioxide emissions resulting from gas fuels have fallen in democracies, CO_2 caused by coal resources has risen during the studied period.

4.6 Conclusion

In this chapter, I studied the role of institutions, focusing on both formal and informal types, in managing global environmental commons and mitigating pollution. To do this, I constructed a panel dataset using the maximum available number of cross-sections and time-series and employed the most scrutinised indicators for representing various aspects of institutions. Additionally, to obtain unbiased and consistent estimations across different models, this research benefitted from the use of three static panel data methods, though the results obtained on the instrumental variable strategy are of particular interest. This chapter was further divided into four studies in order to systematically discuss and interpret the results. The first three studies were arranged to present the main findings, while the last one provided different robustness checks for the reported estimations.

In Study 1, the efficacy of formal institutions in mitigating carbon dioxide emissions was analysed and discussed extensively. By drawing on different political, legal and economic

[208] While positive interaction effects shown in Table 4.A12 point to the differential effects of institutions on emissions that are sourced from electricity and heat production, the negative interactions shown in Table 4.14 suggest complementary impacts of institutions on emissions stemming from burning gas fuels. This means that the positive effects of strong formal institutions on reducing gas-related emissions will be enhanced by proper informal institutional quality. This contradictory result can be due to the constituting components of each source. Because, on top of gas fuel, oil and coal fuels are also contributing to the production of electricity and the heating sector, making this aggregated sector rather different in composition.

indicators, I was able to check the consistency of the findings of this study against previous empirical research in the field of institutions and the environment. I found that the extent of power concentration in the hands of the government matters the most for decreasing carbon emissions. While the empirical findings of this study confirmed the argument of Elinor Ostrom (2010a) regarding the importance of a decentralised system, the evidence was less robust and consistent for the measures of democracy. In the same vein, the strength of the regulatory system and uncorrupted public sector were found to be influential in the process of abating emissions. Overall, the results confirmed the efficacy of formal power in managing the global commons, thus supporting traditional collective action theory.

Study 2, however, was assigned to empirically test the validity of the updated collective action theory, in which social capital was proposed by Elinor Ostrom as being central to sustaining cooperation and reciprocation and solving the issue of free riders overusing shared environmental resources. Therefore, informal institutions were introduced in regression models. In fact, this study proposed a novel approach for evaluating the updated collective action theory in data. First, unlike the existing literature, a new indicator was utilised for measuring informal institutions. This index, social tensions, was then instrumented by a new variable that was constructed for applying in the IV strategy. Benefiting from this specification, I was able to produce more accurate estimations on each of the institutional indicators, relative to the existing empirical studies. As predicted, lower tensions were found to be strongly associated with better air quality. The results of formal indicators further confirmed the findings of the first study.

In Study 3, I intended to check whether the institutional effects on the levels of emissions are co-dependent on or autonomous from each other. To that aim, the specified IV model was further augmented in this study by the addition of the interaction of formal and informal institutions. Study 3 can be considered as an extension to the first two studies. The positive interactions indicated the substitutability of formal and informal institutions on the level of emissions. This means that in countries with strong formal institutions, the negative effects of having lower levels of trust on emitting pollution will be less significant, and vice versa. By considering the interactive terms, I extended the existing empirical research further.

Finally, Study 4 explored the heterogeneity in the institution-environment relationship across different specifications, samples and sources. In fact, robustness estimations were reviewed holistically here. The static model specified in the first three studies was re-estimated with a dynamic panel data model using the GMM approach. The findings were comparable regarding the institutions. When the studied sample of countries was categorised based on the resource-dependency ratio, I found that resource-dependent countries require major improvements in formal institutions for substantially decreasing emissions, while informal institutions should be a priority area for the non-resource-dependent countries. Lastly, taking account of different sources/sectors of emissions helped to shed more light on determining the role of democracy in reducing emissions. It can be proposed that, depending on the type of fossil fuels, democracy might affect emissions in both directions; hence, it cannot be absolute.

Chapter 5

Conclusions

5.1 Research Findings

In this study, the aim was to assess the effects of both formal and informal institutions and their interactions on reducing collective action problems related to carbon emissions mitigations. To do so, I initially took the most comprehensive SES framework as the theoretical foundation for this study. This framework, which has been mostly employed for studying qualitative case studies in micro scale, was reshaped to fit into this cross-country quantitative study in macro scale. Working on such a complex multilevel nested framework provided me with an inclusive list of variables that might be potentially relevant to investigating this relationship. Taking into consideration the research questions and the focal level of the analysis, influential variables were carefully identified.

Since investigating the role of institutions in managing the environment was of the interest of this study, identifying the SES influential variables must be related the pattern of the subsequent interaction and outcome: *self-organising activities (I7)* and *ecological performance measures (O2)*. In this process, I based my discussion in Chapter 2 (Section 2.5) on three features of this study: *(i)* particular research questions, *(ii)* focal level of analysis, and *(iii)* empirical specifications. In total, 12 different second-tier variables were selected to be incorporated into the regression models. The important institutional variables were all adopted from the core of the governance systems *(GS4: regime type; GS6: rules-in-use; GS7: property-rights system; GS8: repertoire of norms and strategies)*. For each regression model, one of the formal institutional variables *(GS4; GS6; GS7)* was coupled with the variable on informal institutions *(GS8)*. Also, in each regression, the product of the institutional variables was included.

The analysis of the main independent variables was further improved by the inclusion of the vector of additional explanatory variables. It contained information related to the characteristics of the actors *(A7: knowledge of SES/ mental models)*, resource systems *(RS5: productivity of the system- RS5-a: forests biocapacity & RS5-b: energy use)*, and broad socioeconomic settings *(S1: economic development; S2: demographic trends; S3: political stability; S6: media organisation*; *S7: technology)*. All the selected variables, which represented the *I7 (self-organising activities)*, were regressed over the *O2 (ecological performance: carbon footprint)*. Moreover, the validity of the EKC relationship was tested by the inclusion of *squared S1 (economic development)* in the dynamic models. The adaptation of the SES framework and identification of its effective internal deeper-level variables was discussed in Chapter 2.

With the selected set of theoretical variables adopted from the SES framework, it was time to look for quantifiable measures. Relying on the environmental economics empirical literature, all the variables were carefully chosen from the most relevant databases, ranging from political (e.g., the PRS group) and economic (e.g., TED) to purely environmental (e.g., GFN). Although the variables were selected from many databases, the sample size was determined by the availability of reliable data. I spent a great deal of time and energy building the dataset; however, the choice of variables was limited for both environmental and institutional measures. Merging the datasets employed on the variables of interest, I constructed a balanced panel of 140 countries for the 26 years between 1990 and 2015. The employed sample, included variables and databases were completely described in Chapter 3.

Subsequently, the methods of estimations were chosen. To that aim, I had to take account of the following critical factors: the focal level of the analysis; the nature of the main independent and dependent variables; and the feasibility of applying the proposed empirical specifications based on the conceptual framework. Among the panel data models, I first relied on the fixed-effect analysis. Since it was cross-country research, the estimations were be improved by the inclusion of the fixed-effect estimator, which took account of the unobserved country-specific heterogeneities. Hence, one of the critical components of the empirical specification, which is related to the focal level of analysis, was solved by the inclusion of the fixed-effect estimator.

Another factor that can also affect the empirical method is the nature of the institutional variables, as the main independent regressors. From a theoretical perspective, both types of institutions are inherently endogenous because they are greatly affected by predetermined historical and cultural factors. In the presence of endogeneity, adopting OLS like what most scholars did, would yield unreliable estimations, therefore, I drew on the IV strategy. The combination of the FE-IV estimator with Huber-White heteroscedasticity-consistent standard errors and year dummies to capture the serial correlation were able to appropriately capture the variations within the dependent variable and correctly estimate the magnitude of the effects of institutions on carbon emissions.

Additionally, for addressing the endogeneity that lies in institutions, exogenous time-variant instruments were introduced in the FE-IV. The current literature suggested using the origins of colonial power or the legal system of a country as qualified instruments for formal institutions. Hence, in this study, such variables were implemented and interacted with time to become time-variant. Nevertheless, empirical research in environmental studies lacked a proper time-variant instrument for informal institutions. Therefore, I constructed a qualified instrument for the employed measure of trust. To do so, I calculated the geographical distances between two countries in the world, using their unique coordinates. Then, the resulted value for each country was weighted by its proximity to conflict-prone zones so that the constructed instrument, *distance to conflict zones*, satisfied the exclusion restriction condition. In this study, I also drew on a new variable for measuring the level of within-nation trust, which can be better explained by the constructed instrument.

Theoretically, it is proposed that environmental problems have an evolutionary character, meaning that emissions over time are dynamically correlated with each other. Since the previous years' emissions are a driving force behind the current year's pollution level, they were controlled in the model. This was taken into consideration by the inclusion of the lag(s) of the emissions in the right-hand-side of the equation and the use of the complex GMM estimation for estimating their effects. This approach also proved to be suitable for indicating the non-linear income-emissions relationship known as the EKC hypothesis. To increase the efficiency of the estimations, the GMM model was augmented by the additional moment conditions constructed by the two-step system equation model. This study's results from using the two-step Sys-GMM provided insights into the institution-environment relationship by testing for the presence of EKC and checking the robustness of the IV results.

In choosing between FE-IV and Sys-GMM, I drew on the FE-IV estimation as the main econometric model. Since achieving this study's aim required the construction of strong institutional analysis. FE-IV enabled me to discuss institutions in depth by allowing for including historical preconditions through the instruments. I also did by including both types of institutions and different institutional measures. In this study, I used seven different institutional measures along with their interactions to assess the significant effects of both formal and informal institutions on the environment. Adopting GMM is not straight forward, as researchers appear to have been reluctant to explain their procedure in papers. Apart from its complexity, GMM can be manipulated by introducing different types of instruments. Hence, it is not as reliable as the FE-IV method. The precision of the adopted estimation techniques was discussed in Chapter 3.

Drawing on the SES framework and multiple regression analysis, this study attempted to answer the main research question, which was about the role of institutions in managing the environment. I found that high quality formal and informal institutions generally led to better environmental outcomes across countries worldwide. These findings further supported the validity of the hypotheses of this study, in which the environmental performance of countries was expected to be positively affected by efficient institutional factors. In Chapter 4, Study 1 was designed to deliver the answer to the first hypothesis. The second study provided the answer to the second hypothesis. Finally, the third hypothesis was addressed in the third study. The consistency of the findings acquired in the first three studies was then indicated in the fourth study of Chapter 4.

The most significant finding to emerge from this study was that good informal institutions, assessed by higher levels of within-nation trust, contributed positively to the emissions reduction process of countries. This was shown by the variable of *religious tensions*, by which a significant and negative relationship with *carbon footprint* was statistically confirmed across all IV and GMM estimations. The results for this variable, which directly measured the level of social tensions arising from ethnoreligious fractionalisation, showed that since the likelihood of adopting cooperation and reciprocation by less heterogeneous communities is higher, the level of CO_2 emissions would be, therefore, lower. This finding supported the prediction of the second hypothesis, in which informal institutions was expected to positively affect the level of emissions. It was also consistent with the prediction of the updated collective action theory, in which cooperation induced by social capital and norms was introduced as an efficient instrument for lessening free-riding risks in global commons and promoting pro-environmental behaviours toward long-term sustainability.

In the context of formal institutions, political and legal institutions emerged as reliable predictors of environmental performance. In this vein, the most important finding was related to the concentration of political power, in which the level of pollution was shown to be strongly affected by the extent of constraints on the executive. This suggested that the lower the concentration of political power in the hands of the ruling elites, the lower the emissions would be in a given country. In other words, the presence of more efficient branches of government entails a higher level of constraints on the executive, which in turn decreases the level of pollution. This finding, which was supported by the first hypothesis and consistent across different estimations, further denotes the importance of decentralised arrangements for successfully managing environmental resources.

Likewise, the importance of law enforcement in mitigating pollution was clearly supported by the current findings. The results showed that better quality regulatory systems positively influenced per capita emissions reduction. This finding also supported the first research hypothesis, and proved to be robust across different estimations, samples and sectors. The research showed, too, that economic institutions matter for the levels of emissions. Strong economic institutions result in better environmental outcomes by reducing the pressures on natural resources through efficient resource allocation as well as restraining the pollution-intensive primary sector of an economy. However, it is difficult to entirely disentangle the effects of economic institutions from political ones as they overlap with each other to the extent that the scope of economic institutions' functions is controlled by the political institutions. This can further explain why the effects of economic institutions on reducing emissions were not found to be as absolute as the political and legal institutions. Based on this study's findings, it is expected that in countries with efficient economic institutions, property-rights are better protected, and thus emissions are lower.

Additionally, it was promised that the findings of this research extend the current knowledge about the role of democracy in protecting the environment and clarify the ambiguity that lies in the democracy-emissions relationship. Based on the empirical results acquired on the reference sample, democratic institutions were shown generally to have made no significant difference to the level of emissions directly, indicating its irrelevancy to the emissions abatement process. However, when the total emissions sample was divided by the polluting sources and sectors, the effect of democracy was no longer found to be absolute. Depending on the type of fossil fuels, democracies responded differently, affecting emissions in both directions. While carbon dioxide emissions resulting from gas fuels fell in democratic countries, coal-type emissions rose during the studied period. The same effect was also apparent in the levels of emissions stemming from the industrial sector. Since manufacturing industries are the main consumer of coal fuels, it can be concluded that democracy is a factor in economic prosperity. Hence, the findings on democracy were not in line with the hypothesis.

Moreover, the interaction of institutions also indicated that the total effects of formal and informal institutions on the level of emissions were interdependent. The findings highlighted the substitutionary effects of institutions, meaning that the positive effects of informal institutions on reducing emissions would be mitigated when formal institutions are weak, vice versa. For instance, democratic institutions made no significant direct impact on the level of *carbon footprint per capita* across all countries; however, it was found that they could affect emissions indirectly through the level of trust. In countries with weak democratic institutions, the effects of a high level of trust on reducing emissions would be mitigated. This finding was consistent across different estimations and robust to the alternative formal institutional indicator. However, it was not exactly consistent with my expectation demonstrated in the third hypothesis.

5.2 Research Contributions

This project is the first comprehensive investigation of the impact of institutions on the environment. Achieving this aim required building theoretical and empirical foundations for analysing institutions in the context of the environment.

I initially reviewed the conventional and updated collective action theories as they are the main two theories in environmental studies. In order to identify what needed to be done next on the institution-environment relationship, multiple theoretical and empirical studies within these two strands of collective action theory were discussed. I found that there is a lack of sound institutional analysis in the empirical studies on the environment. I based that judgment on two factors. First, even on the role of formal institutions, which has been the main object of studies, there is no consensus among scholars; conflicting results on the effects of political institutions, especially democracy, have been obtained on different environmental indicators, in particular carbon emissions. Second, the role of informal institutions has been broadly ignored in this process, which indicated the need for empirical testing of the updated theory.

To build strong institutional foundations and rectify the problems, the present cross-country empirical research attempted to evaluate the inclusive impacts of both formal and informal institutions and their interactions on reducing the concentration of CO_2 emissions. In this study, seven different institutional measures, six of which represented formal institutions, including democracy, were adopted. Further, I drew on a new variable for measuring the level of within-nation trust. It captured the level of social tensions arising from ethnoreligious fractionalisation, instead of directly measuring trust. Compared to the conventional measure, it gave far more observations in terms of the number of years and countries. This inclusion was theoretically and empirically shown to be beneficial for the analysis.

Previous analyses have suffered from the trade-off that they had to make for the sake of including as many countries as possible in their sample. Because of focusing on a large sample of countries with data limitations, such studies had to use cross-sectional regressions, which only provide a snapshot of the situation in a single point of time. In fact, this is the most common issue to arise in the empirical analysis of institutions and the environment, especially in the case of poor countries where the choice of the empirical specification is dictated by data availability. However, in order to obtain the most reliable estimations, I drew on the panel dataset, though it was challenging. Although, the number of observations used in my estimations dropped substantially due to the missing data, considering the number of second-tier variables included (14), countries (98) and the studied period (25 years from 1990-2014), the current constructed cross-sectional time-series sample is still among the most inclusive in the cross-country empirical literature.

To produce consistent and reliable estimations, I relied on two main econometric methods of FE-IV and Sys-GMM. What I noted in the current literature was the lack of implementing IV strategy for estimating the effects of institutions on the environment. While it is a standard method in the institutional economics literature, existing empirical research in environmental studies has mainly drawn on simple estimations such as cross-sectional, random- and fixed-effects OLS. The main reason for that could have been related to the absence of an appropriate time-variant instrumental variable, which denotes the endogenous nature of institutions. Therefore, to my knowledge, the present study is one of the first attempts in environmental literature that examined the institution-environment relationship by FE-IV. I further extended the literature by constructing a qualified instrument named *distance to conflict zones*, for instrumenting the employed measure of trust. The robustness of IV estimations was further checked by Sys-GMM model, which is useful for considering the dynamism in environmental analysis and producing estimations that are robust to endogeneity, serial correlation and heteroscedasticity.

Finally, there are no empirical studies on the sample of resource-rich and -poor countries. So far, empirical studies in environmental studies mainly have divided their studied samples according to the countries' development stage (OECD countries), income range (high- vs low-income countries) or locations (e.g., Europe, Latin America, and Asia). Therefore, the results of this thesis can shed new light on the institution-environment relationship related to the resource-dependent countries: major institutional deficiencies (related to the resource curse hypothesis) were empirically shown (compared to the non-resource-dependent ones). Moreover, this study further extends the current literature on carbon emissions by estimating the effects of institutions on the extent of emissions stemming from fossil fuels and associated sectors across countries. Therefore, this study was one of the first attempt to conduct a comparative analysis on the heterogeneities in the institution-environment relationship.

5.3 Policy Implications

Overall, the findings of this study confirm that the quality of both formal and informal institutions matter for reducing environmental degradation. Nevertheless, for the long-term sustainability of resources, informal institutions are critical. Tackling the stock of carbon confronts all people globally. Hence, it requires awareness on the part of both governments and people to take a range of proenvironmental actions to improve the quality of the environment and tackle climate change. The empirical results of this study confirm this.

The findings of this study have a number of important implications for future practice. The principle implication of this study is that promoting trust should be a priority of countries for achieving environmental goals, especially in the advanced economies where societies are relatively heterogeneous. These days, due to the significant flow of immigrants mostly from poor countries to the developed ones, a country’s population becomes much more culturally heterogeneous; thus, the integration of different ethnicities into hosting societies becomes harder than ever. In nations where communities are more heterogeneous in terms of ethnic and religious identities, the possibility of reciprocal cooperation would be less because it is more difficult for people to connect with and predict the behaviours of those who are not from the same background than those who are.

This implication is further indicated by the results related to the sample of non-resource-dependent countries. In this set of countries, the majority of which are advanced economies, the quality of informal institutions may make improvements to the level of emissions. While the quality of their formal institutions is on average high, these countries also need to mitigate their share of emissions by building an inclusive community where all people from different ethnic and religious backgrounds can trust and cooperate (and reciprocate) with each other.

This is a significant issue for governments, but once effectively put into place, global environmental challenges like mitigating CO_2 emissions would be more easily solved. Therefore, the findings reported here shed new light on how the level of trust can help to solve collective action challenges across different countries.

Another important practical implication is related to formal institutions, in particular the concentration of political power and the strength and impartiality of law enforcement. In countries where the political system is decentralised, policies are less easily overturned, thus the environment is more protected. This study finds that the presence of a higher number of independent legislative units with veto power, including an executive, lower and upper house in the legislative chambers, judiciary and sub-federal entities, lead to a greater level of constraints on the head of the state, and thus decreases the likelihood of overturning policy due to the preference of the executive. In a similar vein, the rule of law lessens the frequency of ignorance of the law for political purposes; hence, the risk of authority collapse would be lower; therefore, it is unlikely that overturning policy happens.

Based on that finding, the implication is that what matters more for environmental conservation is stability in policymaking. The short duration of electoral cycles or judicial inefficiency in a political regime might be one of the reasons for destabilising the policy process. Countries with a decentralised political system and vigorous law enforcement are less prone to policy overturning. Stability and consistency in terms of environmental decisions and policy implementation are even more important since the future costs of current socially degrading activities escalate over time. Key environmental policies, therefore, should be those that plan for the long-term care of the environment.

Furthermore, the policy implication for resource-dependent countries involves the quality of their formal institutions. As well as informal institutions, which are needed in general for achieving sustainability, these countries need to mitigate their emissions by building inclusive institutions where all people can enjoy from political freedoms, equal civil rights, less violence, access to justice, non-discriminatory laws and less corrupt and accountable politicians. The major institutional deficit is a significant barrier for these governments to decrease their share of carbon emissions; therefore, strengthening formal institutions is a top priority policy for resource-dependent countries.

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Appendices

Appendix I

The tables below (Table 2.A1-2.A8), list all the variables included in the revised SES framework, regardless of their relevance to the current study. It is organised in the SES's order, in which second-tier variables are grouped by their core categories, followed by a definition and reason(s) for the inclusion (if indicated by yes) or exclusion (if indicated by no) for each. In providing the definitions and explaining any exclusionary/inclusionary reasons, I mostly rely on three seminal papers: Basurto et al. (2013), McGinnis and Ostrom (2014), and Nagendra and Ostrom (2014).[209] In the following tables, three types of variables are presented:

1. Coloured variables (italicised). They are the ones considered as effective in the process of self-organisation and ecological outcomes. Additionally, reliable data are available at the country level for each of them, thus selected to be included in the regressions in the next chapter. They are 12 second-tier variables in total, which are shown in Table 2.3, as well. They can also be identified with "Yes" in front of their names, showing their inclusion in the equations.
2. Black variables (italicised). The inclusion of these 12 variables can potentially cover 12 more second-tier variables as they are reasonably linked to the selected ones. In the tables, they are italicised with "No" in front of their names, indicating their exclusion.
3. Regular black variables. The rest of the variables that are irrelevant to and excluded from this study are indicated by this font with "No" ahead of their names.

Broad Social-Economic-Political Settings (S)

The category of settings initially includes seven second-tier variables (as depicted in Table 2.A1); however, due to data limitation and irrelevancy of the covered topic, two variables of *S4* (other governance systems) and *S5* (markets) will be excluded. Instead, a squared form of *S1* will be added to the list of variables, to check whether the dynamic models can support the EKC income-emissions relationship or not.

[209] A summary of modifications made by Elinor Ostrom and her co-authors are discussed in Tables 1-2 in McGinnis and Ostrom (2014, pp. 5-9), Table 1 in Nagendra and Ostrom (2014, pp. 5-7) and Tables A.1-A.4 in Basurto et al. (2013, pp. 10-13).

Table 2.A1. Definitions and explanations for included/excluded S's variables

Code	Variables	Y/N?	Definition	Reason for Inclusion/Exclusion
S1	*Economic development*	*Yes*	*The degree to which a country is industrialised and economically developed.*	*Since the focal level of analysis is at the country level, such variables that can take heterogeneities across countries and over time must be incorporated into the model.*
S2	*Demographic trends*	*Yes*	*The population growth (trend), structure and density of a country.*	
S3	*Political stability*	*Yes*	*The durability and stability of a political regime, and less involvement in internal/ external conflicts, as opposed to fragile states.*	
S4	Other governance systems	No	N/A	Irrelevant/ Data limitation.
S5	Markets	No	N/A	Same as above
S6	*Media organisations*	*Yes*	*The presence of and free access to private and public media in a country.*	*Since the focal level of analysis is at the country level, such variables that can take heterogeneities across countries and overtime must be incorporated into the model.*
S7	*Technology*	*Yes*	*The degree to which a country is technologically developed.*	

Notes: This table represents the broad settings' variables. The coloured ones are directly included in the empirical model. Regular black variables are excluded from the analysis.

Resource Systems (RS)

The category of resource systems initially includes nine second-tier variables (as depicted in Table 2.A2); however, considering the specific attributes of the chosen *RS* and data limitations, most of the internal variables within this category are irrelevant, and thus will not be included in the analysis. The details are as follows:

1. Sector *(RS1)* and location *(RS9)* are eliminated from the analysis since the focus of this cross-country study is on only one open-access resource system (earth's atmosphere), in which not much variation is observed across countries.
2. Equilibrium properties *(RS6)* cannot be specified for this resource system, due to the unavailability of reliable data on the market across all countries.
3. Clarity of boundaries *(RS2)* and size of the resource system *(RS3)* are two variables that enable researchers to recognise actors (from others) who are legally permitted to withdraw *RUs*. *RS2* and *RS3* help to sustain the resource and build higher levels of trust within a society (Ostrom, 2007, p. 18; 2012a, pp. 25-26). However, they are withdrawn from the analysis because the earth's atmosphere is an extremely open-access resource

covering the entire world, within which neither size nor its capacity and not even a single distinctive boundary can be clearly defined and measured. Moreover, since the size of the *RS* is infinite, the likelihood of self-organisation is negatively influenced.

Table 2.A2. Definitions and explanations for included/excluded RS's variables

Code	Variables		Y/N?	Definition	Reason for Inclusion/Exclusion
RS1	Sector		No	The focused resource sector is the earth's atmosphere (air quality) and its own unique attributes only. Therefore, I only focus on one sector across countries.	Since the focus of this study is on only one resource sector, its inclusion does not add any value to the analysis.
RS2	Clarity of system boundaries		No	These two factors enable actors to determine the beginning and ending points, and thus spatial magnitude (area) and capacity (volume) of a resource, which in this case, are totally unspecified and unknown for actors; hence, the sector should be considered as one large system covering the entire world.	Since there are no well-defined distinctive boundaries across countries, the size of a particular spatial extent is unmeasurable. Hence, no significant variations can be identified in the quality of the air system.
RS3*	Size of resource system				
	RS3.1	Area			
	RS3.2	Volume			
RS4	*Human-constructed facilities*		*No*	*The degree to which actors can interfere in the system (outside its natural habitat) through the built facilities and technologies. Also, anything that affects the system's natural habitat can affect productivity as well.*	*Any disruptions made by actors can somehow be captured by S7 and RS5, which have already been included in the analysis.*
*RS5**	*Productivity of system*		*Yes*	*The resource's natural habitat is affected by the current production-consumption rate nationally and globally. This rate might be changed by the percentage of land covered in forests and the degree to which a country is emitting pollution from burning fossil fuels. These will shape the productivity rate, through which actors' self-organisation efforts will be affected.*	*Since the forest biological capacity and use of energy across countries affect the production-consumption rate, they are required to be taken into the equation, as there is no data available for measuring the system productivity.*
	RS5-a	*Forests bioapacity*			
	RS5-b	*Energy use*			
RS6	Equilibrium properties		No	Refers to the equilibrium points that can be specified for a resource system if any market is available across countries.	Data limitation
*RS7**	*Predictability of system dynamics*		*No*	*The dynamism of the system depends on the degree to which actors can predict the production-consumption pattern. The predictability of such open-access resource with its mobile units, while almost impossible, is somewhat dependent on the technologies (S7) available and the driving factors of RS5.*	*It can be explained by S7 and RS5, to some extent, which has already been considered in the equation.*

RS8	*Storage characteristics*	*No*	*The degree to which the number of resource units or pollution can be stored/ trapped until harvested/ released. Natural or artificial storage capacity may differ across resource systems, units and countries; however, in this case, it does not vary much.*	*It can be explained by RS5, to some extent, which has already been considered in the equation.*
RS9	Location	No	Refers to the temporal and spatial extent where the resource and its units can be found by harvesters.	As anyone from anywhere can have full unlimited access to this RS, its addition does not make any difference.

Notes: This table represents the core of Resource Systems. The green variables are directly included in the model. Italicised variables (in black) are indirectly included through the inclusion of the coloured ones. Regular black variables are excluded. Variables marked by asterisks are among the variables upon which self-organisation is dependent.

Resource Units (RU)

The category of resource units includes seven variables. However, because this study focuses on a type of global public good - the *RS* (earth's atmosphere) - which cannot be divided into smaller units by definition, the presence of *RU* variables will not make any difference in the analysis. Therefore, their internal variables are entirely excluded, and now *RU* and *RS* are treated as a whole (one aggregated component) in this study:

Table 2.A3. Definitions and explanations for included/excluded RU's variables

Code	Variables		Y/N?	Definition	Reason for Inclusion/Exclusion
RU1*	Resource unit mobility		No	Resource units can be either stationary or mobile. For each type, different governing rules will be needed. In this study, units are mobile moving spatially and temporally, thus, negatively associated with actors' self-organisation efforts.	No substantial variations across countries.
	RU1.1	Mobile units			
RU2	Growth or replacement rate		No	Refers to absolute or relative changes in quantities (reserves) of RU over time. However, as the air system is a renewable RS, the replacement rate stays the same, unless it is disrupted. In this case, changes can be somewhat captured by the proxies used in RS5 (productivity of the system).	Same as above
RU3	Interaction among resource units		No	The units' interaction is neutral unless it is disrupted by the emitted particulates.	Same as above
RU4	Economic value		No	It can be identified by subsistence and market values. However, in this study, they cannot be measured as there is no market for such enormously valued units.	Same as above
RU5	Number of units		No	The number of units is indefinite and cannot be counted, but it can be roughly captured by RS5. As the more polluted a country is, the less oxygen is available.	Same as above

RU6	Distinctive characteristics	No	Refers to specific natural/artificial markings in the appearance of units or/and in actors' behaviours toward using them. In this RS all units are homogenous.	Same as above
RU7	Spatial and temporal distribution	No	Refers to the distribution of units that can be either variable or stable across areas at a single time. Mobile air units are distributed variably across countries.	Same as above

Notes: This table represents the core of Resource Units. All of its variables are excluded from the analysis. Variable marked by asterisks are among the variables upon which self-organisation is dependent.

Governance System (GS)

The category of governance system initially includes eight second-tier variables; however, in this study, *GS* refers to the alternative list of variables (as presented in Table 2.A4). Now, in order to better fit the theory used in this study, GS includes 10 different attributes mainly related to the institutional system's efficiency including regime type, different types of rules, property-rights system and a repertoire of norms and strategies. Further, as actors in the SES framework are either collective or individual agents, the rules that define the responsibilities of agents should then be included as the feature of governance system (McGinnis & Ostrom, 2014, pp. 8-10). The details of the excluded variables are available as follows:

1. Policy area (GS1), geographic scale of governance system *(GS2)*, population *(GS3)* and rule-making organisations *(GS5)* are essential variables in the process preventing environmental degradation; however, due to the focal level of analysis, their inclusions will not make substantial variations across countries. In fact, the problem with *GS1* is the unavailability of reliable data for measuring the number of environmental policies adopted by a government. *GS2* and *GS3* are designed for defining the scale of the *GS* affected by the governance policy. However, in this research, settings can capture variables related to the macro scale of a country. Hence, there might be strong linkages among them, such as *GS5*, the effects of which are somewhat incorporated into *GS4*, while *GS2* and *GS3* are already captured by *S2*.
2. The connection between the proposed *GS5* and *GS3* (organisations and population) can be enhanced through different modes of network structure *(GS9)* consisting of centrality, modularity, connectivity at different levels. However, *GS9* will also be eliminated. Because of the focal level of analysis, its inclusion will not make substantial variations across countries. Besides, network structure, by definition, links *GS3* to *GS5*. When both excluded, it does not make sense to include their mode of connections.

Table 2.A4. Definitions and explanations for included/excluded GS's variables

Code	Variables	Y/N?	Definition	Reason for Inclusion/Exclusion
GS1	Policy area	No	It works exactly like the resource sector (RS1). It refers to policies related to a specific area, e.g., social, economic, environmental, health, etc. In this study, only environmental policies are of interest.	Since the focus of this study is on only one policy area, its inclusion does not add any value to the analysis. Besides, reliable data is not available, hence excluded.
GS2	*Geographic scale of governance system*	*No*	*Refers to the physical geographic range that is affected by the ruling system and its adopted policies. Changes can be roughly taken by S2.*	*In this study, rules and policies affect the entire size of a country. So, its addition does not add value to the analysis.*
GS3	*Population*	*No*	*Refers to the population of actors affected by the regime and its policies. As all actors have access to the RS, the entire population is affected in each country.*	*Any changes in this factor have been completely captured by S2 (demographic trend).*
GS4	*Regime type*	*Yes*	*The political system is mainly divided into two main categories. In an autocratic regime, few elites make autonomous decisions for the entire population. In a democratic regime, politicians are elected by the public through free elections. Since each system implements different administrative policies, based on its constitutions, the outcomes would be different across countries.*	*As it shows the quality of formal political institutions across countries must be included in the model*
GS4.1	*Democratic (polycentric)*			
GS4.2	*Autocratic (monocentric)*			
GS5	Rule-making organisations	No	Refers to multiple-scaled organisations (public, private, voluntary, community-based & hybrid) that are responsible for making rules for individual- and collective-agent actors to facilitate formally structured interactions among them.	Due to the macro level of this study, the addition of such micro variable does not make any changes to the analysis.
GS6	*Rules-in-use*	*Yes*	*Refers to all functional formal and informal rules that shape humans' behaviours and interactions. They are divided into three types, within which interactions are being monitored and sanctioned by specific rules (monitoring rules are implicitly built-in). These three types of rules are inter-connected, within which practical and operational decisions are constrained by collective rules. Collective rules can further be changed by constitutional ones.*	*Due to the macro level of analysis, and the fact that these three types of rules are inter-connected, I will include an all-inclusive variable that can take variations in the broad rules-in-use to have an overall assessment of the quality of formal legal institutions.*
GS6.1	*Operational-choice rules*		*Refers to practical decisions made by actors who are legally allowed to adopt rules. At this level, actors interact based on their preferences and incentives.*	

GS6.2	*Collective-choice rules**		*Refers to rules limiting both citizens and officials in doing operational activities –a process through which institutions are built–which might be reformed later by constitutional rules.*	
GS6.3	*Constitutional-choice rules*		*Refers to rules/decisions determining who is authorised/allowed to (eligibility criteria) participate in making operational rules (or policy-making process).*	
GS7	*Property-rights system*	*Yes*	*Rules on the relationship and responsibilities of actors in regards to their possessions, divided into four types of private, public, common and mixed type of good. This variable, which is also implied in the IAD framework, answers: (i) what can be counted as one's legitimate property (constitutional level)? (ii) What types of property can be expropriated for public use (collective level)? (iii) How can one distinguish actors with the right to harvest or manage from all participants (operational level)?*	*As it indicates the quality of formal economic institutions across countries must be included in the model*
GS8	*Repertoire of norms and strategies*	*Yes*	*Reflects numerous ways, in which decisions related to SES are influenced by culture. It is an encompassing term referring to all norms or shared strategies available for the use of actors within the relevant social and cultural settings. When an actor considers a norm/belief relevant to his/her actions in a particular setting, it can be treated as attributes of that actor (A6).*	*Since informal institutions is a broad term including norms, beliefs, culture, trust and traditions of society, it might be best interpreted as attributes of GS and indicated by the inclusive GS8, which includes the entire norms.*
GS9	Network structure	No	Refers to the link between GS5 and GS3 (population and rule-making organisation) that can be facilitated through different modes of network structure: centrality, modularity and connectivity.	The focal level of analysis and the exclusion of both GS3 and GS5 lead to the elimination of GS9; hence its addition does not make any analytical difference.
GS10	*Historical continuity*	*No*	*As governance systems have deep historical origins, distinguishing between stable systems and recent ones enables one to differentiate their behaviours toward ecological conservation.*	*Stability or fragility of a state has already been captured by S3 (political stability).*

Notes: This table represents the core of Governance Systems. The coloured variables (i.e., blue italic text) are directly included in the empirical model. Italicised variables (in black) are indirectly included through the inclusion of coloured ones. Regular black variables are excluded from the analysis. Variables marked by asterisks are among the variables upon which self-organisation is dependent.

Actors (As)

In the SES framework, the core category of users was changed to actors, since there are different sets of actors participating in different types of activities. However, the former label was not inclusive enough to include individuals' behaviours who are not direct consumers of products of the resource system. Thus, the category of "users" is now included as a sub-category of "actors." With respect to the studied resource system (earth's atmosphere) and the focal level of analysis, most of the internal variables will be excluded from the analysis:

1. *A4* (location) is excluded from the analysis because it is not applicable to this study due to the selected resource system. Likewise, *A8* (importance of the resource), though is an effective factor in the process of alleviating a collective problem, it must be excluded as it cannot be appropriately measured. Because there is no market for such an extremely valuable resource, hence there is not much variation observed across countries.
2. *A6* (norms, trust-reciprocity and social capital) refers to the level of interpersonal trust and social capital, thus must be included in the regression. However, "informal institutions" is an encompassing concept which refers to all norms or shared strategies available for all actors within a relevant socio-cultural context. On the other hand, when an actor considers a norm/belief relevant to his or her actions in a particular context, it can be treated as attributes of that actor. Therefore, instead of using this variable, *GS8* might be best representing informal institutions as a whole (*A6* is replaced with *GS8*).
3. *A3* (history or past experiences) highlights past extracting experiences. They might have destroyed resources, but they can also be improved by learning processes, implying its correlation with *A7*. Similarly, *A5* (leadership/entrepreneurship) shows leadership capabilities, which might be strengthened by the existence of highly educated people in society, highlighting its association with *A7*. In fact, having more and better-educated people is positively linked to conserving the environment as more actors are informed about and aware of their degrading activities and less likely to take polluting actions.

Table 2.A5. Definitions and explanations for included/excluded A's variables

Code	Variables	Y/N?	Definition	Reason for Inclusion/Exclusion
*A1**	*Number of relevant actors*	*No*	*Number of actors who are directly related to harvesting the RS.*	*S3 has already captured any variations in this attribute.*
A2	*Socioeconomic attributes*	*No*	*Actors' socioeconomic conditions that affect resource dynamics.*	*It is excluded because its effects can be captured by S1.*
A3	*History or past experiences*	*No*	*Refers to the historical pattern or past experiences of withdrawing RU caused by the interaction of an actor's behaviour and RS's biophysical characteristics.*	*It is excluded as its effects can be captured by A7.*
A4	Location	No	Refers to the physical location of actors concerning the resource being extracted.	This attribute does not apply to air quality.
*A5**	*Leadership/ Entrepreneurship*	*No*	*Actors with leadership capabilities help to organise their peers to pursue collective actions. The presence of highly educated people increases the likelihood of leadership capability in society.*	*This attribute is also associated with A7.*
*A6**	*Norms (trust-reciprocity)/ Social capital*	*No*	*Social and moral norms help to facilitate cooperation within society for achieving collective goals. Reciprocity refers to the cooperative response by members of society to the actions of their fellow citizens. In this process, trust plays a significant role in sustaining cooperation and reciprocation.*	*Higher levels of A6 are associated with successful collective action, hence, should be considered in the model. However, this variable is strongly connected to GS8. Hence, it is replaced with A6.*
*A7**	*Knowledge of SES/Mental models*	*Yes*	*Refers to the level of education across countries, a process within which actors learn about resources and their biophysical attributes and understand their dynamics. It affects the state of the resource system and better preservation.*	*Since A7 positively affect the state of the RS, a variable capable of capturing the level of education across countries must be included in the equation.*
A8*	Importance of resource (dependence)	No	The degree to which people's lives are dependent on the resource system, mainly financially (as a source of income) and culturally (as a source of values). This affects resource sustainability considerably.	No substantial variations across countries.
A9	*Technologies available*	*No*	*The degree to which technologies used in the extraction process are modern and widely available for people within society for the efficient use of resources.*	*Any change in this factor can be captured by S9 (technology), hence excluded from the analysis.*

Notes: This table represents the core of Actors. The coloured variable is directly included in the empirical model. Italicised variables are indirectly included through the inclusion of coloured ones. Regular black variables are excluded from the analysis. Variables marked by asterisks are among the variables upon which self-organisation is dependent.

Focal Action Situations: Interactions (I) and Outcomes (O)

The focal action situation is comprised of two parts of interactions and outcome. So far, 10 interactions have been observed in the SES framework and produce three types of outcomes: ecological, social and externalities to other SES.

Among all types of interactions, only self-organising activities *(I7)* are studied in this research, since *I7* is mentioned as the most important interaction in the social-ecological context (Ostrom, 2009). The rest of the interactions are excluded from this study because each interaction demands its own specific combination of second-tier variables that may be different from the ones that have already been selected for this study. Therefore, if another interaction is added, then extra variables that are effective enough in the process of this type of interaction and outcome, should also be added to the analysis. However, due to the existing limitations in the empirical specification, the inclusion of extra variables decreases the reliability of estimations. Consequently, only self-organising activities *(I7)* are considered within this study.

Table 2.A6. Definitions and explanations for included/excluded FAS (I)'s variables

Code	Variables	Y/N?	Definition	Reason for Inclusion/Exclusion
I1	Harvesting	No	Refers to the harvesting/withdrawing level of diverse actors at multiple levels.	Such interaction is not considered within this study.
I2	Information sharing	No	It is an important interaction as it facilitates the learning process. Any tools that help to share and distribute information among diverse actors contribute positively to outcomes.	Same as above
I3	Deliberation processes	No	The degree to which a governance system is less centric, the more likely the deliberation processes take place among actors. More negotiation generally results in fewer conflicts.	Same as above
I4	Conflicts	No	Conflicts among actors occur due to the lack of communication among them, appropriate laws and external authorities for practising monitoring and sanctioning processes.	Same as above
I5	Investment activities	No	Any type of investment leading to physical and social capitals that improves the status quo of a place is included here.	Same as above
I6	Lobbying activities	No	Depending on the governance system/type of the regime, the possibility of taking lobbying activates by diverse actors may affect the system either positively or negatively.	Same as above

I7	*Self-organising activities*	*Yes*	*Refers to actors who invest their time and energy in conserving the environment. It depends on 10 second-tier variables (marked with asterisks), which can be mainly divided into three parts: formal and informal institutions and resource's attributes.*	*Out of 10 variables, only three of them (RS5, GS6, A7) directly, and another four of them (RS7, A1, A5, A6) indirectly, and through their strong links to other selected variables are included in the model.*
I8	Networking activities	No	Actors' networking with each other and different types of organisations result in better mutual understandings and higher levels of trust, generating positive outcomes.	Such interaction is not considered within this study.
I9	Monitoring activities	No	Refers to rules and activities designated for monitoring diverse actor's behaviours to oblige them following the rules, leading to lowering deregulated harvesting level and conflicts.	Same as above
I10	Evaluative activities	No	Refers to the feedbacks from the current operated SES that received at later times, which can be used as criteria for evaluating and improving the system.	Same as above

Notes: This table represents Interactions' variables. Only the coloured one is of interest in this study.

Furthermore, in this study, only environmental outcomes *(O2)* are of interest; thus, the rest of the variables are excluded accordingly.

Table 2.A7. Definitions and explanations for included/excluded FAS (O)'s variables

Code	Variables	Y/N?	Definition	Reason for Inclusion/Exclusion
O1	Social performance measure	No	Includes indicators for measuring the social aspect of development.	Such an outcome is not considered within this study.
O2	*Ecological performance measures*	*Yes*	*Includes indicators for measuring the environmental aspect of development.*	*Ecological performance in this study is examined mainly through air quality across countries.*
O3	Externalities to other SES	No	Includes indicators that take account of any externalities that the studied SES might result in other systems, and not the outcome of the studied SES directly.	Such an outcome is not considered within this study.

Notes: This table represents the Outcomes of Focal Action Situation. Only the coloured variable is of interest in this study.

Related Ecosystems (ECO)

The social-ecological systems are inter-linked, within which the sustainability or destruction of one ecosystem may affect the other ones. The category of related ecosystems also highlights three important interlinkages (as depicted in Table 2.A8). As this research focuses on an encompassing resource system that directly affects a number of ecosystems and species, the *ECO3* is irrelevant, while *ECO1* and *ECO2* capture, to some extent, the same thing as what *O2* measures. Therefore, these flows will not be considered in this study.

Table 2.A8. Definitions and explanations for included/excluded ECO's variables

Code	Variables by Categories	Y/N?	Definition	Reason for Inclusion/Exclusion
ECO1	*Climate patterns*	*No*	*Intensive GHGs concentration contributes to global warming, which in turn leads to climate change.*	*As the focus of this study is on the atmospheric disruptions, ECO1 and O2 capture the same thing.*
ECO2	*Pollution patterns*	*No*	*Consistent pollution in a specific area and point of time resulting from the other pollution.*	*As the studied RS and O2 measure air pollution, they are roughly correlated with this variable.*
ECO3	Flows into and out of focal SES	No	Studied SES might affect/be affected by other SES, leading to positive/ negative in/outflows.	Irrelevant to this study.

Notes: This table represents the related Ecosystems' variables. Italicised ones are indirectly included. Regular variable is excluded from the analysis.

Appendix II

Carbon Footprint per capita

The *carbon footprint per capita* is adopted from the 2018 edition of Global Footprint Network, covering the period of 1961-2014. The footprint of carbon dioxide emissions is sourced from the International Energy Agency (IEA) and the United Nation (UN) datasets. It is calculated based on several factors: *(1)* domestic fossil fuel combustion; *(2)* electricity; *(3)* embodied carbon in traded goods and services; *(4)* a country's share of international transport emissions from aviation and marine bunker fuels; *(5)* fugitive emissions from oil and gas flaring; and *(6)* cement production and other non-fossil fuel industrial processes.

Theses six factors make up the total amount of carbon dioxide emissions for each country and is expressed in tonnes of emissions. It is then converted into global hectares based on the footprint intensity of carbon. This conversion factor[210] is derived from the following parameters:

1. The amount of carbon dioxide emissions absorbed by oceans.
2. The yield of the productive land area (forestlands) to absorb the carbon dioxide emissions.
3. The equivalence factor for carbon as a land type.
4. An adjustment factor for temporal changes in yield from the forest.

Accordingly, the *carbon footprint* measures the required amount of biocapacity (the area of forestland) to avoid the accumulation of carbon waste in the atmosphere, beyond what the oceans have already absorbed.

Forest Biocapacity per capita

Forestland provides two services. One is related to its product footprint, including lumber, pulp, timber products and fuelwood consumed by a country annually. The other one is related to its biocapacity for absorbing the carbon footprint: carbon dioxide emitted from burning fossil fuels. Therefore, the *carbon footprint* component of the ecological footprint is calculated as the

[210] To see how conversion parameters work for turning national hectares into a globally comparable standardised hectare, please see the construction of *forest biocapacity*.

amount of forestland needed to remove these carbon dioxide emissions. The calculation of biocapacity for a single land type (e.g., forests), uses data on area, yield factors and equivalence factors, and follows the below equation:

$$BC = A * YF * IYF * EQF$$

Where:

- BC = Biocapacity of a given land type (gha)
- A = Area of a given land type within a country (nha)
- YF = The yield factor[211] of a given land type within a country (wha nha^{-1})
- IYF = Intertemporal yield factor for a given land type for that year (No units)
- EQF = The equivalence factor[212] for a given land type (gha wha^{-1})

The output of the above equation is then divided by the total population of a country to result in *carbon footprint per capita* and *forest biocapacity per capita*. For further details on the construction of each of the above parameters, please see the NFA Guidebook (2018) (Lin et al., 2018).

Political Constraints Index V

The POLCON dataset (2017 edition) contains 90 variables (including country identifiers) for 157 countries between 1960 and 2016. It contains various features of the legislative, executive and judicial branches of government. The central variables (*political constraints index III* and *index V*) are indices that seek to estimate the degree of political constraints.[213] The index is a narrow measure of political institutions and should not be used as a measurement for democracy or good governance. The measure of *political constraints index V* uses the following methodology:

1. Initially, it identifies the number of independent branches of government with veto power over policy change (executive, lower and upper house in the legislative

[211] Yield factors reflect the relative productivity of national and world average hectares of a given land type. In other words, the productivity of a given land type is different across countries, and the yield factor accounts for such differences. Each country, in each year, has a unique yield factor for each land type.

[212] Equivalence factors reflect the relative productivity of world average hectares of different land types. They are the same for all countries and change slightly from year to year. It is 1.28 for both carbon and forestland.

[213] *Political constraints index III* follows the same logic as the *index V* but with only one difference. It does not include two veto points of the judiciary and sub-federal entities.

chambers, judiciary and sub-federal entities). The presence of more effective branches of government (i.e., independent actors with veto power) leads to a greater level of constraints.

2. It is assumed that the preferences of each of these branches and the status quo policy are independently and identically drawn from a uniform unidimensional policy space. This assumption allows for the derivation of a quantitative measure of institutional constraints using a simple spatial model of political interaction.
3. The initial measure is then modified to consider the extent of alignment across branches. It is measured as the extent to which the same party or coalition of parties control each branch (executive and legislature). If, for instance, the legislature is aligned entirely with or completely independent from the executive, the measure of constraints will be affected. The higher the alignment, the lower the level of constraints, and thus the higher the feasibility of policy change.
4. This measure is then further modified to capture the extent of preference heterogeneity within each legislative branch. It is measured as legislative fractionalisation in the relevant house. The higher the fractionalisation (i.e., within-branch heterogeneity), the higher (lower) the costs of overturning a policy is for aligned (opposed) branches.
   - Aligned legislatures with large homogeneous majorities are less costly to manage and control than aligned legislatures with precarious majorities that are highly heterogeneous and/or polarised.
   - In these cases, the party composition of the other branches of government is also relevant to the level of constraints.
   - For example, if the party controlling the executive enjoys a majority in the legislature, the level of constraints is negatively correlated with the magnitude and concentration of that majority.
   - By contrast, when the executive is faced with an opposition legislature, the level of constraints is positively correlated with the magnitude and concentration of the legislative majority.
   - A heavily fractionalised opposition with a precarious majority may provide the executive with a lower level of constraints due to the difficulty in forming a cohesive legislative opposition bloc to any given policy.

- Therefore, valuable information on the preferences of various actors (i.e., the extent of alignment across and within branches) can affect the extent of political constraints.

5. The final measure of *political constraints*, then, ranges from zero (the most hazardous) to one (the most constrained). Note that this measure of *political constraints* is based solely on the number of de jure veto points in a given polity.[214]

Combined Polity Score

The Polity IV dataset (2018 edition) provides data on the combined *polity score* for 167 countries over the years 1800-2017. The unified *polity score* ranges from -10 (full autocracy) to $+10$ (full democracy). It is computed simply by subtracting the *autocracy* value from the *democracy* value. These two are the annual measures of institutionalised *democracy* and *autocracy*. They are composite indices derived from the coded values of authority characteristic component variables.

In fact, the *polity* scheme consists of six components, measuring: *(1)* three key qualities of executive recruitment (regulation of chief executives; competitiveness of executive recruitment and openness of executive recruitment); *(2)* constraints on executive authority; and *(3)* two aspects of political competition (regulation of participation and the competitiveness of participation). These six components are used to measure and distinguish autocratic regimes from democratic ones, which are described below.

Institutionalised democracy is an additive 11-point indicator $(0-10)$ and conceived as three essential, interdependent elements. The first is the presence of institutions and procedures through which citizens can express effective preferences about alternative policies and leaders. The second is the existence of institutionalised constraints on the exercise of power by the executive. The third is the guarantee of civil liberties to all citizens in their daily lives and acts of political participation. Hence, the operational indicator of *democracy* is derived from the coding of four categories: the competitiveness of political participation; the openness of executive recruitment; the competitiveness of executive recruitment; and constraints on the chief executive.

[214] See (Henisz, 2015) and Henisz and Zelner (2005) for further details.

Institutionalised autocracy is an additive 11-point indicator $(0-10)$. Authoritarian regimes sharply restrict or suppress competitive political participation. Their chief executives are chosen in a regularised process of selection within the political elite, and, once in office, they exercise power with few institutional constraints. Most modern autocracies also exercise a high degree of directiveness over social and economic activity, but it can be regarded as a function of political ideology and choice, not a defining property of autocracy. Social democracies also exercise relatively high degrees of directiveness. Hence, the operational indicator of *autocracy* is derived from the same factors that have been used for constructing *democracy*; however, one more factor (regulation of participation) is added to the construction of this variable.[215]

The combined *polity score* is further modified, and in this study the revised version is used. The applied revisions are related to Standardized Authority Codes (-66, -77 and -88), which are respectively assigned to the periods of interruption, collapse and transition in the central authority. These codes that are reflected in the values of *polity*, *democracy*, and *autocracy scores* are treated differently in the *revised combined polity score*. In the case of transition (-88), values are prorated across the time-span. Also, the data are converted to neutral score 0 in the cases of interregnum (-77), and the cases of foreign interruption (-66) are treated as "system missing." For further details on sub-categories and the revisions made to the above three factors, see Marshall, Gurr, and Jaggers (2018).

Level of democracy

The variable, *level of democracy*, is a composite index based on the average of the three variables. Initially, the *polity score* from the Polity IV Project is transformed to a $0-10$ scale. Then, *political rights* and *civil liberties* from the Freedom House (FH) database are averaged into a single variable. The mean of the FH variables is then transformed into an 11-point scale $(0-10)$ variable, just like the *polity score*. Finally, the Polity IV and FH variables are averaged into the *level of democracy* index. The final variable is taken from the QoG dataset (January 2019 version).[216]

[215] The two variables of *institutionalized democracy* and *autocracy* do not have any categories in common, as different weights and sub-categories are used for the *autocracy* than *democracy* factors.

[216] For further details on the methodology of the index in the QoG dataset, see Teorell et al. (2019).

The Freedom House database divides countries into a 7-scale sub-category that falls under two categories of *political rights* and *civil liberties*.[217] FH uses a system of ratings, in which each country receives a rate between $1 - 7$, with 1 showing the highest degree of freedom and 7 is the smallest degree. Each country receives two ratings (one for *political rights* and one for *civil liberties*).

In the beginning, the broad category of *political rights* includes 10 indicators that assess a country in three areas: *(i)* electoral process (3); *(ii)* political pluralism and participation (4); and *(iii)* functioning of government (3). In each of the three areas, political rights is defined (in order) as an individual's ability to: *(i)* vote freely for distinct alternatives in legitimate elections; *(ii)* participate freely in the political process through competing for public office and joining political parties and organisations; and *(iii)* elect representatives who have a decisive impact on public policies and are accountable to them.

Subsequently, *civil liberties* includes 15 indicators that assess a country in four areas: *(i)* freedom of expression and belief (4); *(ii)* associational and organisational rights (3); *(iii)* the rule of law (4); and *(iv)* personal autonomy and individual rights (4). In each of the four areas, *civil liberties* is defined (in order) as an individual's ability to: *(i)* exercise freedoms of expression and belief; *(ii)* be able to assemble and associate freely; *(iii) h*ave access to an established and equitable system of the rule of law; and *(iv)* enjoy personal freedoms, including free movement, the right to hold private property, social freedoms and equal access to economic opportunities without interference from the state.

The distinction, then, is that *political rights* enable people to participate freely in the political process, and *civil liberties* allow for personal autonomy over political, social and economic freedoms. One significant aspect of FH is that it assesses the real-world rights and freedoms enjoyed by individuals, rather than governments or government performance per se. It means that FH does not believe that legal guarantees of rights are sufficient for on-the-ground fulfilment of those rights. While both laws and actual practices are factored into scoring decisions, greater emphasis is placed on implementation. For further details on the scoring and rating and the complete list of questions used in this process, see Freedom House (2018).

[217] These subcategories, which are drawn from the Universal Declaration of Human Rights in 1948, represent the fundamental components of freedom, irrespective of geographic location, ethnic or religious composition or level of economic development.

Law and Order

The 2017 edition of the ICRG dataset from Political Risk System (PRS) Group contains data on 12 political risk components for 146 countries[218] between 1984 and 2016. The minimum number of points that can be assigned to each component is zero, while the maximum number of points is either 6 or 12. In every case, the lower the risk point total, the higher the risk, and the higher the risk point total, the lower the risk. For further details on the full list of political risk components, see Howell (2015).

Although *law and order* is a single variable, its two elements (i.e., "law" and "order") are evaluated separately. Each of these elements is rated from 0 to 3. For instance, a given country in a single year receives a high score (e.g., 3 out of 3) in terms of its judicial system, but a very low rating (e.g., 1 out of 3) if the law is frequently ignored for political purposes without effective sanctions. They are then added together and form the final unified variable of *law and order* that ranges between 0 and 6. In this case, the total rating for the country in this *law and order* is 4.

Corruption

Like the above variable, *corruption* is one of the 12 components of political risk included in the ICRG dataset from the PRS group. Political corruption *(i)* reduces the efficiency of government and businesses by signalling to people that positions of power are given through patronage and nepotism (and not personal ability), hence leading to popular discontent. It further *(ii)* distorts the economic and financial environments by encouraging the development of a black market, and *(iii)* results in unrealistic and inefficient controls over the state economy, thus injecting instability into the political process.

As events in recent years have shown, political corruption can affect countries regardless of their stage of development (i.e., both rich and poor) and political system (i.e., democratic and non-democratic institutions). In countries with higher risks of corruption, for example, revealing a significant scandal provokes a backlash and results in the fall of a government (e.g., Japan), major reorganisation of the political institutions (e.g., Italy), or the collapse of authority and *law and order* (e.g., DR Congo, formerly known as Zaire). One common characteristic of

[218] The six countries are: Czechoslovakia, East Germany, West Germany, New Caledonia, Serbia and Montenegro. The USSR is excluded due to the political union/separation.

all three countries is that they had the same party or government in power for decades, implying that the years that a government has been continuously in power is one possible indicator of potential corruption.

On that basis, the highest risk ratings tend to signify an accountable democracy whose government has been in office for less than five years. An intermediate rating often indicates a country whose government has been in office for more than 10 years and where a large number of officials are appointed rather than elected. The lowest ratings are usually given to one-party states and autarchies. For further details, see Howell (2015).

Investment Profile

Investment profile contains three factors of contract viability/expropriation risk, profits repatriation and payment delays, each of which is assigned a maximum score of four points and a minimum score of zero. A score of 0 equates to “very high risk,” and the score of 4 equates to “very low risk.”

Government Stability

The $0 - 12$ risk ratings are the sum of risks assigned to three subcomponents, each with a maximum score of 4 points. A score of 4 equates to “very low risk” and a score of 0 indicates the opposite (i.e., “very high risk”). The subcomponents are government unity, legislative strength and popular support.

Freedom of the Press

Freedom House (2017 edition) provides information on *freedom of the press* for 199 countries and territories since 1980. *Freedom of the press* is the most comprehensive dataset available on global media freedom and serves as a key resource for policymakers, journalists and scholars worldwide.

The level of press freedom in each country and territory is evaluated based on 23 questions that are divided into three broad categories: legal, political and economic environments.[219] A country’s final score $(0 - 100)$ is computed by adding points allocated for each question in each of the three key components. For instance, the legal environment encompasses eight

[219] For seeing the full list of questions, within each area and the rating process, see Freedom House (2017).

questions, each of which is assigned a number (maximum 6 points), equating to a total of 30 points. Likewise, the political environment includes seven questions for a total of 40 points. The same applies for the economic environment, in which eight questions make up to 30 points out of 100. For each question, lower points are assigned to more free environments, while higher points are assigned to less free environments. A total score of 0 to 30 results in a press freedom status of "Free;" 31 to 60 results in a status of "Partly Free" and 61 to 100 indicates a status of "Not Free."

Total Factor Productivity Growth

The 2017 version of TED from the Conference Board is a comprehensive database with annual data covering 123 countries in the world. *TFP* takes into account not only labour as an input but also the contributions of physical, human and other intangible capital to the production of goods and services. It is not measured directly; instead, it is estimated as a residual after accounting for the contributions of all other factors of production to growth in output (i.e., by subtracting the sum of two-period average labour share weighted input growth rates – employment quantity and labour quality – from the output growth rate). For further details on estimations on *TFP growth*, see the TED methodology (de Vries & Erumban, 2017).

Appendix III

First-Stage Results: Colonial Origins

Table 4.A1 shows the first-stage results related to *political constraints*. In the first two models, the results indicate that, unlike other colonisers, Spanish colonial power matters in explaining current institutional development. While in the third model, it is shown that former French colonies have lower constraints on executives than colonies of British Empire.[220] These results are consistent with the works of Djankov and Reynal-Querol (2010) and La Porta et al. (1999), where they proposed that the efficacy of government is relatively higher in former colonies of British power than those of other colonisers, including the French. These findings further imply the persistency of institutional arrangements over time, meaning that once the institutions were founded in the colonies, the generated rules and norms from those institutions set constraints on future institutional changes (Tebaldi & Elmslie, 2013).

Furthermore, the results on *religious tensions* also show the relevancy of the constructed instrument to the current level of social tensions. As indicated in columns (2) and (3), *distance to conflict zones* is highly correlated with the measure of trust. A one-unit increase in the risk factor of a country would decrease the level of trust by around -2.5 units. The significant negative sign means that the higher risk of a country, resulting from being close to the conflict-prone zones and/or involved with internal/external violence, leads to the higher level of tensions and, thus, higher emissions. This result is consistent with the theory, based on which the instrument is built.

Table 4.A1. Model (1)'s first-stage and second-stage estimations using colonial origins

Panel A: Second-stage Results			
Carbon Footprint	(1)	(2)	(3)
Political Constraints Index V	-1.070***	-1.556***	-0.669**
	(0.340)	(0.441)	(0.263)
Religious Tensions		-0.383***	-0.287***
		(0.102)	(0.083)
PolCon*TnsRelig			0.596***
			(0.229)

[220] As shown in the first-stage results, one of the instruments for formal institutions (i.e., "Others") is dropped from the analysis. It is unavoidable, as the instruments here are constructed by the interaction of *colonial origins* with a time trend.

Obs.	1,730	1,730	1,730
R-squared	0.176	-0.397	-0.156
No of Countries	83	83	83
Control	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Panel B: First-stage Results			
Political Constraints Index V	(1)	(2)	(3)
Never Colonised * *t*	-0.005*	-0.006*	0.052***
	(0.003)	(0.003)	(0.018)
British * *t*	0.003	0.003	0.115***
	(0.003)	(0.003)	(0.024)
French * *t*	-0.000	-0.000	0.092***
	(0.004)	(0.004)	(0.034)
Spanish * *t*	-0.010***	-0.010***	-0.012
	(0.004)	(0.004)	(0.023)
Others * *t*	-	-	-
Religious Tensions			
Distance to Conflict Zones		-2.708***	-2.479**
		(0.813)	(1.068)
Interaction: PolCon*TnsRelig			
Distance to Conflict Zones * Never Colonised * *t*			0.094***
			(0.014)
Distance to Conflict Zones * British * *t*			-0.183***
			(0.069)
Distance to Conflict Zones * French * *t*			-0.108
			(0.100)
Distance to Conflict Zones * Spanish * *t*			-0.082**
			(0.032)
Distance to Conflict Zones * Others * *t*			0.015
			(0.046)
Panel C: Identification Tests			
	(1)	(2)	(3)
Cragg-Donald Wald F Statistic	17.24	11.13	6.39
Kleibergen-Paap rk Wald F Statistic	11.21	8.12	8.10

Stock-Yogo weak ID test critical values			
Maximal IV bias	16.85 (5%)	8.78 (10%)	5.83 (20%)
Maximal IV size	13.96 (15%)	11.22 (15%)	-
No. of Endogenous Regressors (K1)	1	2	3
No. of Excluded Instruments (L1)	4	5	10

Notes: Dependent variable is *carbon footprint per capita*. Independent variables representing formal and informal institutions are *political constraints index V* $(0-1)$ and *religious tensions* $(0-6)$. Higher values (in parenthesis) indicate stronger formal and informal institutions. *PolCon*TnsRelig* is the interaction of *political constraints index V* and *religious tensions.* Panel A shows the second-stage results. Column (1)-(3) reports estimations from fixed-effects IV regressions of the dependent variable against each of the institutional variables, using command *xtivreg2* in Stata. Control variables are included in regressions. Panel B shows the corresponding first-stage results. Initially, column (1)-(3) reports estimations of *political constraints index V* instrumented by *trend of colonial origins* (i.e., dummies on colonial origins interacted with time). The variable *Others* (i.e., other colonial powers) is omitted. Next, column (1)-(2) reports estimations of *religious tensions* instrumented by *distance to conflict zones*. Further, column (3) reports estimations of *PolCon*TnsRelig* instrumented by the product of *trend of colonial origins* and *distance to conflict zones*. Panel C shows the identification tests. *Cragg-Donald Wald F Statistic* meets the *Stock-Yogo weak ID test* critical values. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01*, ** *p<0.05*, * *p<0.1*.

New Formal Institutions' IV: Legal Origins

The variable *legal origins* was first constructed by La Porta et al. (1999), and the data is adopted from QoG. It is a set of five dummy variables, including English common law, French civil law, socialist law, and German and Scandinavian commercial codes. The variable for French civil law receives 1 for countries that have been mainly affected by the legal system of France, and 0 otherwise. Table 4.A2 shows the robustness test of the results obtained on the main model (M1) to the use of *legal origins* instead of *colonial origins* as the instrument.

Table 4.A2. Model (1)'s first-stage and second-stage estimations using legal origins

Panel A: Second-stage Results			
Carbon Footprint	(1)	(2)	(3)
Political Constraints Index V	-2.024** (0.894)	-1.712** (0.824)	-1.729*** (0.500)
Religious Tensions		Yes	Yes
PolCon*TnsRelig			Yes

	(1)	(2)	(3)
Obs.	1467	1467	1467
R-squared	-0.170	-0.098	-0.081
No of Countries	68	68	68
Control	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Panel B: First-stage Results			
Political Constraints Index V	(1)	(2)	(3)
English Common Law * *t*	0.005***	0.005***	0.093***
	(0.001)	(0.002)	(0.017)
French Civil Law * *t*	0.001	-0.000	0.060***
	(0.001)	(0.002)	(0.016)
Communist Law * *t*	0.003	0.003	0.24***
	(0.004)	(0.004)	(0.021)
German Commercial Code * *t*	0.001	0.001	0.070***
	(0.001)	(0.001)	(0.014)
Scandinavian Commercial Code * *t*	-	-	-
Distance to Conflict Zones		Yes	Yes
Distance to Conflict Zones * Legal Origins* *t*			Yes

Notes: Dependent variable is *carbon footprint per capita*. Independent variables representing formal and informal institutions are *political constraints index V* $(0-1)$ and *religious tensions* $(0-6)$. Higher values (in parenthesis) indicate stronger formal and informal institutions. *PolCon*TnsRelig* is the interaction of *political constraints index V* and *religious tensions.* Panel A shows the second-stage results. Column (1)-(3) reports estimations from fixed-effects IV regressions of the dependent variable against each of the institutional variables, using command *xtivreg2* in Stata. Control variables are included in regressions. Panel B shows the corresponding first-stage results. Column (1)-(3) reports estimations of *political constraints index V* instrumented by *trend of legal origins* (i.e., dummies on legal origins interacted with time). The variable *Scandinavian Commercial Code* is omitted. *Religious tensions* is instrumented by *distance to conflict zones*. *PolCon*TnsRelig* is instrumented by the product of *trend of legal origins* and *distance to conflict zones*. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

In Table 4.A2, both the first- and second-stage results are reported. As can be seen, *political constraints* is negatively correlated with the environmental indicator across three estimations. This is consistent with the findings of Model (1). The first-stage results also show that, unlike other legal systems, the British common law consistently affects the efficacy of political institutions. This might be due to the relatively higher political freedom in common law countries than countries with civil and socialist laws (La Porta et al., 1999). The findings on other legal systems are consistent with the mentioned study. For instance, the authors expect that in terms of government efficiency, countries with German laws perform as high as common law countries, while civil law countries are intermediate. Socialist law countries are also expected to do well with respect to public goods provision.

Cross-Sectional Analysis

To test the validity of the IVs used for instrumenting formal institutions *(trend of colonial origins)*, and check the robustness of the results reported in Table (4.1), (4.5) and (4.7), I performed a cross-sectional two-stage least squares (2SLS) analysis. Here, I ignored the time dimension and used *colonial origins* as the instrument for formal institutions. The following table (Table 4.A3) contains the results of the IV-2SLS estimations for the first three models (M1-3) across two years of 1995 and 2010.

As indicated, Table 4.A3 consists of nine columns. The three columns of (1), (4) and (7) show the effects of formal political institutions only. So, the results of these columns can be compared with the results of Table (4.1). The next three columns ((2), (5), and (7)) contain the results of the models with both formal and informal institutions, so they should be compared with Table (4.5). The last three columns ((3), (6), and (9)) report estimations with the interaction of institutions. These results correspond to the ones reported in Table (4.7). Overall, as can be seen from Table 4.A3, the IV-2SLS results on formal political institutions show a significant negative correlation with the dependent variable *(carbon footprint per capita)* both in 1995 and 2010. It means that better formal institutions, consistent with current literature, are in line with lower environmental degradations. These results remain consistent even when I include informal institutions and the interactive terms in the model. Therefore, Table 4.A3 can confirm the findings of the research (obtained with FE-IV estimations) on formal institutions.

Table 4.A3. Robustness tests on formal institutions (IV-2SLS estimations)

	Model (1)			Model (2)			Model (3)		
	IV-2SLS			IV-2SLS			IV-2SLS		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
YEAR	1995			1995			1995		
Political Constraints Index V	-2.404	-2.91*	-2.607*						
	(1.571)	(1.579)	(1.398)						
Level of Democracy				-.258	-.434**	-.396**			
				(.174)	(.205)	(.192)			
Combined Polity Score							-.109*	-.152**	-.148**
							(.063)	(.065)	(.07)
Religious Tensions		Yes	Yes		Yes	Yes		Yes	Yes
Interactions			Yes			Yes			Yes
_cons	-11.763***	-8.646***	-9.499***	-11.069***	-5.971	-7.892*	-11.93***	-8.156**	-7.888**
	(3.166)	(3.133)	(3.194)	(3.452)	(4.079)	(4.234)	(2.997)	(3.184)	(3.731)
Obs.	71	71	71	71	71	71	70	70	70
R-squared	.737	.733	.714	.749	.716	.61	.749	.73	.578
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

YEAR	2010			2010			2010		
Political Constraints Index V	-1.57	-2.354*	-2.648						
	(1.13)	(1.33)	(1.993)						
Level of Democracy				-.538***	-.502***	-.79**			
				(.209)	(.193)	(.33)			
Combined Polity Score							-.244***	-.24***	-.317**
							(.08)	(.074)	(.131)
Religious Tensions		Yes	Yes		Yes	Yes		Yes	Yes
Interactions			Yes			Yes			Yes
_cons	-12.543***	-11.089***	-11.196***	-5.567	-5.66	-1.877	-7.241**	-6.837**	-6.538**
	(2.234)	(2.391)	(1.984)	(3.81)	(3.651)	(4.71)	(2.856)	(2.743)	(3.022)
Obs.	82	82	82	83	83	83	82	82	82
R-squared	.756	.723	.735	.761	.751	.704	.766	.753	.725
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(9)). Independent variables representing formal political institutions are *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$. Higher values (in parenthesis) indicate stronger formal institutions. *Religious tensions* $(0-6)$ represents informal institutions. Higher values show higher levels of trust (i.e., better informal institutions). *Interactions* represent three interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, and *Polity*TnsRelig*. Control variables are included in all regression models (column (1)-(9)). Model (1)-(3) reports two-stage least squares (2SLS) estimations of the dependent variable against each of the institutional variables across two years of 1995 and 2010, using command *ivreg2* in Stata. Model (1) reports coefficients of *political constraints index V*, using *colonial origins* as an instrument. Model (2) reports coefficients of *level of democracy*, using *colonial origins* as an instrument. Model (3) reports coefficients of *combined polity score*, using *colonial origins* as an instrument. *Religious tensions* is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *colonial origins* and *distance to conflict zones*) is used for instrumenting *interactions*. Each of the three models reports IV-2SLS estimations: *(i)* formal institutions only (shown in column (1)/(4)/(7)), *(ii)* formal and informal institutions (shown in column (2)/(5)/(8)), and *(iii)* formal and informal institutions with interaction (shown in column (3)/(6)/(9)). All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

To further check the validity of the formal institutions' IV, I have also performed another test as one may be concerned about the violation of exogeneity assumption. Since countries today allocate more foreign aid to their former colonies, which can further affect their GDP, trade, migration, etc.[221] While it is a concern for almost all studies that use such IVs for their measures of institutions, to address this issue here, formal institutions are considered exogenous this time. When I ignored the presence of endogeneity in formal institutions and performed fixed-effects panel analysis (OLS-FE),[222] the results on formal political institutions showed quite the opposite direction (i.e., positive). When I added the endogenous informal institutions to the model and estimated the regressions with the main econometric technique (FE-IV), these results remained consistent.[223] Consequently, FE analysis is not an appropriate approach for analysing the effects of institutions, and hence *trend of colonial origins* have enough predictive power to solve the endogeneity of formal institutions.

Internal and External Conflicts

The ICRG system evaluates countries' political, financial and economic risk levels and assigns risk assessments (ratings) to each country in different areas. Two areas of the political risk components are *internal* and *external conflicts*, each of which is scaled on a 13-point spectrum.

The variable of *internal conflict* evaluates political violence in the country and its impact on governance. It is constructed based on three subcomponents: civil war and coup threats; terrorism and political violence; and civil disorders. In countries where the government is not directly/indirectly involved in any armed conflict and arbitrary violence against its own people, the highest rating is given ($\cong 12$). The lowest rating is also given to a country that is involved in an on-going civil war ($\cong 0$). The score changes based on whether: *(i)* the civil conflict is nationwide (or restricted to a specific region); *(ii)* the violent actions are irregular (or sustained) or carried out for a purpose like terrorism; *(iii)* the opposition groups are small (i.e., few individuals with little/no support) or well-organised; and *(iv)* the threat involves only the government (or businesses) or both.

[221] This issue is further examined in the section on the mis-specified model. So, the table of results is not reported here.

[222] FE can take account of the endogeneity to some extent, as it can capture the time-invariant unobservable factors.

[223] Formal institutions were still positive, while informal institutions indicated the expected negative correlation with the dependent variable.

The variable of *external conflict* assesses the risks to the incumbent government. It is composed of three subcomponents: war; cross-border conflict; and foreign pressures. These criteria can be classified into two categories: violent and non-violent external pressure from foreign actors.[224] Diplomatic pressures, trade restrictions, sanctions and geographical disputes are examples of non-violent pressures; cross-border armed conflicts, foreign-supported insurgency and full-scale warfare are examples of violent pressures. External conflicts can also affect the economy, in particular business and investment, adversely. Distortions in the allocation of resources, the imposition of restrictions and sanctions on operations, trade and investment are a few of the many downsides of the conflicts.

For further details on the political risks, please see the ICRG codebook (Howell, 2015).

New Informal Institutions' IV

To test the sensitivity of the results obtained on informal institutions (Table 4.5), for which *distance to conflict zones* is used as the IV, I have constructed two new variables based on the ICRG data on conflicts and used them as new instruments for *religious tensions*.

The first instrument is based on *internal conflict*, which is then weighted by the inverse distance (exactly the same as what I did in Equation 4.5).[225] However, the only difference here is that *external conflict* is excluded from the construction of this IV. The underlying idea for constructing this instrument is that most of the effects of conflict on migration flows will be from within-nation conflict, not the external one, therefore, excluded. This will, in turn, make neighbouring countries more vulnerable to social tensions. This new instrument is called $internal\ risk\ factor$ of country i.[226]

The second instrument is constructed purely based on *external conflict*. This variable is already exogenous, because it considers incidents that happen outside of the home country, so it is not required to be weighted by the distance. The idea for making this instrument is to avoid some double counting that might have been caused by the current procedure for constructing the

[224] Foreign action includes threats imposed by a single/group of countries or the whole international community.

[225] To avoid violating the exogeneity assumption, *internal conflict* is required to be weighted by the inverse distance. Otherwise, it would be endogenous and self-driven, capable of affecting the environmental quality of the home country directly.

[226] *Distance to conflict zones* is actually showing $total\ risk\ factor$ of country i. However, since *external conflict* is excluded here, this new instrument is called $internal\ risk\ factor$.

initial instrument (i.e., *distance to conflict zones*).[227] This new instrument is called $external\ conflict\ risk$ of country i. Table 4.A4 compares the results of informal institutions, which are instrumented additionally by the two new IVs:

Table 4.A4. Sensitivity analysis on informal institutions (IV estimations)

	Total Risk Factor	**Internal Risk Factor**	**External Conflict Risk**
	Model (1)	Model (2)	Model (3)
	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)
Religious Tensions	-.971**	-.526*	-.537***
	(.434)	(.289)	(.19)
Obs.	1739	1739	1739
R-squared	-1.945	-.325	-.353
No. of Countries	83	83	83
Control	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes
Country FE	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in column (1)-(3). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Variables representing formal institutions are excluded from all models. Control variables are included in all models. All three models reports estimations of the dependent variable against *religious tensions* only, using three different instrumental variables. Model (1)-(3) reports estimations of *religious tensions* that is instrumented by (1) *distance to conflict zones*, (2) *internal risk factor*, and (3) *external conflict risk*. All regressions are estimated with fixed-effects IV regressions, using command *xtivreg2* in Stata. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The table above contains three models, in which informal institutions is instrumented by three different IVs. In Model (2) and (3), *religious tensions* is instrumented by the new IVs, *internal risk factor* and *external conflict risk*, that are substituted the original instrument, *total risk factor*, in Model (1), so that the robustness of the first model can be further examined. As shown in Table 4.A4, the estimations are quite consistent across three models, indicating that informal institutions is negatively correlated with *carbon footprint per capita*. To have a better understanding of the consistency of estimations across the three IVs, I then replicated the regression results reported in Table 4.5 with the two new IVs.

[227] As *external conflict* is already measuring the impact of cross-border conflicts and foreign pressures.

Table 4.A5. Robustness tests on informal institutions (IV estimations)

	Panel (A): Internal Risk Factor						Panel (B): External Conflict Risk					
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Religious Tensions	-.351***	-.284***	-.295***	-.434***	-.333***	-.294***	-.341***	-.311***	-.311***	-.253***	-.337***	-.31***
	(.099)	(.076)	(.074)	(.148)	(.093)	(.074)	(.084)	(.069)	(.069)	(.075)	(.111)	(.068)
Political Constraints Index	-1.462***						-1.421***					
	(.422)						(.433)					
Level of Democracy		.048						.022				
		(.054)						(.056)				
Combined Polity Score			-.018						-.018			
			(.023)						(.023)			
Law & Order				-.694***						-.435***		
				(.244)						(.116)		
Corruption					-.17						-.797**	
					(.143)						(.313)	
Investment Profile						-.005						-.002
						(.028)						(.028)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Obs.	1730	1739	1717	1739	1739	1739	1730	1739	1717	1739	1739	1739
R-squared	-.295	.158	.135	-.989	.043	.144	-.262	.122	.11	-.129	-1.153	.121
No of Countries	83	83	82	83	83	83	83	83	82	83	83	83
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(12)). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Control variables are included in all models. Column (1)-(12) reports estimations of the dependent variable against each of the institutional variables. Panel A reports estimations of model (1)-(6) in which *religious tensions* is instrumented by *internal risk factor* (column (1)-(6)). Panel B reports estimations of model (1)-(6) in which *religious tensions* is instrumented by *external conflict risk* (column (7)-(12)). All variables on formal institutions are instrumented by *trend of colonial origins*. All models in each panel are estimated with fixed-effects IV regressions, using command *xtivreg2* in Stata. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01, *** *p<0.05, ** *p<0.1*.

As illustrated in Table 4.A5, the results on *religious tensions* are quite consistent across the two different IVs. Also, the estimations, in terms of sign, significance and even magnitude of the coefficients, are quite comparable with Table 4.5. The presented results in both tables seem to confirm that, no matter what instruments I use for informal institutions, its effects on *carbon footprint per capita* are strongly robust and negative. The same level of consistency is also observed on formal institutions across two mentioned tables (i.e., Table 4.5 and Table 4.A5).

The Mis-specified and Lagged Models: Bad Control Problem

As mentioned in Study 3 of Chapter 4, one may argue that all the regressions presented in this research suffer from the classic bad control problem, in which control variables are themselves outcomes of the variable(s) of interest. This is a concern as, on the one hand, institutions are underlying factors that can affect almost everything. However, on the other hand, if it is the case, then institutions should not be taken as the main independent variables along with other covariates in any study. While there are several studies, including Fredriksson & Neumayer (2013) and Carattini et al. (2015), where both formal and informal institutions are employed as the main regressors along with other covariates like *GDP per capita*.

Also, as thoroughly discussed in Chapter 2, the process of selecting variables in this research is totally based on the employed theoretical framework. For instance, according to the SES framework, large-N cross-country studies like the present research need to take account of variables in the broad settings (which includes economic development, demographic trend, etc.). However, to address this issue in data, I have run the mis-specified model, where all control variables are excluded from the regressions. Moreover, as a further check, I have also run models, where all control variables are lagged, as institutions today cannot affect previous outcomes. The results of both tests are provided in Table 4.A6 and 4.A7.

As can be seen in Table 4.A6, *religious tensions* is negatively affecting the dependent variable across all models. This negative connection also holds for formal institutions. Further, interactions are positive, showing the substitutionary effects of both types of institutions, as documented before. Overall, table 4.A6 shows that, in the absence of all control variables, institutions are still negatively associated with *carbon footprint per capita*. These results, which are in line with previous estimations shown in Table 4.7-4.8,[228] can further mitigate the exogeneity concern, through which institutional IVs are posited to be correlated with controls.

Note that a different set of instruments have been used for the mis-specified model than in Table 4.7-4.8.[229] This is because the new set of IVs produce relatively higher F-statistics

[228] The same mis-specified regressions are also estimated for models with only formal institutions, only informal institutions, and formal and informal institutions. The results are consistent with the below findings.

[229] In Study 1, 2 and 3 of Chapter 4, the estimations on formal and informal institutions use *trend of colonial origins* and *distance to conflict zones (total risk factor)* as the original set of instruments. However, here I have additionally used *the trend of legal origins* for instrumenting formal institutions. Also, the informal institutions' IV is broken into its constituents. Now, two IVs of *internal risk factor* and *external risk* are used for instrumenting informal institutions.

(shown in the last row of the below table) compared to the original ones. This would, in turn, reduce the bias in the second-stage results.

Table 4.A6. Mis-specified model (IV estimations)

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-.075*	-.02	-.023	-.073**	-.071*	-.076*
	(.043)	(.039)	(.039)	(.035)	(.04)	(.04)
Political Constraints Index V	-.561***					
	(.157)					
PolCon*TnsRelig	.14					
	(.126)					
Level of Democracy		-.084***				
		(.027)				
Democ*TnsRelig		.023*				
		(.012)				
Combined Polity Score			-.033***			
			(.011)			
Polity*TnsRelig			.008			
			(.006)			
Law & Order				.001		
				(.033)		
LawOrd*TnsRelig				.002		
				(.027)		
Corruption					.017	
					(.037)	
Corr*TnsRelig					.004	
					(.022)	
Investment Profile						-.037**
						(.016)
Invest*TnsRelig						-.008
						(.013)
Obs.	2350	2352	2286	2352	2352	2352
R-squared	-.049	-.039	-.014	-.037	.021	-.017
No. of Countries	95	95	93	95	95	95
Cragg-Donald F Statistic	6.17	6.50	6.68	5.98	6.36	7.41
Control	No	No	No	No	No	No

Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(6)). Independent variable representing informal institutions is *religious tensions* $(0 - 6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0 - 1)$, *level of democracy* $(0 - 10)$, and *combined polity score* $(-10 - +10)$ for political institutions; *law and order* $(0 - 6)$ and *corruption* $(0 - 6)$ for legal institutions; *investment profile* $(0 - 12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions.* Model (1)-(6) reports mis-specified estimations of the dependent variable against each of the institutional variables, excluding all control variables. All six models are estimated with fixed-effects IV regressions, using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins* and *trend of legal origins*. Likewise, the variable on informal institutions is instrumented by *internal risk factor and external risk*. The product of instrumental variables is used for instrumenting interactive terms. All regressions are performed on the sample of all countries. The critical values of *Cragg-Donald F Statistic* all meet the Stock-Yogo thresholds. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

To provide further robustness checks on the issue of bad control problem, I have analysed models with lagged control variables. In these models, I have taken the first lag of all control variables and used them along with the level institutional measures. The reason for that is current year institutional qualities cannot affect the previous year's socio-economic outcomes. Hence, it can further clarify the said problem. Table 4.A7 contains the results of these models. As illustrated in the table below, the results on formal, informal and the interactions of institutions are quite consistent in terms of the direction, the statistical significance and even the magnitude of coefficients with the ones reported in Table 4.7-4.8. Also, similar to the mis-specified model, the robustness of estimations are also tested across models with only formal institutions as in Study 1, and models with both formal and informal institutions as in Study 2. The findings here are consistent with the ones presented in Study 1 and 2.

Table 4.A7. Lagged control variables (IV estimations)

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-.285***	-.275***	-.346***	-.278***	-.319***	-.152**
	(.081)	(.081)	(.088)	(.091)	(.074)	(.065)
Political Constraints Index V	-.37*					
	(.219)					
PolCon*TnsRelig	.524**					
	(.206)					

Level of Democracy		-.07				
		(.064)				
Democ*TnsRelig		.073***				
		(.021)				
Combined Polity Score			-.022			
			(.026)			
Polity*TnsRelig			.035***			
			(.011)			
Law & Order				-.513***		
				(.117)		
LawOrd*TnsRelig				.059		
				(.042)		
Corruption					-.083	
					(.083)	
Corr*TnsRelig					.094***	
					(.03)	
Investment Profile						-.011
						(.022)
Invest*TnsRelig						.059***
						(.015)
Observations	1650	1661	1640	1661	1661	1661
R-squared	-.053	-.137	-.234	-.304	.015	.205
No. of Countries	83	83	82	83	83	83
Control (Lagged)	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(6)). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions.* Model (1)-(6) reports estimations of the dependent variable against each of the institutional variables, taking the first lag of all control variables. All six models are estimated with fixed-effects IV regressions, using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

List of All Countries

Below, a list of countries used in the empirical analysis is provided. It is called the base sample or sample of all countries (AC) in all studies above. Out of the listed ones above, 15 countries are dropped from the IV analysis, due to the presence of singletons:

Table 4.A8. The sample of all countries (AC)

			Country				
1	Albania	26	Ecuador	51	Lithuania	76	Slovak Rep.
2	Algeria	27	Estonia	52	Luxembourg	77	Slovenia
3	Angola	28	Ethiopia	53	Malaysia	78	South Africa
4	Argentina	29	Finland	54	Malta	79	Spain
5	Armenia	30	France	55	Mexico	80	Sri Lanka
6	Australia	31	Germany	56	Moldova	81	Sudan
7	Austria	32	Ghana	57	Morocco	82	Sweden
8	Bahrain	33	Greece	58	Mozambique	83	Switzerland
9	Bangladesh	34	Guatemala	59	Myanmar	84	Tanzania
10	Belgium	35	Hungary	60	Netherlands	85	Thailand
11	Bolivia	36	India	61	New Zealand	86	Trinidad and Tobago
12	Brazil	37	Indonesia	62	Niger	87	Tunisia
13	Bulgaria	38	Iran, Islamic Rep.	63	Nigeria	88	Turkey
14	Cameroon	39	Iraq	64	Norway	89	Ukraine
15	Canada	40	Ireland	65	Pakistan	90	United Arab Emirates
16	Chile	41	Israel	66	Peru	91	United Kingdom
17	China	42	Italy	67	Philippines	92	United States
18	Colombia	43	Jamaica	68	Poland	93	Uruguay
19	Congo, Dem. Rep.	44	Japan	69	Portugal	94	Venezuela, RB
20	Costa Rica	45	Jordan	70	Qatar	95	Vietnam
21	Cote d'Ivoire	46	Kazakhstan	71	Romania	96	Yemen, Rep.
22	Croatia	47	Kenya	72	Russian Federation	97	Zambia
23	Czech Republic	48	Korea, Rep.	73	Senegal	98	Zimbabwe
24	Denmark	49	Kuwait	74	Serbia		
25	Dominican Rep.	50	Latvia	75	Singapore		

Notes: This table provides the list of 98 countries, out of which 15 countries are excluded from the panel IV analysis: Algeria, Bulgaria, Ecuador, Finland, Guatemala, Hungary, Iran, Islamic Rep., Iraq, Jamaica, Morocco, Senegal, South Africa, Trinidad and Tobago, Ukraine and Uruguay.

List of the Resource-Dependent Countries

Table 4.A9. The sample of resource-dependent countries (RDC)

	Country	Region	Resource Type	
1	Albania	Eastern Europe and post-Soviet Union	Hydrocarbons	Oil/Gas
2	Algeria	The Middle East and North Africa	Hydrocarbons	Oil
3	Angola	Sub-Saharan Africa	Hydrocarbons	Oil
4	Bahrain	The Middle East and North Africa	Hydrocarbons	Oil
5	Bolivia	Latin America	Hydrocarbons	Gas
6	Cameroon	Sub-Saharan Africa	Hydrocarbons	Oil
7	Chile	Latin America	Minerals	Copper
8	Colombia	Latin America	Both	Oil/Gas/Gold
9	Congo, Dem. Rep.	Sub-Saharan Africa	Both	Oil/Copper/Diamonds
10	Cote d'Ivoire	Sub-Saharan Africa	Hydrocarbons	Oil/Gas
11	Ecuador	Latin America	Hydrocarbons	Oil
12	Ghana	Sub-Saharan Africa	Both	Oil/Gold
13	Guatemala	Latin America	Both	Oil/Nickel
14	Indonesia	South-East Asia	Both	Oil/Gas/Copper/Tin/Gold
15	Iran, Islamic Rep.	The Middle East and North Africa	Hydrocarbons	Oil
16	Iraq	The Middle East and North Africa	Hydrocarbons	Oil
17	Kazakhstan	Eastern Europe and post-Soviet Union	Hydrocarbons	Oil
18	Kuwait	The Middle East and North Africa	Hydrocarbons	Oil
19	Mexico	Latin America	Both	Oil/Gold/Silver
20	Mozambique	Sub-Saharan Africa	Both	Gas/Bauxite
21	Niger	Sub-Saharan Africa	Minerals	Uranium
22	Nigeria	Sub-Saharan Africa	Hydrocarbons	Oil
23	Norway	Western Europe and North America	Hydrocarbons	Oil
24	Peru	Latin America	Minerals	Copper/Gold/Silver
25	Qatar	The Middle East and North Africa	Hydrocarbons	Gas
26	Russian Federation	Eastern Europe and post-Soviet Union	Hydrocarbons	Oil
27	South Africa	Sub-Saharan Africa	Minerals	Gold/Platinum/Coal

28	Sudan	Sub-Saharan Africa	Hydrocarbons	Oil
29	Tanzania	Sub-Saharan Africa	Minerals	Gold/Precious
30	Trinidad and Tobago	The Caribbean	Hydrocarbons	Gas
31	United Arab Emirates	The Middle East and North Africa	Hydrocarbons	Oil
32	Venezuela, RB	Latin America	Hydrocarbons	Oil
33	Vietnam	South-East Asia	Hydrocarbons	Oil
34	Yemen, Rep.	The Middle East and North Africa	Hydrocarbons	Oil
35	Zambia	Sub-Saharan Africa	Minerals	Copper

Notes: This table provides a list of resource-dependent countries (RDC). Out of the listed ones, seven countries are excluded from the analysis: Algeria, Ecuador, Guatemala, Iran, Iraq, South Africa, and Trinidad and Tobago. Their politico-geographic regions are based on Hadenius and Teorell (2007) classification. For further information on resource-rich countries, see, e.g., Baunsgaard, Villafuerte, Poplawski-Ribeiro, and Richmond (2012), International Monetary Fund (2012), Venables (2016), and RGI (2017).

Different Sample: Non-Resource-Dependent Countries

Table 4.A10 presents the results related to the combined effects of institutions on the level of carbon emissions across upper-middle and high-income non-resource-dependent countries:

Table 4.A10. The sample of high- and upper-middle income NRDC (IV estimations)

Panel B(1): Non-Resource-Dependent Countries (UMI & HI)						
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-0.325**	-0.540**	-0.804***	-0.356*	-0.628**	-0.212*
	(0.158)	(0.216)	(0.305)	(0.185)	(0.306)	(0.110)
Political Constraints Index V	0.310					
	(0.477)					
PolCon*TnsRelig	0.847***					
	(0.288)					
Level of Democracy		-0.058				
		(0.139)				
Democ*TnsRelig		0.160***				
		(0.050)				
Combined Polity Score			0.110			
			(0.138)			
Polity*TnsRelig			0.104***			
			(0.027)			

Law & Order				-0.120		
				(0.145)		
LawOrd*TnsRelig				0.070		
				(0.051)		
Corruption					-0.109	
					(0.184)	
Corr*TnsRelig					0.225**	
					(0.097)	
Investment Profile						0.033
						(0.051)
InvPro*TnsRelig						-0.002
						(0.038)
Obs.	918	918	896	918	918	918
R-squared	0.321	-0.088	-0.251	0.282	-0.138	0.420
No of Countries	44	44	44	44	44	44
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon footprint per capita* in all regression models (column (1)-(6)). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions*. Control variables are included in all models. Panel B(1) reports estimations of model (1)-(6) for the sample of upper-middle and high-income non-resource-dependent countries (UMI-/HI-NRDC). All six models are estimated with fixed-effects IV regressions (column (1)-(6)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Different Sector: Manufacturing Industries and Construction

Table 4.A11 presents the results related to the combined effects of institutions on the level of carbon emissions that stem from manufacturing industries and construction:

Table 4.A9. Carbon emitted from manufacturing industries (IV estimations)

Panel A(1): Manufacturing Industries & Construction						
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-0.304**	-0.305**	-0.400***	-0.080	-0.331***	-0.245***
	(0.131)	(0.130)	(0.145)	(0.183)	(0.124)	(0.086)
Political Constraints Index V	0.368					
	(0.318)					
PolCon*TnsRelig	0.862**					
	(0.414)					
Level of Democracy		0.189**				
		(0.075)				
Democ*TnsRelig		0.103***				
		(0.035)				
Combined Polity Score			0.111***			
			(0.035)			
Polity*TnsRelig			0.043**			
			(0.018)			
Law & Order				-0.448***		
				(0.153)		
LawOrd*TnsRelig				0.250***		
				(0.079)		
Corruption					-0.277*	
					(0.151)	
Corr*TnsRelig					0.225***	
					(0.065)	
Investment Profile						-0.093***
						(0.028)
InvPro*TnsRelig						0.037
						(0.024)
Obs.	1721	1730	1708	1730	1730	1730
R-squared	-0.023	-0.060	-0.079	-0.137	-0.123	0.077
No of Countries	82	82	81	82	82	82
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon emissions per capita* sourced from manufacturing industries and construction sector. Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig*, *Democ*TnsRelig*, *Polity*TnsRelig*, *LawOrd*TnsRelig*, *Corr*TnsRelig*, and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions.* Control variables are included in all models. Panel A(1) reports estimations of the new dependent variable against each of the institutional variables. All six models in Panel A(1) are estimated with fixed-effects IV regressions (column (1)-(6)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01*, ** *p<0.05*, * *p<0.1.*

Different Sector: Electricity and Heat Production

Table 4.A12 presents the results related to the combined effects of institutions on the level of carbon emissions that stem from electricity and heat production:

Table 4.A10. Carbon emitted from electricity and heat production (IV estimations)

Panel C(1): Electricity & Heat Production						
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-0.422**	-0.471***	-0.687***	-0.528**	-0.482***	-0.174*
	(0.177)	(0.179)	(0.225)	(0.242)	(0.152)	(0.104)
Political Constraints Index V	-1.739***					
	(0.504)					
PolCon*TnsRelig	1.160**					
	(0.482)					
Level of Democracy		-0.174				
		(0.112)				
Democ*TnsRelig		0.152***				
		(0.042)				
Combined Polity Score			-0.113*			
			(0.059)			
Polity*TnsRelig			0.094***			
			(0.026)			

Law & Order				-0.999***		
				(0.263)		
LawOrd*TnsRelig				0.021		
				(0.092)		
Corruption					0.014	
					(0.187)	
Corr*TnsRelig					0.141**	
					(0.062)	
Investment Profile						-0.052
						(0.035)
InvPro*TnsRelig						0.114***
						(0.032)
Obs.	1721	1730	1708	1730	1730	1730
R-squared	-0.485	-0.482	-1.080	-0.803	-0.139	-0.044
No of Countries	82	82	81	82	82	82
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *carbon emissions per capita* sourced from electricity and heat production sector. Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig, Democ*TnsRelig, Polity*TnsRelig, LawOrd*TnsRelig, Corr*TnsRelig,* and *InvPro*TnsRelig,* represent the interaction of each variable on formal institutions with *religious tensions*. Control variables are included in all models. Panel C(1) reports estimations of the new dependent variable against each of the institutional variables. All six models in Panel C(1) are estimated with fixed-effects IV regressions (column (1)-(6)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01*, ** *p<0.05*, * *p<0.1*.

Different Dependent Variable: Greenhouse Gas Emissions

Table 4.A13 present the results related to the combined effects of institutions on GHG emissions (equivalent to tons of CO_2 emission per capita). Overall, the results seem to confirm

that countries with higher quality of institutions are likely to decrease their atmospheric concentration of greenhouse gas emissions.[230]

Table 4.A11. The impacts of institutions on greenhouse gas emissions (IV estimations)

Panel A: GHG Emissions (Tons of CO2 equivalent per capita)						
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-.053	-.08	-.075	-.06	-.087	-.01
	(.063)	(.063)	(.069)	(.063)	(.065)	(.066)
Political Constraints Index V	-1.047***					
	(.299)					
PolCon*TnsRelig	.057					
	(.171)					
Level of Democracy		.029				
		(.049)				
Democ*TnsRelig		-.016				
		(.015)				
Combined Polity Score			-.008			
			(.018)			
Polity*TnsRelig			-.003			
			(.008)			
Law & Order				-.181*		
				(.095)		
LawOrd*TnsRelig				-.006		
				(.028)		
Corruption					-.189*	
					(.099)	
Corr*TnsRelig					.013	
					(.028)	
Investment Profile						-.028*
						(.017)
InvPro*TnsRelig						.028**
						(.013)

[230] It is just *religious tensions* that does not seem to be statistically linked to the level of atmospheric GHG emissions, though it shows a negative association. This can be related to the scope of this variable, as it measures a collection of toxic gases, in releasing which people might not have a big role as they normally have in emitting carbon, thus, trust might be irrelevant here. Also, GHGs are not properly controlled in the right-hand-side of the equation; an issue that is initially pointed in the SES framework. Now that the level of trust is indicated to be insignificant, it can be expected that the interactions become insignificant too.

Obs.	1547	1552	1537	1552	1552	1552
R-squared	-.175	.03	.047	-.078	-.038	-.009
No of Countries	82	82	81	82	82	82
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *greenhouse gas emissions* equivalent to carbon dioxide emissions (tons per capita). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig, Democ*TnsRelig, Polity*TnsRelig, LawOrd*TnsRelig, Corr*TnsRelig*, and *InvPro*TnsRelig* represent the interaction of each variable on formal institutions with *religious tensions*. Control variables are included in all models. Panel A reports estimations of the new dependent variable against each of the institutional variables. All six models in Panel A are estimated with fixed-effects IV regressions (column (1)-(6)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** *p<0.01*, ** *p<0.05*, * *p<0.1*.

Different Dependent Variable: Methane Emissions

Table 4.A14 presents the results related to the effects of formal and informal institutions (with interactions) on CH_4 emissions (equivalent to tons of CO2 emission per capita). As indicated, the results seem to confirm that higher quality of formal and informal institutions results in lower levels of methane emissions across all countries within the sample (1990-2014).

Table 4.A14. The impacts of institutions on methane emissions (IV estimations)

Panel B: Methane Emissions (Tons of CO2 equivalent per capita)						
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Tensions	-.197**	-.216**	-.285***	-.238**	-.198**	-.067
	(.083)	(.093)	(.105)	(.096)	(.085)	(.077)
Political Constraints Index V	.032					
	(.286)					
PolCon*TnsRelig	-.01					
	(.162)					

Level of Democracy		-.185***				
		(.06)				
Democ*TnsRelig		.058***				
		(.019)				
Combined Polity Score			-.064**			
			(.027)			
Polity*TnsRelig			.036***			
			(.012)			
Law & Order				-.236**		
				(.104)		
LawOrd*TnsRelig				-.034		
				(.034)		
Corruption					.035	
					(.096)	
Corr*TnsRelig					-.016	
					(.027)	
Investment Profile						.02
						(.016)
InvPro*TnsRelig						.045***
						(.013)
Obs.	1569	1574	1554	1574	1574	1574
R-squared	.087	-.33	-.561	-.127	.074	.07
No of Countries	83	83	82	83	83	83
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is *methane emissions* equivalent to carbon dioxide emissions (tons per capita). Independent variable representing informal institutions is *religious tensions* $(0-6)$. Higher values show higher levels of trust. Independent variables representing formal institutions are: *political constraints index V* $(0-1)$, *level of democracy* $(0-10)$, and *combined polity score* $(-10-+10)$ for political institutions; *law and order* $(0-6)$ and *corruption* $(0-6)$ for legal institutions; *investment profile* $(0-12)$ for economic institutions. Higher values (in parenthesis) indicate stronger formal institutions. Six interactive terms of *PolCon*TnsRelig, Democ*TnsRelig, Polity*TnsRelig, LawOrd*TnsRelig, Corr*TnsRelig,* and *InvPro*TnsRelig*, represent the interaction of each variable on formal institutions with *religious tensions*. Control variables are included in all models. Panel B reports estimations of the new dependent variable against each of the institutional variables. All six models in Panel B are estimated with fixed-effects IV regressions (column (1)-(6)), using command *xtivreg2* in Stata. In IV regressions, all variables on formal institutions are instrumented by *trend of colonial origins*. Likewise, the variable on informal institutions is instrumented by *distance to conflict zones*. The product of instrumental variables (i.e., *trend of colonial origins* and *distance to conflict zones*) is used for instrumenting the interactive terms. All regressions are performed on the sample of all countries. Robust standard errors are in parenthesis. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.