[Beyond democracy: Assessing the effect of democratic qualities on CO_2]

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Master Thesis in Climate Change Management

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Sogndal
[June 2019]

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Western Norway University of Applied Sciences

TITLE

Master thesis in Climate Change Management

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Thesis submitted: Spring 2019	Open thesis
Main Supervisor: Erling Holden Co-supervisors: Kristin Linnerud, Morten Simonsen	
Keywords: Sustainable development, Democracy, Democratization, Climate Change, Mitigation, CO_2, Institutions, Inequality, V-dem.	Number of pages: 73 + Appendix: 81 Sogndal, 03.06, 2019

This thesis is a part of the master's program in Climate Change Management (Planlegging for klimaendringer) at the Department of Environmental Sciences, Faculty of Engineering and Science at the Western Norway University of Applied Sciences. The author(s) is responsible for the methods used, the results that are presented and the conclusions in the thesis.

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Preface

The process of executing this thesis has been rather thankful. I cannot remember any period of particular stress or heartache. Instead, it has been quite fun. That does not, however, mean that I did not work hard or that I had everything figured out from day one. I spent about one-fourth of the designated time investigating a different research question before I figured out that it was neither particularly interesting nor important. Of course, it was not for naught, it led to the research question that you will soon be presented.

The fact that this process has been rather painless is due, in large part, to the people surrounding me. Special thanks should be given to the main supervisor Erling for involving me in a larger research community, encouraging me to present my thesis to experts outside HVL, and general nudges in the right directions throughout the process. His insight, big-picture-ideas and notes on structuring the thesis have been crucial for the end-product. Thanks should also be given to Kristin and Morten for great discussions, help and feedback on my choice of methods, and Mark for helping me with all sorts of R stuff. Kirsti: thank you for being you. Lastly, I want to thank my dog. For once, he has been consistently well-behaved over a longer period of time not making too much of a fuzz when I am out of the house. You have been a good boy. Yes, you have.

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Abstract

Democracy is the preferred system of government when social and economic development is the goal, but what is the effect of democratization on climate change mitigation? Two decades of research into this question has so far led to ambiguous conclusions. This has prompted authors to question some of the assumptions in these studies, in particular the fact that all democracies are treated the same and measured by few and similar democracy indices.

This thesis contributes to the discussion by going beyond the narrow definition of democracy and, instead, investigating the effects of several democratic qualities on CO_2 emissions. The thesis introduces theoretical insights from environmental political science research and creates a framework for hypothesizing the effects of electoral democracy, liberal democratic qualities, deliberative democratic qualities, egalitarian democratic qualities and participatory democratic qualities on CO_2 emissions in countries. The hypotheses are tested using mixed effects models with random slope and intercept and a temporal correction structure to account for serial correlation on a panel of 161 countries over 23 years, both for the entire panel and for different income-groups.

The thesis provides two robust findings that have important policy implications. Firstly, increasing regional democracy in low-income countries is associated with an increase in CO_2 emissions per capita. Secondly, and most importantly, increasing egalitarian democratic qualities in countries correspond with a rather strong increase in CO_2 emissions per capita throughout the sample. Egalitarian democratic qualities measure the level of equal access to power, equal protection of rights and liberties and equal distribution of resources between and within genders and social groups, indicating that a trade-off exists between reducing inequalities and mitigating climate change. In a sustainable development context, this means that certain sustainable development goals, such as “inclusive and equitable quality education” (SDG 4) and reducing “inequalities within and between countries” (SDG 10) are in direct conflict with effective climate action, and that mitigating climate change might require an even stronger effort than anticipated to avoid unwanted trade-offs.

Samandrag på norsk

Demokrati er det føretrekte styresettet når sosial og økonomisk utvikling er målet, men kva er effekten av demokratisering på klimagassreduksjon? To tiår med forsking på dette spørsmålet har so langt ført til tvitydige konklusjonar. Som ein konsekvens har artikkelforfattarar i det siste byrja å stilla spørsmål ved premissa i desse studiane, spesielt det faktum at alle demokratiske land vert handsama likt og målt med få og like demokratiindeksar.

Denne oppgåva bidreg til diskusjonen gjennom å utvide den smale definisjonen av demokrati og i staden etterforske effekten av fleire typar demokratiske kvalitetar på CO_2-utlsepp. Oppgåva hentar inn teoretisk innsikt frå miljøretta statsvitskapleg forsking som utgjer grunnlaget for ei rekke hypotesar om korleis demokrati, liberale demokratiske kvalitetar, deliberative demokratiske kvalitetar, egalitære demokratiske kvalitetar og deltakande demokratiske kvalitetar påverkar CO_2-utslepp i land. Hypotesene vert testa ved bruk av mixed effects modellar med random slope og intercept og ein tidsmessig korreksjonsstruktur som handsamar seriekorrelasjon i eit panel på 161 land over 23 år, både for heile panelet og for forskjellige inntektsgrupper.

Oppgåva har to robuste hovudfunn med potensielt stor politisk innverknad. Det første funnet er at ei auke i regionalt demokrati er assosiert med ein auke i CO_2-utslepp per person i låginntektsland. Det andre, og aller viktigaste funnet, er at aukande egalitære demokratiske kvalitetar i land korresponderer med ein relativt sterk auke i CO_2-utselpp per person i heile panelet. Egalitære demokratiske kvalitetar er eit mål på nivået av lik tilgang til makt, lik beskyttelse av rettar og fridomar og lik distribusjon av ressursar mellom og innad i sosiale grupper og kjønn. Dette funnet indikerer at ein auke i likskap ikkje går overeins med klimagassreduksjon. I ein bærekraftig utviklings-kontekst betyr dette at nokre av bærekraftmåla, slik som «inkluderande, rettferdig og god utdanning» (bærekraftmål 4) og å «redusere ulikskap i og mellom land» (bærekraftmål 10) er i direkte konflikt med klimagassreduksjon. Det tyder òg på at ein kraftigare innsats trengs for å unngå uønska kompromiss i framtida.

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1. Introduction

In the minds of scholars and policymakers alike, democracy has first and foremost carried intrinsic value. But what is the instrumental value of democracy? In light of the current sustainable development discourse, how does democracy, and democratic properties, affect the achievement of other goals? Most importantly, how does it affect climate change mitigation? This thesis takes a novel approach to investigating these questions by focusing on a large subset of institutional qualities related to democracy, in addition to democracy itself, and the role they play in mitigating climate change.

The accumulation of greenhouse gases from anthropogenic sources in the atmosphere is changing the natural climate systems, and the societal transformation needed to avoid dangerous and irreversible climate change are "(…) unprecedented in term of scale (…) and imply deep emissions reductions in all sectors" (IPCC, 2018). Despite an overwhelming amount of scientific evidence and consensus that the climate is changing and the time horizon for effective mitigating action is running out, the global response to climate change has been relatively muted. Some have argued that this is because there are too few democracies in the world to take conscious and cooperative action against the issue (Clulow, 2019; Gore, 1992; Payne, 1995). Others have argued the opposite, saying that the democratic system is either too strong: the public's unwillingness to adopt climate friendly behavior is indiscriminately accepted by governments (Midlarsky, 1998; Shearman & Smith, 2007; Sjöstedt & Jagers, 2014), or too weak: the public's opinion is largely overruled by corporate interests in democratic capitalist systems (Dryzek, 1992; Mayer, 2017).

Still, democracy is the preferred system of government when social and economic development is the goal. Democracies are better at alleviating poverty (Bueno de Mesquita, Smith, Siverson, & Morrow, 2003), at reducing inequalities (Ross, 2006), and at sustaining economic growth (Doucouliagos & Ulubaşoğlu, 2008) to mention some of the Sustainable Development Goals (SDGs) (United Nations, 2015) the world has agreed to focus on the next decade. Although democracy is not explicitly mentioned in the SDGs, democratic principles "runs through the [SDGs] like a golden thread" (United Nations, 2016). In certain sustainable development models, democracy is also an intrinsic goal (Holden, Linnerud, Banister, Wierling, & Schwanitz, 2018). In a sustainable development-context, it is therefore crucial to identify a potential trade-off between democratization, with the institutions that characterize it, and climate change mitigation efforts.

The relationship between democracy and climate change mitigation efforts, typically CO_2 emissions, has been investigated empirically for two decades already (Arvin & Lew, 2011; Bättig & Bernauer, 2009; Clulow, 2019; Farzanegan & Markwardt, 2018; Farzin & Bond, 2006; Gallagher & Thacker, 2008; Gleditsch & Sverdup, 2002; Joshi & Beck, 2018; Kinda, 2011; Lægreid & Povitkina, 2018; Li & Reuveny, 2006; Lv, 2017; Mayer, 2017; Midlarsky, 1998; Policardo, 2016; Povitkina, 2018; You, Zhu, Yu, & Peng, 2015). Although a majority of the studies find some evidence that increasing levels of democracy slightly reduces CO_2 emissions in countries, it is hard to find an unequivocal interpretation of the relationship. The variety of explanations is extensive. For example, Lv (2017), Lægreid and Povitkina (2018) and Arvin and Lew (2011) all agree that the effect of democracy depends on the level of income in a country, but have separate opinions on what level of income provide a positive effect. Lv (2017) find that democratization decreases emissions in high-income countries, Lægreid and Povitikina (2018) that it decreases emissions in low-income countries, and Arvin and Lew (2011) that democratization decreases emissions in middle-income countries, while it *increases* emissions in both high and low-income countries. Other studies argue that corruption (Povitkina, 2018), existing emissions (Bättig & Bernauer, 2009; You et al., 2015), income inequality (Policardo, 2016) and democratic stock (Gallagher & Thacker, 2008) create the condition where democracy have significant effects on CO_2 emissions.

This lack of robust conclusions in the literature has recently led authors to question some of the assumptions in these studies, in particular the fact that all democracies are treated the same and measured by few and similar democracy indices. Mayer (2017) suggests that “future research in this area, rather than relying on single indicators of democracy, could investigate the relationship between different characteristics of democracy and environmental performance”. Similarly, Joshi and Beck (2018) argue that “future scholarship on democracy and the environment should aggressively grapple with democracy at the meso-level by focusing on institutions and political subsystems”. The concept and practice of democracy is far from identical in all countries, with variations in elections, contestation, constitutionalism, freedoms, participation, deliberation and political equality (Coppedge, Lindberg, Skaaning, & Teorell, 2016). By measuring all countries by the same standard, important distinctions are lost. In this thesis, I expand on the question of whether democracy matters by examining how different democratic qualities affect countries’ abilities to mitigate climate change. My research question is as follows:

- *How does different democratic qualities relate to CO_2 emissions in countries over time?*

The research question is accompanied by several hypotheses presented in the next chapter. This thesis is, to my knowledge, the first attempt at answering this question. The task requires disaggregating the concept of democracy into meaningful components so that they can be examined separately. Until recently, this has not been a straight-forward process because existing measures of democracy has been based on a narrow variety of definitions, usually measuring freedoms, elections or contestation (Coppedge et al., 2011). Instead, I use the new Varieties of Democracy (V-Dem) (Coppedge et al., 2018) dataset, which separates democracy into five separate components: electoral democratic qualities, liberal democratic qualities, deliberative democratic qualities, egalitarian democratic qualities and participatory democratic qualities. My thesis revolves around these five concepts. I aim to provide a theoretical framework for understanding how they relate to CO_2 emissions in countries, and longitudinal cross-country evidence of the relationships.

The thesis is onwards divided into five chapters. In the Theory and hypothesis chapter I will explain each of these V-dem indices more in depth. I will attempt to build a framework to explain how each of these democratic qualities relate to per capita CO_2 emissions in nations by mapping the mechanisms found in empirical and theoretical literature. I will use the identified mechanisms to hypothesize a relationship between each of the democratic qualities and CO_2 emission per capita. In the Data and Method chapters, I will explain how I aim to examine these relationships. In the Results chapter, I will present the results from my analysis which I then discuss in detail in relation to the hypotheses in the Discussion.

2. Theory and hypotheses

Both data and operationalizations of democratic qualities (henceforth DQs) comes from Varieties of democracy (V-Dem). V-Dem is different from other commonly used democracy indices in several regards. For one, the project is admirably large. Over 3000 country experts are involved in measuring democracy, institutions and governance in over 200 countries since the year 1789 (Coppedge et al., 2018). Secondly, the V-dem dataset consists of 450 indicators that help make up five entirely separate measures of DQs (Coppedge et al., 2016). This opens up the possibility of examining a wider variety of research questions such as the one stated in this thesis. A number of alternative democracy datasets exist and are commonly used throughout the literature, but these indices rarely go beyond measuring a few liberal or electoral traits. Two datasets are, by far, the most commonly used in the environmental democracy literature (Coppedge et al., 2011): First, the Freedom House project provides indices on civil liberties, individual rights and rule of law (Freedom House, 2018), which are aspects of democracy that are covered by the electoral and liberal DQs in V-dem. Second, the Polity IV project provides measures of free and fair elections, suffrage and political competitiveness (Marshall, Gurr, & Jaggers, 2016), aspects that are largely covered by the electoral DQ in V-dem. Others exist, such as the Economist Intelligence Unit (2018), the Worldwide Governance Indicators (Kaufmann & Kraay, 2019), the Bertelsmann Transformations Index (Bertelsmann Stiftung, 2018) and the Lexical Index of Electoral Democracy (Skaaning, Gerring, & Bartusevičius, 2015), but none of these cover the multitude of years, countries and, most importantly, democratic qualities as V-dem does. Thirdly, the data availability, quality and reliability are superior (Povitkina, 2018). Typically, every one of the 450 indicators in the dataset is coded based on input from at least five separate country experts for every year and country (Coppedge et al., 2016).

The five DQs operationalized and measured by V-Dem is the electoral, the liberal, the deliberative, the egalitarian and the participatory qualities. The electoral DQ is the only index that can be regarded as a measure of democracy (Coppedge et al., 2016), in contrast to the other DQs which are measures of qualities closely related to democracy. An example of the latter is direct democracy and the use of referendums, measured by the participatory DQ index. While it is undoubtedly a democratic trait, it is hard to determine if countries that have a high degree of direct democracy are more democratic than countries that have less direct democracy. It is therefore entirely possible that countries with high levels of electoral DQ can have moderate or even low levels of any of the other DQs, and vice versa, although they are all moderately to highly empirically correlated. I use the term “democratic qualities” to emphasize the context they have been operationalized in, as qualities identified in democratic polities, and as qualities that separates democratic polities from each other.

In this chapter I will outline the contents of the different democratic quality (henceforth DQ) indices I use in the analysis. All DQs and their subcomponents are shown in Table 1. I aim to relate each of these DQs to CO_2 emissions through theoretical and empirical arguments found in the literature and identify mechanisms that explain how the relationships work. I use the identified mechanisms to hypothesize the direction of each effect of DQ on CO_2 emissions per capita.

Table 1. The democratic qualities and their subcomponents

Democratic quality	*Subcomponents*
Electoral DQ	Freedom of expression and alternative sources of information
	Freedom of association
	Share of population with suffrage
	Clean elections
	Elected officials
Liberal DQ	Equality before the law and individual liberty
	Judicial constraints on the executive
	Legislative constraints on the executive
Deliberative DQ	Resoned justification
	Common good
	Respect counterarguments
	Range of consultation
	Engaged society
Egalitarian DQ	Equal protection
	Equal access
	Equal distribution
Participatory DQ	Civil society participation
	Direct popular vote
	Local government
	Regional government

This approach is ambitious. There is no literature that directly relates any of the five DQs, except electoral, to CO_2 emissions. Instead, only some of the subcomponents of each DQ have documented or theoreticized direct or indirect effects on CO_2 emissions or other environmental outcome, and some subcomponents within the same DQ have contrasting effects on CO_2. The mechanisms are therefore dominated by ambiguity. Still, I believe it is crucial to make an attempt. If the mechanisms presented in this chapter leads to hypotheses that are all disproved, it would still provide important insight. Importantly, the next researcher investigating a similar research question would have something to build their theoretical foundation upon.

2.1 The Electoral Democratic Quality

The electoral DQ is V-Dem's attempt at measuring the core values of democracy that must be in place for a nation to be regarded as democratic (Coppedge et al., 2018). The electoral DQ uses Dahl's (1998) concept of polyarchy, which identifies five political institutions as the defining elements of modern representative democracy: elected officials, free, fair and frequent elections, freedom of expression and a free media, freedom of association, and universal suffrage.

As this index is regarded as a measure of the universal definition of democracy, I apply the literature that have examined differences between democracies and non-democracies using its general definition, and how they affect environmental performance. Particularly Payne (1995), Clulow (2019) and Burnell (2012) makes great contributions in this regard. I have condensed their respective contributions down to a list of five mechanisms commonly mentioned in the literature which all relates to V-Dem's definition of electoral DQ. All but one mechanism serves as a duel-edge sword, meaning that under certain conditions it can act both to reduce and increase CO_2 emissions.

Firstly, democracies are more cooperative than non-democracies (Payne, 1995). Although this aspect is not measured explicitly in the electoral DQ index, empirical evidence points to the fact that democracies are better than non-democracies in participation and ratification of international environmental agreements (Bättig & Bernauer, 2009). When democracies come together in large-scale international cooperation their possibility and ability to put pressure on non-compliant nations are also higher (Bättig & Bernauer, 2009) increasing the effectiveness of agreements. But democracies are, however good at making promises, not particularly good at keeping them. In fact, democracies do not perform significantly better than autocracies when the outcome of international agreements are studied (Bättig & Bernauer, 2009; Burnell, 2012).

Secondly, democratic leaders are accountable for how well they perform (Burnell, 2012; Clulow, 2019; Payne, 1995). Democratic leaders cannot simply ignore voter concerns, as such behavior will put them out of office. Payne (1995) argues that this is one of the reasons why democracies will implement more ambitious environmental policies than autocracies. But this argument relies on the fact that environmental concern is higher than, for instance, the concerns for economic growth or job creation in the electorate. Mayer (2017) highlights the perspective that when public opinion on job creation and economic growth are the most dominant, democratic leaders can be pressured into adapting measures that directly or indirectly reduces environmental quality. This has been found to be the case especially in developing countries (Povitkina, 2018), where there are more pressing concerns than environmental quality. But the phenomenon exists in developed nations as well, argues Midlarsky (1998). The accountability of elected officials in democracies leads them to constantly having to please the public, often resulting in cost-effective policies with low impact but short-term payoffs instead of long-term cost-demanding high-impact policies. Bättig & Bernauer (2009), among others (see e.g. Farzin & Bond, 2006), questions whether there really is higher demand for climate change in democracies, arguing that the accountability-mechanisms first and foremost might work to promote environmental degradation.

Thirdly, freedoms to express and associate increases the opportunity to organize on environmental issues and put pressure on the government (Burnell, 2012; Payne, 1995). A free media provides alternative sources of information, providing the electorate with critical information on the leaders' performance. Mistakes and unsuccessful policies are more likely to be surfaced in a democracy (Burnell, 2012), and voters can punish their leaders for environmental degradation. Still, Midlarsky (1998) reminds us that freedoms also mean freedoms for anti-environmental interests. Large corporations benefiting from environmental degradation typically have significant resources to spend on lobbyism and can use the democratic freedoms to successfully spread anti-environmental opinions.

Fourthly, the time horizons of effective climate change mitigation policies are significant (Clulow, 2019). For autocratic leaders, the main concern is to remain in power. They are therefore more inclined to divert their limited resources away from long-term policies into measures ensuring that they remain in power short-term (Fredriksson & Neumayer, 2013; Li & Reuveny, 2006). This argument is usually countered with the fact that democratic leaders indeed also have short-term concerns, an important one being regular elections. The nature of climate change makes it a long-term issue, and the benefits of mitigation policies cannot be reaped by policymakers in office. Therefore, such policies might be unpopular in democracies (Burnell, 2012).

Fifthly, the cost of staying in power takes a different form in democracies compared to non-democracies (Bueno de Mesquita et al., 2003). For democratic leaders to stay in power, they need to please the majority. One way to do this, is to provide public goods that benefit all more or less equally. For non-democratic leaders to remain in power, they need the loyalty of a much smaller group of military and economic elite members of society (Bueno de Mesquita et al., 2003). This loyalty is not bought by provisioning public goods, but rather by private goods, such as real estate and material wealth. Mitigating climate change should therefore be regarded as a higher priority in democratic countries as it is a common good (Bättig & Bernauer, 2009; Farzin & Bond, 2006).

From these mechanisms it is not straight-forward to conclude on the relationship between electoral DQ and CO_2 emissions. Still, the bulk of empirical literature that investigates the relationship, as mentioned in the introduction, agrees on a negative relationship, i.e. that a higher level of democracy is associated with a decrease in CO_2 emissions in countries. From this, I hypothesize the following:

H_1: *An increase in the level of electoral DQ in countries over time is associated with a* decrease *in per capita CO_2 emissions.*

2.2 The Liberal Democratic Quality

The liberal DQ inhabits the democratic principle of "(…) protecting individual and minority rights against the tyranny of the state and the tyranny of the majority" (Coppedge et al., 2018). The DQ measures this ability by examining the limits placed on government. Countries with constitutionally protected civil liberties, a strong rule of law with an autonomous judicial branch which decisions are respected by the executive, and a legislative branch with power to investigate, oversee and question the executive have high scores on this index.

One parallel that is useful when contextualizing the liberal DQ, is the debate on gun control in the USA. Although the majority of the population agrees that gun laws should be stricter (Gramlich, 2018), the constitutional right for citizens to keep and bear arms makes establishing stricter policies a difficult task. In this regard, individual rights triumphs over the majority will. Likewise, it has been theoreticized that the ability to implement policies aimed at reducing consumption, and consequently CO_2 emissions connected to resource extraction, production, transport and use, is a difficult task in countries with a high degree of the liberal DQs. de Geus (2004) argues that "Western liberal democracies have always stressed that the freedom to consume keeps the capitalist economic system going and constitutes an inalienable right of the individual citizen", and that these countries therefore have been reluctant to design policies that restricts it. Bättig and Bernauer (2009) finds that democracies have a harder time reducing emissions in the transport sector than in the energy and heat sector, pointing to the fact the policies affecting personal mobility is especially problematic in countries with certain democratic qualities. Adom et al (2018) instead finds that democracy lowers CO_2 emissions in the transport sectors, but raises it in manufacturing and construction. It is, however, unclear in both of these studies whether it is the liberal qualities that has these effects on sectoral emission, as they use indices that includes both electoral and liberal components (Freedom House, 2018; Marshall et al., 2016).

Although there are contesting evidence in the empirical literature, I hypothesize the following, mainly based on the theoretic argument from de Geus (2004):

***H_2*:** *An increase in the level of liberal DQ in countries over time is associated with an* increase *in per capita CO_2 emissions.*

2.3 The Participatory Democratic Quality

The participatory DQ is an index that includes aspects of active participation by citizens in electoral and non-electoral processes, as well as the presence and strength of local and regional democratic institutions. It holds that direct rule by citizens is preferred as it is a more active from of participation than the indirect. Countries with high levels of direct democracy, high levels of participation in civil society organizations and strong local and regional governments, score highly on this index (Coppedge et al., 2018).

The first subcomponent, the direct democracy part, values the use of ballots to determine policy implementation. A few studies (Bornstein, 2007; Bornstein & Lanz, 2008; Bornstein & Thalmann, 2008) have looked specifically at environmental referendums in Switzerland, the country with the highest level of direct democracy (Coppedge et al., 2018). They point to three key arguments in the discussion on the relationship between direct democracy and emissions: Firstly, voters have a hard time understanding difficult subject matters during political campaigns, and usually rely on heuristic cues and shortcuts, and “the way the wind is blowing” when finding their position on such issues. This might prove detrimental to approval rates of policies that alters the status quo, as power elites benefiting from the status quo can shape the direction of the debate in the public arena (Bornstein & Thalmann, 2008). Secondly, voters are mostly concerned about maximizing personal utility when stepping into the voting booth, even when deciding on public goods. Although values and ideologies plays its part, the subjective benefits and costs expected from a policy shapes the decision of the voter, and since mitigation policies such as carbon taxation might affect the price of consumption of certain goods, such policies are unpopular (Bornstein & Lanz, 2008). Bornstein (2007) also provides empirical evidence that in times of financial pessimism, the acceptance rate of environmental ballots are particularly low. Thirdly, the number of veto actors in policy processes, i.e. actors that can stop policies from being implemented, inhibits political institutions from being fluid and flexible (Bornstein, 2007). A high number of veto actors is preferable when the status quo is desired (Lægreid & Povitkina, 2018; Paola & Jamieson, 2018), but since mitigating climate change require a certain societal transition (IPCC, 2018), the extra veto actor, i.e. the public, makes it harder to implement mitigation policy.

The second subcomponent, participation in civil society organizations, is closely related to the production of post-material values (Inglehart & Welzel, 2005). Citizens engaged in civil society organization are more likely to adopt altruistic values, such as climate concern, if they participate in civil society organizations (Putnam, 2016). In addition, a vibrant civil society plays a crucial part in pressuring governments into adopting such value-based policies (Lægreid & Povitkina, 2018). Lægreid & Povitkina (2018) also show empirically that a high degree of civil society participation, combined with high levels of democracy, corresponds with a reduction in CO_2 emissions.

The third and fourth subcomponents of the participatory DQ is the strength of local and regional democracy. Although the consequences of climate change are global, many of the mitigation efforts has to be taken at the local levels. Collier (2007), looking at local governments in EU countries, find that underfunded municipalities are ineffective in implementing mitigation policy, and argues that «unless appropriate supporting measures are implemented at both EU and national levels (...), local authorities have only limited scope for action» (Collier, 2007).

From these arguments, it is hard to find one decisive hypothesis to put forth. The participatory DQ is an index with high diversity among the subcomponents. It is intuitively hard to find a common ground in which to build a theoretic framework for the aggregated effect of all components. I therefore provide hypotheses for each of the four subcomponents. I will use these subcomponents in a supplementary analysis, separate from the main analysis, to determine the isolated effects of each of these contrasting subcomponents.

H_3: *An increase in the level of direct democracy in countries over time is associated with an* increase *in per capita CO_2 emissions.*

H_4: *An increase in the level of civil society participation in countries over time is associated with a* decrease *in per capita CO_2 emissions.*

H_5: *An increase in the level of local democracy in countries over time is associated with a* decrease *in per capita CO_2 emissions.*

***H_6*:** *An increase in the level of regional democracy in countries over time is associated with a* decrease *in per capita CO_2 emissions.*

2.4 The Deliberative Democratic Quality

The deliberative DQ focuses on the process of reaching decisions in a polity. A deliberative process is one where the public debate is characterized by a respectful, inclusive dialogue, where political elites justify their positions in terms of the public good and counter-arguments are respected and acknowledged. The subcomponents that make up the index are five in number: Firstly, whether public reasoned justification is given by decision makers in policy processes. Secondly, whether the common good is emphasized in these public justifications. Thirdly, whether political elites acknowledge and respect counterarguments. Fourthly, whether there is a wide range of consultation at elite levels. And fifthly, whether the public debate and discussions during policy processes is open to, and characterized by, an engaged society (Coppedge et al., 2018).

I do not necessarily understand this index to be measure of deliberation in the form of designed citizen forums where participants, in interaction with experts and advocates, produce recommendations and justifications for policy action (Dryzek & Pickering, 2017), although this is also an important part of the literature on institutions and climate change mitigation. Instead, I understand the deliberative process measured by this index mainly as a contrast to the "decide-announce-defend" approach in policy making, in which agency experts make decision, and then try to "tell people what is good for them" (Stave, 2002). This implies an understanding of decisions as made and discussed mainly among the political elites, but that an inclusive, wide and respectful dialogue is encouraged at all levels, and that the public is consulted in public forums such as the media and public hearings before decisions are made.

This form of deliberation has several benefits, according to theoretical literature. The double resource benefit in including and consulting a wide range of actors in policy processes is often mentioned (Drews & van den Bergh, 2016; Dryzek & Pickering, 2017; Renn & Schweizer, 2009; Stave, 2002): Firstly, policy makers gets a wider range of views on a policy before implementation, increasing the possibility of choosing the "best" option. Secondly, a wide range of consultation and a respectful dialogue increases the legitimacy of the chosen policy. This is crucial for turning mitigation output into mitigation outcome (Stave, 2002). Achieving an environmental goal often require public support of funding initiatives, and may require certain actors to change their behavior, and "while some success can be achieved through economic incentives and regulations, stakeholders are more likely to support policies if they understand the causes of the problem and the consequences of policy decisions" (Stave, 2002). Also, when the legitimacy rests on the recognition that the chosen policy option might serve the common good best, but at the cost of some individual interests, such as consumption or mobility, the people who may feel they are worse off than before, but "who recognize the moral superiority of the solution" (Renn & Schweizer, 2009), can abstain from disrupting policy implementation. In this sense, policy makers attain recourses for implementation of policies as well. From these arguments I hypothesize the following:

H_7: *An increase in the level of the deliberative DQ in countries over time is associated with a* decrease *in per capita CO_2 emissions.*

2.5 The Egalitarian Democratic Quality

The egalitarian DQ measures material and immaterial inequalities. It holds that inequalities inhibits the exercise of formal rights and liberties and diminish the ability of citizens from all social groups to participate. Countries where individual rights and freedoms are protected equally across social groups, resources are equally distributed, and access to power is equally distributed across groups, genders and socioeconomic class score highly on this index (Coppedge et al., 2018). The resources in question refers to food, water, housing, education and healthcare, I therefore do not mention mechanisms specifically related to income inequality. For a discussion on that, see section 3.4.

Paola and Jamieson (2018) argue that voter ignorance is a significant problem in many democracies. And even if a citizen trusts the science, the role of expert knowledge is often contested. "A democratic citizen can recognize expertise and accept the science of, say, climate change, and still object to the expert who counsels some course of action: "You may be right, but who made you boss?"" (Paola & Jamieson, 2018). This is a rationale that could possibly be counteracted by a more equal distribution of educational access, which can alter the group dynamics and help shorten the divide between experts and non-experts. Equal distribution also means that material needs are more likely to be met in society, opening up the possibility of pursuing post-material and altruistic values such as environmental integrity (Inglehart & Welzel, 2005). Additionally, there is a view that women are more concerned for the environment, pointing to the fact that countries with equal access to power across genders should perform better in terms of mitigating climate change (Burnell, 2012). From these arguments, I hypothesize the following:

H_8: *An increase in the level of the egalitarian DQ in countries over time is associated with a* decrease *in per capita CO_2 emissions.*

2.6 summing up

In this chapter, I have presented the five different DQs operationalized and measured by V-dem, their properties and subcomponents, and how and why they relate to per capita CO_2 emissions in countries. Since the participatory DQ has subcomponents with somewhat contrasting effects on CO_2, I create in total eight directional hypotheses: on for each of the four subcomponents of the participatory DQ and one for each of the four remaining DQs.

3. Data

In this chapter, I describe the contents of all variables used in the analysis and how each term is operationalized. Each variable is related to CO_2 emissions through certain mechanisms that explain how the relationship works. I start with the dependent variable (section 3.1), before moving on to the main independent variables of interest, the democratic qualities (DQs) (section 3.2). I have six control variables in the analysis and explain why I have chosen them in section 3.3. In section 3.4, a few control variables omitted from the analysis for various reasons are outlined. I end this section by giving a justification for the chosen range of years in the study (section 3.5). All variables and their status in the analysis are outlined in Table 2.

Table 2. All variables with status and data source.

Variable	*Definition*	*Status*	*Source*
CO_2pc	Carbon dioxide emissions (metric tons per capita)	Dependent	World Bank (2019)
Electoral DQ	Electoral democratic quality	Independent	V-dem (2018)
Liberal DQ	Liberal democratic quality	Independent	V-dem (2018)
Deliberative DQ	Deliberative democratic quality	Independent	V-dem (2018)
Egalitarian DQ	Egalitarian democratic quality	Independent	V-dem (2018)
Participatory DQ	Participatory democratic quality	Independent	V-dem (2018)
Civil Society	Civil Society Organization participation. Subcomponent of Participatory DQ	Independent	V-dem (2018)
Direct	Direct democracy. Subcomponent of Participatory DQ	Independent	V-dem (2018)
Local	Local democracy. Subcomponent of Participatory DQ	Independent	V-dem (2018)
Regional	Regional democracy. Subcomponent of Participatory DQ	Independent	V-dem (2018)
GDPpc	Gross domestic product per capita (constant 2005 international $)	Control	Institute for Health Metrics and Evaluation (2018)
$GDPpc^2$	GDPpc squared	Control	
Trade	Ratio of imports plus exports of GDP	Control	World Bank (2019)
Urbanization	Amount of population living in urban areas	Control	World Bank (2019)
Trend	General time trend	Control	
Oilpc	Oil production per capita (billion metric tons)	Control	Ross & Mahdavi (2015)
Gini	Income inequality index	Omitted	
Energy use	Energy use per capita	Omitted	
Energy intensity	Carbon intensity of energy	Omitted	
Energy mix	Share of renewable energy	Omitted	
Corruption	Corruption index	Omitted	

3.1 Dependent variable

The dependent variable in this study is national Carbon Dioxide (CO_2) emissions, measured in metric tons per capita. I use CO_2 emissions as a proxy for countries' contribution to climate change, as this is the standard approach. CO_2 makes up the largest share of greenhouses gases contributing to climate change and global warming. The data is gathered from the World Bank's World Development Indicators (World Bank, 2019). According to the World Bank definition, CO_2 emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during the consumption of solid, liquid, and gas fuels and gas flaring. Thus, CO2 emission is calculated primarily through the amount of energy consumption. In spite of these relative shortcomings, this is the proxy most commonly used in the literature (see e.g. Clulow, 2019; Joshi & Beck, 2018; Lægreid & Povitkina, 2018; Lv, 2017; Mayer, 2017; You et al, 2015) due to data availability and reliability (Clulow, 2019). For this reason, and the fact that using the same proxy as other studies provides more comparable results, I use data from the World Bank.

An alternative approach could be to study countries' commitment to climate change mitigation, instead of the outcome, i.e. CO_2 emissions. Neumayer (2002) makes a strong case for this approach. He argues that the main difference we expect to see between democratic countries and non-democratic countries are the commitment, or efforts, to reduce emissions. Because of the significant time-lag between policy implementation and outcome, studying the outcome will not tell us the difference in nations' efforts and therefore provide limited insight into the role of democracy in climate change mitigation.

I have two main counterarguments to Neumayer (2002): Firstly, the time-lag argument, although true, should be given less importance today than in 2002, when mitigation efforts was in its infancy. Today, we would expect policy measures to be, at least to some degree, translated into outcome. Secondly, we are *more* interested in outcome than in commitment. If, for instance, democratization results in higher national emissions, all else equal, it is of less importance how high the national reduction efforts and commitments are. Still, climate change mitigation policy could be a relevant control variable to include in this study. But due to poor data availability, I do not model the effect of policies.

3.2 Independent variables

In this study I am interested in the comparative effect of five main independent variables, electoral democratic qualities (DQs), liberal DQs, deliberative DQs, egalitarian DQs and participatory DQs. Since the aggregation of the participatory DQ carry less intuitive meaning than the other indices (see section 2.3), I disaggregate the index, and use its subcomponents in a supplementary analysis.

All the DQ indices, except the deliberative DQ, are aggregated measures of several subcomponent indices, shown in Table 1. For example, the Liberal DQ index is an aggregated measure of three subcomponent indices, namely the "Equality before the law and individual liberty index", the "Judicial constraints on the executive index" and the "Legislative constraints on the executive index" (Coppedge et al., 2018). These subcomponents are made up of a combination of observations and expert knowledge gathered through Likert-type scale questionnaires from a total of over 3000 country-experts around the world. The country-experts are chosen based on academic credentials. To mitigate possible biases and unreliability, the country-experts work with years and countries they know best. Each country-expert also provide a certainty rating to their own coding which is taken into account in the Bayesian factor analysis that weights the indicators and aggregates them into the indices in the dataset (Coppedge et al., 2018).

All the component indices used in this analysis are conceptually unique in the sense that they do not share any of the same indicators. Still, I believe it is unlikely that the DQs do not somewhat overlap, as they are measures of qualities related to the same concept. For instance, I expect "Engaged society", a subcomponent of the deliberative DQ, to measure some of the same attributes as "Civil society participation", a subcomponent a the participatory DQ. Likewise, I believe that for a country to score highly on deliberative DQ, it has to have a certain degree of "Equal access to power", a subcomponent of the Egalitarian DQ. For this reason, I do not include interactions between any of the indices in my models.

The indices range on a continuous scale from 0 to 1, with higher values corresponding to higher measured amounts of either of the qualities. The indices are moderately to highly empirically correlated (Spearman's r = 0.6–0.9). All data comes from Varieties of Democracy (V-dem) (Coppedge et al., 2018).

3.3 Control variables

There are a number of factors that affect the level of CO_2 emissions in nations. In this study, I use control variables established in the empirical literature as determinants of national CO_2 emissions to isolate the effect of democracy and democratic qualities. In 17 past studies looking at the relationship between democracy and CO_2 (Arvin & Lew, 2011; Bättig & Bernauer, 2009; Clulow, 2019; Farzanegan & Markwardt, 2018; Farzin & Bond, 2006; Gallagher & Thacker, 2008; Gleditsch & Sverdup, 2002; Joshi & Beck, 2018; Kinda, 2011; Lægreid & Povitkina, 2018; Li & Reuveny, 2006; Lv, 2017; Mayer, 2017; Midlarsky, 1998; Policardo, 2016; Povitkina, 2018; You et al., 2015), the total number of different control variables is close to 50. Including all these would lead to issues with overspesification and multicollinearity (Crawley, 2015). To achieve a parsimonious model, I include only the most common and best documented control variables.

3.3.1 GDP per capita and GDP per capita squared

The most commonly used determinant of national CO_2 emissions is national income. I use gross domestic product (GDP) per capita, attained from the Institute for Health Metrics and Evaluation (IHME) to measure this property. IHME have merged six of the most used indicators of GDP per capita for 210 countries from 1950 to 2015 to create an indicator without gaps (James, Gubbins, Murray, & Gakidou, 2012). The values are measured in 2005 international dollars.

Economic development, in addition to population growth, is the most important driver of CO_2 emissions globally (Blanco G. et al., 2014). The environmental economic literature states that the effect of economic growth on CO_2 emissions depends on the outcome of three separate mechanisms: changes in scale, composition and technology (Grossman & Krueger, 1995). Firstly, "scale" changes refer to the fact that production is a component of GDP. Increases in GDP per capita lead to increases in production and subsequent increases in CO_2 emissions through energy consumption and natural resource extraction, as long as the nature of the economic activity stays the same. Secondly, "composition" changes refer to what the economic activity consists of. Many studies argue that long-term increases in GDP per capita leads to a gradual shift in economic activity, first from primary towards secondary sectors, thereby increasing carbon-intensity of production, and later from secondary towards tertiary sectors, thereby decreasing carbon-intensity of production (Sarkodie & Strezov, 2019). Thirdly, "technology" changes also refer to the positive impact that high levels of economic development can have on CO_2. When countries reach a certain level of economic development, they tend to spend more on research and development and the replacement of old technologies with new, more efficient and less carbon-intensive ones. If the net "technology" and "composition" effects is stronger than the "scale" effect, the negative impact of GDP per capita on the environment would only be visible at lower levels of economic development. At higher levels, increases in GDP per capita would lead to a reduction of CO_2 emissions. This inverted-U shape of the relationship between GDP per capita and CO_2 emissions, is commonly referred to as the environmental Kuznets curve (Blanco G. et al., 2014).

The inverted U-shaped environmental Kuznets curve (EKC) hypothesis has not been found to be very robust (Blanco G. et al., 2014). In a preliminary review of the literature on the relationship between democracy and CO_2, I found evidence of an inverted U-shaped EKC in some studies (Farzanegan & Markwardt, 2018; Farzin & Bond, 2006; Li & Reuveny, 2006), while others concluded that the relationship was exactly opposite, i.e U-shaped (Arvin & Lew, 2011), others that it was S-shaped (Gallagher & Thacker, 2008), and others that it was monotonic and positive (Joshi & Beck, 2018; Lægreid & Povitkina, 2018; You et al., 2015). One common understanding, however, and the one referred to in the IPCCs 5th assessment report, is that the effect of GDP per capita on per capita CO_2 emissions is driven by the rate of economic growth, and since the fastest growing economies typically are low- and medium-income countries, the effect of GDP per capita on per capita CO_2 is typically lower in high-income countries than in low- or medium-income countries (Blanco G. et al., 2014). To model the non-linear effect of GDP per capita on CO_2 emissions, I include a GDP per capita squared term, as this has become the standard estimation technique for analyzing this effect (Sarkodie & Strezov, 2019).

Several authors also argue that the effect of democracy on CO_2 emissions per capita is conditioned by the level of income in a country. Farzin and Bond (2006) and Lv (2017) includes an interaction term between GDP per capita and democracy in their studies, and find the term to be significant and negative, meaning that countries with high levels of democracy and high levels of income reduce CO_2 emissions, while countries with only high levels of democracy does not. Lægreid and Povitkina (2018) finds similar evidence by constructing dummy variables for democratic and incorrupt governments and including an interaction term between the dummy and GDP per capita. They find that the interaction effect is significant and negative, while the effect of democratic incorrupt governments alone is positive. Lastly, Arvin and Lew (2011) constructs dummy variables based on income group and fins that for low and middle income countries, the effect of democracy on CO_2 emissions per capita is negative.

I investigate this relationship in a separate set of models by constructing dummy variables for different levels of GDP per capita for easy coefficient interpretation. Although there is an infinite number of ways to divide GDP per capita into categories, I choose, for parsimonious reasons, to I divide it into four income groups: very high (from the 75^{th} percentile to the 100^{th} percentile), high (from the median to the 75^{th} percentile), medium (from the 25^{th} percentile to the median), and low (from the 25^{th} percentile to the 0^{th} percentile).

3.3.2 Trade openness

My third control variable is trade openness, measured as the share of imports and exports as a percentage of GDP. The main reason to include this variable, is that it taps into the relationship between GDP per capita and its squared term, and per capita CO_2 emissions (Cole & Neumayer, 2005). The "composition" and "technology" change mechanisms (mentioned above) hypothesize that economies transition towards less carbon-intensive sectors and means of production as the economy matures. This suggests that developed countries might be importing its pollution-intensive products from the developing world instead of producing it themselves, the so-called "pollution displacement-hypothesis". According to this hypothesis, an increase in trade openness overall will have opposite effects for developed and developing countries. For developed countries, an increase in trade openness might explain the emission reductions hypothesized by the EKC at high levels of income if they import, instead of produce, their carbon-intensive goods. Likewise, in developing countries, an increase in trade openness might explain the emission increase hypothesized by the EKC at low levels of income as they produce and export the carbon-intensive goods the high-income countries consume (Cole & Neumayer, 2005). It is therefore an important variable to include to reduce this possible spurious EKC-effect between GDP per capita and per capita CO_2 This variable also involves changes to environmental regulation, as some international trade treaties countries sign may require regulatory changes at home (Li & Reuveny, 2006). The data for trade openness comes from the World Development Indicators (World Bank, 2019)

3.3.3 Urbanization

My fourth control variable is urbanization, measured as the share of the population living in urban areas. The effect of urbanization on CO_2 is somewhat ambiguous. On the one hand, urbanization can lead to less per capita CO_2 emissions partly because private transport needs are lower and can be covered by public transportation in densely populated areas and cities (Poumanyvong & Kaneko, 2010). The energy needs for heating is also comparatively lower in cities because people inhabit less space and live in smaller housing units (Timmons, Zirogiannis, & Lutz, 2016). On the other hand, urbanization can lead to higher per capita CO_2 emissions, especially in countries at the low and intermediate levels of development, as urbanization is often accompanied by an increase in manufacturing activities in these countries (Poumanyvong & Kaneko, 2010). Data on urbanization comes from the World Development Indicators (World Bank, 2019).

3.3.4 Trend

Following Farzanegan & Markwardt (2018) and Lægreid & Povotkina (2018), I include a time trend as my fifth control variable. This is to control for the effect of a common technological progress on CO_2 emission.

3.3.5 Oil production per capita

My sixth control variable is oil production per capita. I include this variable to proxy the presence of strong petroleum lobbies that might make climate policies harder to implement (Lægreid & Povitkina, 2018; Povitkina, 2018). The extent of oil production per capita might also indicate the petroleum industry's share of the economy, and the relative importance of maintaining high levels of production. The share of oil revenues in GDP would serve as a better proxy for the latter, but due to data availability, this is not included. As Lægreid & Povitkina (2018) argues, oil reserves, in addition to coal production and reserves, should be included for a fuller picture of the role of carbon-intensive industry, but this data is not openly available. Oil production is measured in billion metric tons, and is gathered from Ross and Mahdavi (2015). I divide oil production by population numbers gathered from the World Development Indicators (World Bank, 2019) to achieve a variable for oil production per capita. Descriptive statistics of all variables is available in the appendix (section 9.1).

3.4 Omitted variables

3.4.1 Income inequality

One control variable that I would like to include, is income inequality. The literature on the effect of income inequality on CO_2 emissions contains competing views. On the one hand, higher income inequality could lead to more CO_2 emissions as it reinforces the power of the richest members of society, who has no interest in protecting the environment (Berthe & Elie, 2015; Boyce, 1994). On the other hand, increasing income inequality can lead to less CO_2 emissions, particularly in developing nations, because the threshold for a more carbon-intensive lifestyle, e.g. affording cars for transport and modern energy sources for heating and cooking, is reached for a larger number of households when income is distributed more evenly (Grunewald, Klasen, Martínez-Zarzoso, & Muris, 2017; Heerink, Mulatu, & Bulte, 2001).

Income inequality is typically measured using Gini. Gini gives the theoretical value of 1 in nations with perfect inequality, i.e. where one person receives all the income. Similarly, Gini has the theoretical value of 0 when everyone in a country has the exact same income. Due to the fact that I have not been able to attain consistent high-quality data for Gini, I do not control for this effect in my main analysis. The field is dominated by small-N studies (Berthe & Elie, 2015), suggesting that data availability is an issue for others as well. One study that does succeed, however, in using Gini for a similar time frame and number of countries, is Grunewald et al (2017). Their data comes from the Standardized World Income Inequality Database, a database that contains data from a number of different sources that uses different estimation techniques and different methodology. Grunewald et al (2017) use an algorithm to fill in missing values and make the data from different sources comparable. I have not been able to reproduce their efforts.

3.4.2 Energy mix and intensity

Following Lægreid and Povitkina (2018), I do not control for energy use, -intensity or -mix (share of renewables). These variables are commonly included to account for technological progress (Clulow, 2019; Joshi & Beck, 2018), as a proxy for energy subsidies (Farzanegan & Markwardt, 2018), or to model the direct link between energy consumption and emissions (Joshi & Beck, 2018; Mayer, 2017). I do not include these variables as they tap into the mechanisms that explains a potential EKC-relationship between GDP per capita and CO_2 emissions per capita, i.e. changes in the composition and technology of production (Lægreid & Povitkina, 2018).

3.4.3 Corruption

Some studies (Lægreid & Povitkina, 2018; Povitkina, 2018) has examined how the presence of corruption mediates the relationship between democracy and CO_2 emissions per capita. Based on evidence from Lewis (2007) and Wilson and Damania (2005), they argue that the process from policy output to intended environmental outcomes require that the public officials are incorrupt. More corrupt officials tend to enrich themselves instead of pursuing policy goals (Lewis, 2007) and to underreport harmful activity, such as emission levels (Wilson & Damania, 2005). Lægreid and Povitkina (2018) find no evidence that corruption affects the relationship, while Povitkina (2018), using an interaction term between democracy and corruption, find that democracy is associated with less CO_2 emissions, but only in countries where corruption is low. I omitted this variable after significance-testing of the effect using likelihood ratio tests (explained in section 4.2). The effect of corruption was not significant in any of the robustness test models. Most importantly, it did not alter the interpretation of any of the other coefficients in the slightest. The interaction effect between corruption and democratic quality was not significant in any of the models either. Still, to include it as an interaction and assume an index that measures corruption as something entirely separate from indices measuring DQs is unlikely to be a true assumption. Although corruption is not directly part of the operationalization of any of the DQs, I find it hard to image that the measurement methods and tools does not capture elements of corruption when measuring democracy and democratic qualities.

3.5 Time span

In this study, the analysis ranges from the year 1992 to 2014. Many similar studies (Arvin & Lew, 2011; Lægreid & Povitkina, 2018; Li & Reuveny, 2006; Policardo, 2016; Povitkina, 2018) looking at the effect of democracy on CO_2 emissions over time use data for national emissions starting in the 1950s, 1960s or 1970s, and study the effect over several decades. Although this might make sense for other environmental outcomes, such as air pollution and land degradation, it hardly makes sense for CO_2, except as a way to increase the number of observations and the statistical power of the models. In those decades there were hardly any scientific consensus on the issue, and much less an organized effort to reduce emissions around the world, meaning that fluctuations in CO_2 emissions for these years is hard to contribute to political and institutional processes.

Instead, one reasonable starting point for global climate change mitigation efforts might be the late 1980s: in 1987, *Our common future* (UN World Commission on Environment and Development, 1987) put climate change into a global development context and highlighted its negative impacts, in 1988, the Intergovernmental Panel on Climate Change was set up, and in 1989, a number of high-level political conferences were held around the world that discussed the climate change issue (Gupta, 2010). Still, it was not until 1992 when the United Nations Framework Convention on Climate Change was adopted at the Earth Summit in Rio de Janeiro, that an international agreement on the issue existed. The treaty defined its objective as “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (United Nations, 1992), and marks the beginning of international climate change mitigation efforts. For that reason, my analysis starts in 1992. It ends in 2014 because of data availability for oil production.

4. Method

My final panel dataset consists of 161 countries (available in the appendix, section 9.2), measured from 1992 to 2014. The panel is unbalanced, containing 3452 units (country-years), meaning that not all countries have observations for all 23 years. In this chapter, I start by outlining the dominant traditional and current approaches to modeling panel data before describing the caveats of these approaches as identified in contemporary statistical literature and further provide a detailed explanation of my choice of method (section 4.1). I continue by describing how the models are specified and why in section 4.2. Section 4.3 contains the model validation process and outlines the different tests used and justifications for the choices made. Section 4.4 explains how and why I have landed on the robustness test chosen for the analysis.

4.1 Choice of method

The dominant approach for modeling panel data, until recent years, has been pooled Ordinary Least Squares (OLS) regression (see e.g. Bättig & Bernauer, 2009; Gleditsch & Sverdup, 2002; Midlarsky, 1998; Neumayer, 2002). The problem, however, with modelling panel data using this technique, is that it violates the critical assumption of independent errors (Finch, Bolin, & Kelley, 2014). CO_2 emission levels from the same country are more likely to be similar than CO_2 emission levels from different countries. Failing to model this multilevel data structure will result in an inappropriate estimate of the standard errors for the model parameters, and most likely also heterogeneity bias. Results from simple pooled OLS regressions, available in the Appendix (section 9.3), show that the effects of different democratic qualities, except egalitarian, on per capita CO_2 emissions are consistently negative. As I will show, this is not the case, and using this modelling technique would lead to false estimations. Figure 4.1 illustrates this heterogeneity bias. The OLS regression line, represented by the dashed line, fails to account for the hierarchical data structure, thereby falsely estimating a net negative effect of a certain democratic quality on CO_2 emissions per capita.

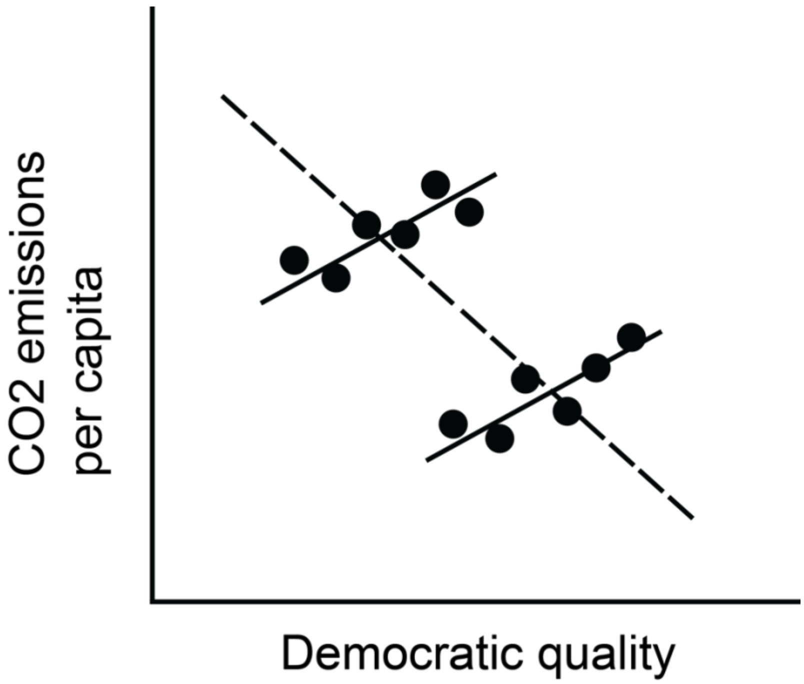

Figure 4.1. Illustration of the heterogeneity bias in an OLS-model. Points represent country-years, dashed lines the OLS-estimated regression line, and solid lines within-country effects. Adopted from Clulow (2019).

One way to provide evidence behind the claim that emission levels are more similar within countries than between countries, as shown in Figure 4.1, is by calculating the intraclass correlation coefficient (ICC). This is a measure of the proportion of variance in the dependent variable that occurs between countries versus the total variation present (Finch et al., 2014). For my sample of 161 countries and 23 years, the ICC show that 92% of the variation in the data is between countries, and only 8% of the variation occurs within countries.

In the field of political science, several approaches to modeling hierarchical data such as years nested in countries, and estimating both the effect within countries and between countries, while accounting for the heterogeneity bias problem, exist. Two methods: the fixed effects model, referred to as "the gold standard" by Bell & Jones (2015), and the random effects model, are particularly common. However, Bell et al (2018) argue that "… the random effect model provides everything the fixed effects model provides and more". Fixed effects models construct dummy variables for each higher-level entity, i.e. countries in my dataset, and/or the high-level interactions with the time-varying covariates, to avoid the heterogeneity bias in the OLS model. By doing this, it effectively controls out all the higher-level variance in the sample, and only the within-effects are estimated, "… and so nothing can be said about a variable's between-effects or a general effect" (Bell & Jones, 2015). Instead, random effect models solve the heterogeneity bias problem by estimating the error term differently. By partitioning the unexplained residual variance into two: the higher-level residuals for each higher-level entity (country), and the occasion-level residuals for each occasion (years) for each higher-level entity (country), the random effects model allows for differential intercepts (between-effects) by estimating the deviation in the higher-level residuals from the mean residuals (Bell & Jones, 2015). The equation for a random intercept model with one independent variable would then be (adopted from Bell et al (2018)):

Equation 1

$$y_{it} = \beta_0 + \beta_{1W}(x_{it} - \bar{x}_i) + \beta_{2B}\bar{x}_i + (v_i + \epsilon_{it})$$

Here y_{it} is the dependent variable, measured for each higher-level entity i and occasion-level t. x_{it} is a time-varying independent variable divided into two: β_{1W} represents the average within effect of x_{it}, whilst β_{2B} represents the average between effect. v_i represents the residuals for each higher-level entity, and ϵ_{it} are the occasion-level residuals for each occasion for each higher-level entity. β_0 is the intercept.

If the model is specified to allow for differential slopes (within-effects), as well, the equation would look like this (Bell et al., 2018):

Equation 2

$$y_{it} = \beta_0 + \beta_{1W}(x_{it} - \bar{x}_i) + \beta_{2B}\bar{x}_i + v_{i0} + v_{i1}(x_{it} - \bar{x}_i) + \epsilon_{it}$$

Here, the random part of the model includes two terms for the higher-level entities: v_{i0} represents the residuals attached to the intercept, whilst v_{i1} represents the residuals attached to the slope, turning β_{1W} into a weighted average of the within effect.

To model the hierarchical data structure, I use multilevel linear modeling (MLM), a type of random effect modeling. Figure 4.2 show that the effect of democracy on per capita CO_2 emissions is non-uniform across countries. For some countries the bivariate correlation is positive and strong (e.g. Bosnia and Herzegovina), for others the effect it is negative (e.g. Afghanistan). This is true for the other democratic qualities as well. This exemplifies the crucial importance of applying a model that accounts for these individual differences. If the model does not take the variations in slope into account, the model will underestimate the standard errors (Bell et al., 2018), increasing the possibility of a type 1 error. Bell et al (2018) and Barr et al (2013), among others, have shown via simulations that random effect models without random slopes have a higher type 1 error rate in general.

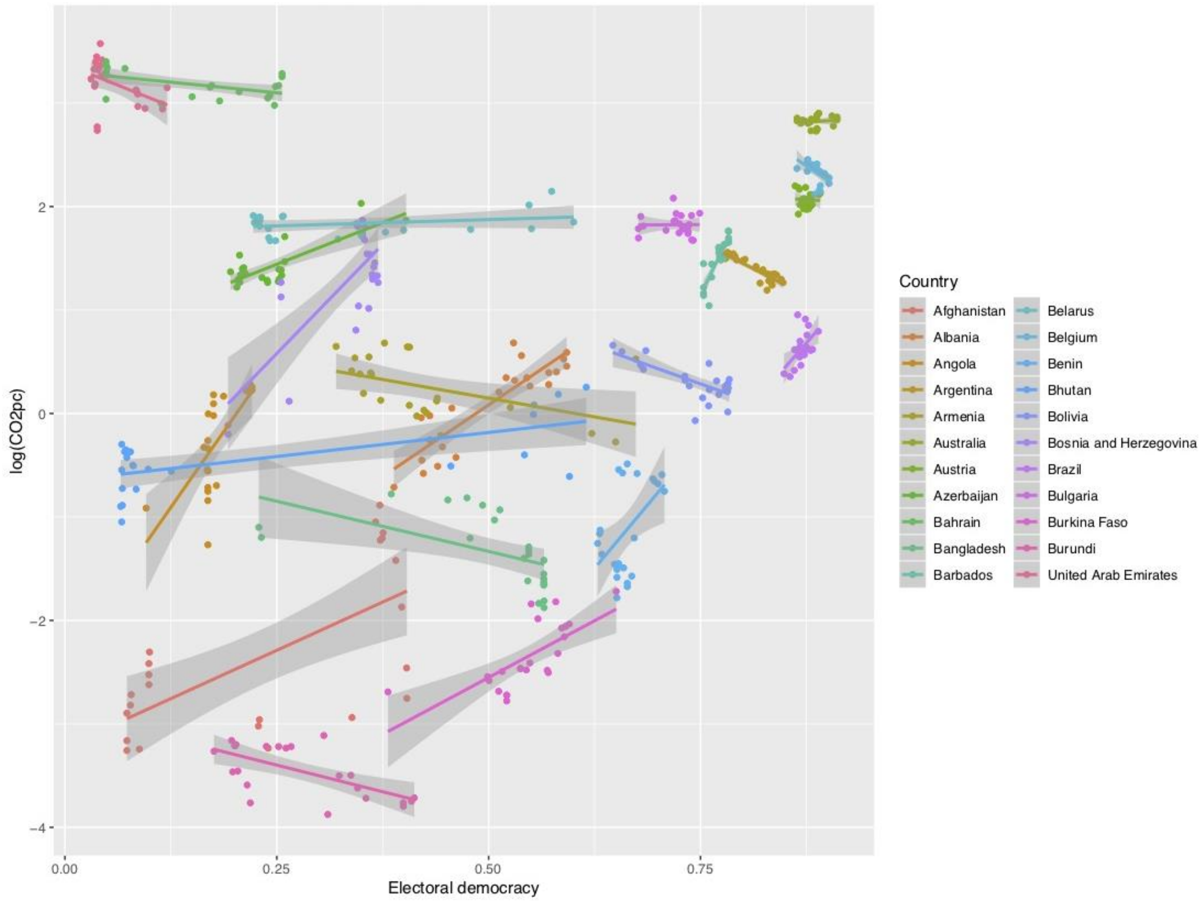

Figure 4.2. Plot of the hierarchical data structure in the dataset. The natural logarithm of CO_2 emissions per capita and electoral democracy for the 20 first countries in my panel dataset. Points represent observations in country-year. Lines represent the estimated bivariate OLS regression line for each country.

4.2 Model specification

I test the significance of the random effects in the model using a likelihood ratio test (LRT). The test is performed by comparing the goodness of fit of an alternative model to a full model (Luke, 2017; Zuur, Ieno, Walker, Saveliev, & Smith, 2009), i.e. a model with both random intercepts and random slopes for each democratic quality with a model without a random slope. The result from this test confirmed that including random slope in the model provides a better fit to the data for all democratic qualities, except for the egalitarian democratic quality. The result from the LRT for electoral democracy was $L = 13.28$ ($df = 12$, $p < 0.01$), for liberal democratic qualities $L = 10.72$ ($df = 12$, $p < 0.01$), for deliberative democratic qualities $L = 16.38$ ($df = 12$, $p < 0.001$), for egalitarian democratic qualities $L = 0.93$, ($df = 12$, $p > 0.1$) and for participatory democratic qualities $L = 37.39$ ($df = 12$, $p < 0.001$). Including random slope for egalitarian democratic qualities did not alter the size or significance of the estimated effect, so I include a random slope for egalitarian democratic qualities.

I use LRTs to test the significance of the control variables as well. This is way to circumvent the issue connected with p-values obtained from t-tests in panel models (Bates, 2006; Luke, 2017). When these models become complex, i.e. multi-level, unbalanced or corrected for temporal and spatial correlation, it is not at all obvious which degrees of freedom should be used in the calculation of the p-values in t-tests, and the reliability of t-tests for testing significance is limited (Luke, 2017). LRT does not have this problem, as it compares the total model fit of two different models to see which one is better. This method has been proven to be sensitive to sample size, but in large datasets, such as mine, it is known to perform well (Luke, 2017). The LRTs show that the effects of all control variables are significant at the 0.05 level.

As control variables, I have both gross domestic product (GDP) per capita and its squared term. This means, effectively, that these measures are highly correlated. Including both of them in their original state would likely lead to a false estimation of the effects (Finch et al., 2014). I therefore center these variables by subtracting the mean from each individual value. I calculate the variance inflation factor (VIF) to investigate the presence of collinearity after centering, and find no values above 2, meaning no collinearity is present (Finch et al., 2014; Zuur et al., 2009). Before centering, the calculated VIF for GDP per capita and GDP per capita squared were above 70. During data exploration, I also found some quite high bivariate correlations between other variables, e.g. Urbanization and GDP, in addition to the between-correlations of the democratic quality (DQ) indices. For this reason, and for easier interpretation of the intercept, I do the same for all other right-hand-side variables.

4.3 Model validation

As with all regression, certain assumptions need to be upheld for the model to provide valid results. These are, most importantly, normality, homogeneity and independence (Zuur et al., 2009). The first assumption, normality, refers to how the residuals from a fitted model are distributed. A linear model assumes the residuals to have a normal distribution. According to Zuur et al (2009), several authors argue that violation of normality is not a serious problem as long as the sample size is large enough. I investigated the distribution of the residuals graphically by pooling all the residuals together and making a histogram of them. Using the raw untransformed data lead to serious violations of normality. To achieve normality, I transformed the data for several heavily skewed variables using the natural logarithm of the values. These were GDP per capita and GDP per capita squared, Oil production per capita, Trade openness, and the dependent variable: CO_2 emissions per capita. Log-transforming variables, both independent and dependent, to achieve normality, is currently a widely used approach in the field (see e.g. Mayer, 2017; Lægreid & Povitkina, 2018; Povitkina, 2018; Lv, 2017). After transformation, the histogram of residuals (available in the appendix, section 9.4) showed only slight negative skewness.

The second assumption, homogeneity, refers to the spread of the data at each X value. Ideally, the spread of the residuals should be equal for all values of X (Zuur et al., 2009). I checked for homogeneity graphically by plotting the residuals against the fitted values (available in the appendix, section 9.4). No violation of homogeneity was detected. I could also have performed a number of tests to assess both the assumption of normality and homogeneity, but since small violations of these assumption is acceptable (Zuur et al., 2009), many of the homogeneity tests require perfect normality (Zuur et al., 2009) and the statistical literature generally recommends graphical assessments (Crawley, 2015; Finch et al., 2014; Zuur et al., 2009), I stick to that.

The third assumption, independence, is the most critical assumption in linear regression (Zuur et al., 2009). The assumption is violated if the Y value at X_i is influenced by other X_i. There are basically two ways this violation can happen: Firstly, if the relationship between an independent and dependent variable is non-linear, and you fit a straight line through the data, the residuals will show a clear pattern if you plot them against the independent variable: all residuals will be positive or negative. This can be dealt with through transforming the data and "linearizing the relationship" (Zuur et al., 2009). Secondly, if the data is correlated with other data either spatially or temporally, the residuals will also show a clear pattern or clustering.

To test the first type of violation, I plotted the residuals against the data from each variable in the model, including possible omitted variables. After some of the variables were log-transformed, I detected only very small signs of unequal variance in one variable, namely the country-variable (graph available in the Appendix, section 9.4). The second type of violation is partitioned into two: temporal correlation and spatial correlation. Temporal correlation happens when the values for one observation at time t is correlated with an observation at an earlier time, for instance $t - 1$. Since my dataset is longitudinal with one observation per year, and CO_2 emissions for one year are expected to be similar to CO_2 emissions from the previous year, I expect temporal correlation to be present. To test for temporal correlation, I plotted the auto-correlation function (ACF) (Zuur et al., 2009). This showed serious temporal correlation. To correct for this, I added a correlation correction structure to the model, a type of weighting function that removes the temporal covariance. Following Zuur et al (2009), I tested a number of different correction structures with LRTs to see which one provided the best fit to the data, while still correcting the temporal correlation, and ended up with a Gaussian correlation structure as the best fit.

The other way to violate the second part of the independence assumption, is by not accounting for spatial correlation, if this is present (Zuur et al., 2009). One would expect that neighboring countries are more similar than countries that are far apart, as they often share similar cultural, political and economic characteristics. I tested for spatial autocorrelation using a Moran's I test. Moran's I is calculated by comparing the residuals from a fitted model with the latitude and longitude of each country capital to see if the unexplained variance correlates with the geographical properties of the dataset (Jackson, Huang, Xie, & Tiwari, 2010). The result from the Moran's I test indicated that spatial autocorrelation was indeed present ($p < 0.001$). But after random effects and temporal autocorrelation was accounted for, the test showed that the spatial correlation was not significant at the 0.05 level. I also tested if certain spatial correction structures approved the model fit using LRT and found that the model was indeed better without further spatial correction (Zuur et al., 2009).

After validation, this is the final form of the model:

Equation 3

$$lnCO_2pc_{it} = \beta_0 + \beta_1 DQ_{it} + \beta_2 lnGDPpc_{it} + \beta_3 lnGDPpc^2{}_{it} + \beta_4 Urban_{it} + \beta_5 lnTrade_{it} + \beta_6 lnOilpc_{it} + \beta_7 Trend_i + v_{i0} + v_{i1}(x_{it} - \bar{x}_i) + h(\epsilon_t, \epsilon_s) + \epsilon_{it}$$

Here, $lnCO_2pc_{it}$ represents the natural logarithm of CO_2 emissions per capita, measured for each country i and year t. DQ_{it} represents the democratic quality in each model, $lnGDPpc_{it}$ and $lnGDPpc^2{}_{it}$ represents the natural logarithm of GDP per capita and its squared term, $Urban_{it}$ represents the level of urbanization, $lnTrade_{it}$ represents the natural logarithm of trade openness, $lnOilpc_{it}$ represents the natural logarithm of oil production per capita, $Trend_i$ represents the technological time trend and $h(\epsilon_t, \epsilon_s)$ represents the temporal error correction function for the correlation between year t and year s (Zuur et al., 2009). See equation 2 for details on the random effect estimations. In the beta estimates from the model output, the β_{1W} and β_{2B} coefficients from equation 1 and 2 is combined into one weighted average effect of both the within and between effect of an independent variable. Therefore, in equation 3, β_1 represents the combined coefficients of β_{1W} and β_{2B}.

I run four separate sets of models. The first is the main analysis, where I run the model above once for each DQ to estimate the comparative effects of each DQ on CO_2 emissions per capita. In the second set of models, I run the model once for every subcomponent of the participatory DQ. In the third set of models, I run a slightly different model, where interactions between each DQ and dummy variables for income group is included. The third set of models look like this:

Equation 4

$$lnCO_2pc_{it} = \beta_0 + \beta_1 DQ_{it} * \beta_8 GDPpcVeryHi_{it} + \beta_1 DQ_{it} * \beta_9 GDPpcHi_{it} + \beta_1 DQ_{it} * \beta_{10} GDPpcMed_{it} + \beta_2 lnGDPpc_{it} + \beta_3 lnGDPpc^2{}_{it} + \beta_4 Urban_{it} + \beta_5 lnTrade_{it} + \beta_6 lnOilpc_{it} + \beta_7 Trend_i + v_{i0} + v_{i1}(x_{it} - \bar{x}_i) + h(\epsilon_t, \epsilon_s) + \epsilon_{it}$$

Here, $\beta_8 GDPpcVeryHi_{it}$ represents the dummy variable for income group "very high", $\beta_9 GDPpcHi_{it}$ the dummy variable for income group "high" and $\beta_{10} GDPpcMed_{it}$ the dummy variable for income group "medium". The "low" income group is used as reference. I do not omit the GDP per capita or GDP per capita squared variables from this analysis. The presence of these variables is still crucial for estimating the controlled effect of the DQs and omitting them therefore causes inflated standard errors even though GDP per capita is included as dummy variables. The variance inflation factor (VIF) for these models are higher, though all variables have values below 6. This is regarded, by some authors (Zuur et al., 2009), as too much collinearity to include in an analysis, while others (Finch et al., 2014) argue that it lies within a reasonable cut-off range. I therefore continue with this approach but interpret the results with caution. The fourth set of models use the subcomponents of the participatory DQ for an analysis on the effect on CO_2 emissions per capita for different levels of GDP per capita, similar to the former set of models.

4.4 Robustness testing

Although the model validation process provided no particular reason to question the results from the models in my main analysis, I conduct a robustness test on a balanced table. There are three reasons why I think this is a suitable test for robustness in the estimates. The first reason is that I expect the missing values in my dataset to be systematically missing, i.e. violating the missing completely at random- and missing at random-principles (Christophersen, 2013; King, Honaker, Joseph, & Scheve, 2001). I expect this because many missing values corresponds with socioeconomic or historical contexts. For instance, many of the countries that came out of the Soviet Union, Czechoslovakia and Yugoslavia, have missing values for the first years after they became autonomous. Similarly, many underdeveloped, less democratic war prone countries have missing values, while highly developed, more democratic countries at peace, rarely do. This gives a bias to the models as they use listwise deletion of all missing data, meaning that they remove the entire row of data if one observation for one variable is missing and only estimate the effect of complete observation rows. One way to tackle this issue, is to impute this data manually or via algorithms, but as King et al. (2001) points out, this "…requires much expert knowledge [and] there is little consensus about this even among the experts". The second reason is that the number of parameters in an unbalanced panel from which to calculate p-values is unclear. As mentioned above, t-tests use the degrees of freedom as the denominator when calculating p-values. But when these come from an unbalanced panel, it is unclear whether the number of observations, the number of higher-level entities or the number of random effects should be used (Luke, 2017). One way to assess the validity of p-values from t-tests from an unbalanced panel, is to use LRTs in a similar way as explained above, the other is to apply the same model to a balanced panel and see if the p-values are similar. I do both to limit the possibility of a type 1 error.

The third reason for using a balanced panel as a robustness test is that balancing the dataset effectively removes the small violation of normality and the small violation of independence, in addition to removing any outlier countries detected from the data exploration or model validation process.

An acknowledgement of the trade-off between removing countries and achieving a balanced panel is needed. The fact that information about my population is effectively removed in the balancing process means that the inference from my models is weakened for the omitted countries, and possibly for the entire population. One could even argue that removing countries with missing values would leave to even more biased results than I get from the systematic missing values, as I control out countries systematically. The results from the robustness tests should therefore be interpreted with this recognition in mind. My balanced panel contains 142 countries (available in the appendix, section 9.2) from 1995–2014. The dataset contains fewer years than the main panel. This comes as a result of an unavoidable trade-off between maintaining a large number of countries and the original time span.

All modeling, testing and graphing are performed in R (R Core Team, 2018) using the following packages: "lme4" (Bates et al., 2017), "nlme" (Bates & Pinheiro, 2018), "ape" (Paradis & Schliep, 2019), "gstat" (Pebesma, 2004) , "stargazer" (Hlavac, 2018), "ggplot2" (Wickham, 2017), "moments" (Komsta & Novomestky, 2015), "data.table" (Srinivasan, 2019), "visreg" (Breheny & Burchett, 2017).

5. Results

In this chapter, I start out by presenting the results from the analysis of the different democratic qualities' (DQs) effect on CO_2 emissions per capita (subsection 5.1.1). I present and interpret all coefficients, including control variables, and provide a particularly detailed substantive interpretation for the effects of the DQs and the results regarding the environmental Kuznets curve (EKC) theory. Then, I present the results for the subcomponents of the participatory democratic quality (DQ) (subsection 5.1.2). After that, the effect of DQs on CO_2 per capita at different income levels is presented, both for the DQs (5.1.3) and for the subcomponents of the participatory DQ (5.1.4). Robustness testing is done on the same models, but with a balanced panel instead (5.2.1–5.2.4). I compare the robustness tests with the original models and argue, based on the results, that the egalitarian DQ should be disaggregated and examined in the same way as the participatory DQ. The results therefore end with a presentation of the subcomponents of the egalitarian DQ (5.3), before I sum up the most important finding (5.4).

As mentioned in the previous chapter, the estimated p-values from t-tests are not always reliable for unbalanced panels. I do, however, still print the significance level provided by the p-values from t-tests in all models, as this is the common approach. The deviations in the estimated p-value from the t-test to the Likelihood ratio tests (LRT) in my models are very small, and if it is not explicitly mentioned in the text, they fall within the same confidence interval. Because of the data transformations used, substantive interpretation of coefficients is not straight-forward. I therefore back-transform the data in a few different ways, following Ford (2018) and UCLA (2018), to provide the interpretations I present in this chapter. I do not provide interpretations for non-significant effects.

5.1 Main analysis

5.1.1 DQs and CO_2

Table 3. Relationships between democratic qualities and CO^2 per capita

	Model 1	Model 2	Model 3	Model 4	Model 5
Electoral DQ	0.093				
Liberal DQ		0.032			
Deliberative DQ			0.016		
Egalitarian DQ				0.304***	
Participatory DQ					0.166
lnGDPpc	0.595***	0.584***	0.591***	0.576***	0.581***
$lnGDPpc^2$	–0.096***	–0.097***	–0.096***	–0.098***	–0.097***
Trend	–0.011***	–0.011***	–0.010***	–0.010***	–0.010***
Urbanization	0.027***	0.028***	0.028***	0.028***	0.028***
lnTrade	0.060***	0.059***	0.057***	0.057***	0.058***
lnOilpc	0.073**	0.069*	0.054	0.084**	0.069*
Constant	0.639***	0.640***	0.638***	0.643***	0.635***
Observations	3 452	3 445	3 455	3 455	3 455
Countries	161	161	161	161	161
AIC	–4 275	–4 266	–4 282	–4 280	–4 307
BIC	–4 189	–4 180	–4 196	–4 193	–4 221

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. DQ: democratic quality, GDP: gross domestic product, pc: per capita, ln: natural logarithm.

Table 3 shows the relationships between the different democratic quality indices and the dependent variable, the natural logarithm of CO_2 emissions per capita. Looking at the coefficients for the DQ variables, the first important observation to make is that only one of them has a significant effect on CO_2 per capita: the egalitarian DQ. All other DQ effects are not significantly different from zero at any level (p>0.1).

Starting with the first variable, electoral DQ, the coefficient (0.093) in Model 1 is positive, but not significantly different from zero (p>0.1), i.e. I do not reject the null hypothesis. The same goes for liberal DQ in Model 2. The coefficient (0.032) is positive, but not significant. The deliberative DQ coefficient (0.016) in Model 3 is not significant either.

Egalitarian DQ is the only variable with a significant effect on CO_2 emissions per capita (p<0.01). The effect is interestingly positive, meaning that an increase in egalitarian DQ corresponds with an increase in CO_2 per capita. For substantive interpretation, I exponentiate the coefficient divided by 100 and subtract 1 before multiplying the number with 100 (Ford, 2018), and find that an increase in 0.01 in the egalitarian DQ index (which ranges from 0 to 1) corresponds to a CO_2 per capita increase of 0.304%, holding all other variables constant. For a large, high-emitting country in the medium range of the egalitarian DQ index, such as China, with a score of 0.36–0.49 in the period of study, an increase in, say, 0.2 in the index would correspond to an increase in CO2 emissions per capita of 6.268 % ($\left(\exp\left(\frac{0.304}{100} * 20\right) - 1\right) * 100$), or more strikingly, a total 645 million metric tons from 2014-levels, holding other variables constant. That is the same as Iran, the world's seventh highest emitter, emitted in total in 2014 (World Bank, 2019). The coefficient for participatory DQ in Model 5 is also positive but not significant.

The coefficients for the control variables are roughly the same in all five models. I therefore only provide interpretations for the coefficients in Model 1. The coefficient for GDP per capita (0.595) is positive and significant ($p<0.01$). Since the variable is log-transformed, the coefficient should be interpreted as the percentage increase in CO_2 per capita for each percentage increase in GDP per capita (Ford, 2018): Increasing GDP per capita by 1 %, increases CO_2 per capita by 0.595 %. GDP per capita squared is significant ($p<0.01$) and negative. The coefficient should be interpreted in the same way as GDP per capita: Increasing GDP per capita squared by 1 % decreases CO_2 per capita by 0.096 %. The coefficients have contrasting effects on CO_2 per capita, which seems, at first glance, to be evidence of an inversed U-shaped EKC-curve, i.e. that increasing GDP per capita in high-income countries decreases CO_2 emissions, while the opposite is true for low-income countries. Figure 5.1 shows how the predicted inversed U-shaped EKC-curve would look like. However, the turning point for the EKC-curve, i.e. the amount of per capita income a country must reach for the effect of GDP per capita on CO_2 emissions to be negative, is predicted to be at 110 003.8 international 2005 dollars. There is only one country-year in the entire dataset that has a value above 110 003.8 $, and that is Qatar in 2014. In fact, the 99th percentile of GDP per capita is 51 795 $, as illustrated in Figure 5.1 by the hatched area. This means, in practice, that a turning point of the EKC-curve is not observed, and that my results do not provide any evidence for a negative effect of GDP per capita on CO_2 at any level of income. Although the predicted equation can be used to extrapolate beyond the observed range, as in Figure 5.1, it is strictly valid only within the range of the observed data (Altman & Bland, 1998). Only a slight moderation of the effect size is therefore predicted at higher levels of observed GDP per capita. This result is similar to many others in recent years (see e.g. Joshi & Beck, 2018; Lægreid & Povitkina, 2018; Sarkodie & Strezov, 2019; You, Zhu, Yu, & Peng, 2015).

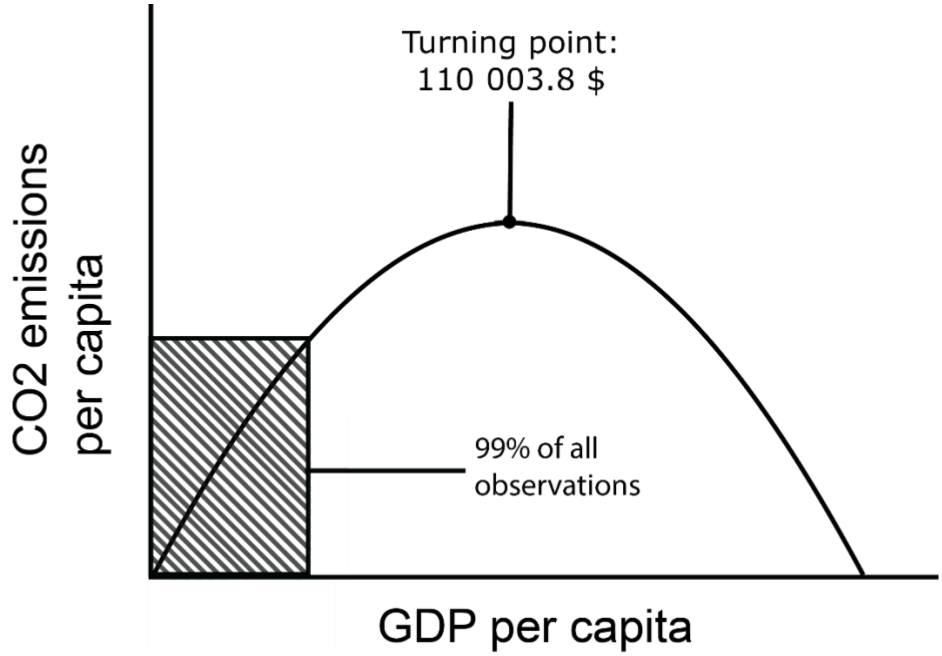

Figure 5.1. The predicted effect of GDP per capita on CO2 per capita from Model 1. The curve represents the combined effects of GDP per capita and GDP per capita squared on CO_2 emissions per capita from Model 1 in Table 3 ($CO_2pc = 0.595 * GDPpc - 0.096 * GDPpc^2$) when holding all other variables constant. The hatched area represents 99% of all observations, indicating that the effect of GDP per capita on CO_2 per capita is close to monotonic, but still slightly non-linear.

The next control variable in Table 3, is the trend variable. The coefficient is negative (–0.011) and significant ($p<0.01$). This variable works as a proxy for common technological improvements and efficiency gains over time and shows that this reduces emissions. The reduction in CO_2 emissions per capita is 1.094 % for each year that passes, holding all other variables constant. The coefficient for urbanization (0.027) is positive and significant ($p<0.01$) and shows that increasing urbanization is connected with a high increase in emissions. The model predicts an increase of 2.737 % in CO_2 per capita for each extra unit increase in urbanization, i.e. each percentage point of the total population living in urban areas. This finding is similar to Povitkina (2018). The next control variable, lnTrade, is the natural logarithm of import plus export as a percentage of GDP, also called trade openness. The coefficient (0.060) is positive and significant ($p<0.01$), indicating that a 1 % increase in trade openness corresponds to an increase in CO_2 emissions per capita of 0.060 %. Oil production per capita has a similar effect. The coefficient (0.073) is positive and significant ($p<0.05$), meaning that a 1 % increase in oil production per capita corresponds with an increase of 0.073% in CO_2 emissions per capita. The significance for oil production per capita varies depending on the DQ variable used in the model. In Model 3, the effect is not significant, and in Model 2 and 5 the effect is only significant at the 0.1 level. The coefficient for the constant is positive (0.639) and significant ($p<0.01$). Since the dependent variable is log transformed and all right-hand side variables are centered, this value is the natural log of the geometric mean of CO_2 per capita when all variables are at their mean (Ford, 2018; UCLA, 2018). This value carries little substantive meaning.

AIC (Akaike information criterion) and BIC (Bayesian information criterion) are measures of goodness of fit and model complexity (Zuur et al., 2009). Lower numbers indicate a better fit to the data.

5.1.2 Participatory DQ and CO_2

Table 4. Relationships between subcomponents of participatory DQ and CO^2 per capita

	Model 1	Model 2	Model 3	Model 4
Civil Society	0.024			
Direct		–0.154*		
Local			0.109**	
Regional				0.122**
Observations	3 445	3 455	3 397	3 454
Countries	161	161	160	161
AIC	–4 272	–4 277	–4 230	–4 294
BIC	–4 186	–4 191	–4 144	–4 208

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. Control variables omitted.

Table 4 shows the subcomponents of the participatory DQ, and their relationship with the dependent variable, CO_2 emissions per capita. The control variables show very similar results to Table 3 and have been omitted from Table 4. For the full table, see the Appendix (section 9.5). In Model 1, the coefficient for Civil society participation (0.024) is positive, but not significant. The coefficient for Direct democracy (–0.154) is negative and significant at the 0.1 level. This means that a higher level of direct democracy is connected with a decrease of CO_2 emissions. The predicted effect of an increase in 0.01 on the Direct democracy index is a reduction of 0.154% in CO_2 emissions per capita, holding all other variables constant. Local democracy has the opposite effect on CO_2 emissions. The coefficient in Model 3 (0.109) is positive and significant at the 0.05 level. An increase in the local democracy index by 0.01 corresponds with an increase of 0.109 % in CO_2 emissions per capita. Regional democracy has a similar effect as local democracy. An increase in the regional democracy index by 0.01 corresponds with an increase of 0.122 % in CO_2 emissions per capita.

5.1.3 DQs and CO_2 by income group

Table 5. Relationships between democratic qualities and CO_2 per capita for different income groups

	Model 1	Model 2	Model 3	Model 4	Model 5
Electoral DQ	0.186**				
Electoral DQ * GDPpcMed	–0.062				
Electoral DQ * GDPpcHi	–0.199*				
Electoral DQ * GDPpcVeryHi	–0.239*				
Liberal DQ		0.092			
Liberal DQ * GDPpcMed		–0.111			
Liberal DQ * GDPpcHi		–0.076			
Liberal DQ * GDPpcVeryHi		–0.088			
Deliberative DQ			0.043		
Deliberative DQ * GDPpcMed			–0.031		
Deliberative DQ * GDPpcHi			–0.037		
Deliberative DQ * GDPpcVeryHi			–0.075		
Egalitarian DQ				0.314***	
Egalitarian DQ * GDPpcMed				0.046	
Egalitarian DQ * GDPpcHi				–0.022	
Egalitarian DQ * GDPpcVeryHi				–0.198	
Participatory DQ					0.331**
Participatory DQ * GDPpcMed					–0.154
Participatory DQ * GDPpcHi					–0.236
Participatory DQ * GDPpcVeryHi					–0.358*
Observations	3 452	3 445	3 455	3 455	3 455
Countries	161	161	161	161	161
AIC	–4 240	–4 229	–4 243	–4 245	–4 274
BIC	–4 117	–4 106	–4 121	–4 122	–4 151

* p<0.1, ** p<0.05, *** p<0.01. Dependent variables: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. Reference group: Low-income countries.

Table 5 shows how the effect of DQs on CO_2 emissions per capita works at different levels of income. The income groups are shown in Table 6.

Table 6. Income groups analyzed in tables 5 and 7.

Group (variable name)	Income range (pc)	Statistical range
Low income	175.4$ – 1 644.1$	Minimum – 25th percentile
Medium income (GDPpcMed)	1 644.1$ – 5 157.6$	25th percentile – median
High income (GDPpcHi)	5 157.6$ – 14 534.3$	Median – 75th percentile
Very high income (GDPpcVeryHi)	14 534.3 – 110 379.3$	75th percentile – maximum

Income measured in 2005 international dollars (World Bank, 2019). See the Appendix (section 9.6) for a list of countries in each income group. pc: per capita.

The control variables in the models in Table 5 show very similar results to Table 3 and have been omitted from Table 5. For the full table, see the Appendix (section 9.5). The reference group is low-income countries. In Model 1, the coefficient for electoral DQ (0.186), i.e. the electoral DQ in countries at low levels of income, is positive and significant ($p<0.05$). This means that an increase in electoral DQs in low-income countries leads to more emissions, specifically 0.186 % per 0.01 unit increase in the electoral DQ index. At higher levels of income, the opposite effect is observed. In medium-income countries, the effect is not significant, but in high-income (–0.199) and very high-income (–0.239) countries, the coefficients are negative and stronger than the reference group effect. Adding these coefficients to the coefficient for the reference group (0.186) gives a net decrease in CO_2 emissions per capita of 0.013 % and 0.053 % for high-income and very high-income countries respectively, per 0.01 unit increase in electoral DQ in these income groups, holding all other variables constant. The effects are, however, only significant at the 0.1 level. For liberal and deliberative DQ, none of the effects are significant. For egalitarian DQ, the effect is positive (0.314) and significant ($p<0.01$) for low income-countries, but not significant for any other income groups. The effect size is similar to that in Table 3 and indicates that the effect of egalitarian DQ on CO_2 emissions per capita is, first and foremost, valid for low-income countries. The effect of participatory DQ is significant ($p<0.05$) and positive (0.331) for low-income countries, while the opposite is observed for very high income-countries, where a net decrease of 0.027% is expected for every 0.01 unit increase in the participatory DQ index, holding all other variables constant. This indicates that DQs may mitigate emissions, but only if countries have a very high-income level. The effect is, however, only significant at the 0.1 level.

5.1.4 Participatory DQ and CO_2 by income group

Table 7. Relationships between subcomponents of participatory DQ and CO_2 per capita for different income groups

	Model 1	Model 2	Model 3	Model 4
Civil Society	0.132			
Civil Society * GDPpcMed	–0.092			
Civil Society * GDPpcHi	–0.160			
Civil Society * GDPpcVeryHi	–0.276**			
Direct		–0.353**		
Direct * GDPpcMed		0.290*		
Direct * GDPpcHi		0.282		
Direct * GDPpcVeryHi		0.189		
Local			0.165**	
Local * GDPpcMed			–0.076	
Local * GDPpcHi			–0.081	
Local * GDPpcVeryHi			–0.108	
Regional				0.196**
Regional * GDPpcMed				–0.037
Regional * GDPpcHi				–0.126*
Regional * GDPpcVeryHi				–0.159*
Observations	3 455	3 455	3 397	3 454
Countries	161	161	160	161
AIC	–4 238	–4 244	–4 191	–4 258
BIC	–4 115	–4 121	–4 069	–4 135

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. Reference group: Low-income countries.

In Table 7, the effect of the subcomponents of participatory DQ on CO_2 per capita is analyzed. Similar to Table 5, the reference group is low-income countries. In Model 1, the only significant effect is the effect for very high-income countries. The coefficient (–0.276) is negative and significant (p<0.05), indicating that a vibrant civil society corresponds with a reduction in emissions in the highest-income countries. Adding the coefficient (–0.276) to the reference coefficient (0.132) gives a net expected effect of 0.144% decrease in CO_2 emissions per capita for each 0.01 unit increase in the civil society participation index in countries with very high income, holding all other variables constant. Direct democracy has a significant negative effect on CO_2 emissions per capita in low income-countries, according to Model 2. The coefficient (–0.353) is significant at the 0.05 level. Direct democracy has a net negative effect in medium-income countries, as well, when adding the coefficient (0.290) to the reference coefficient (–0.353) of 0.063% per 0.01 unit increase in the index, holding all other variables constant. This effect is only significant at the 0.1 level. For local democracy, the effect is only significant for low-income countries (0.165, $p<0.05$). The effect is positive. Regional democracy has a net positive effect on CO_2 emission per capita in all income groups, but the effect is only significant at the 0.05 level in low-income countries. Here, an increase in CO_2 emissions per capita is predicted per 0.01 unit increase in the regional democracy index. In high and very high-income countries the effect is net positive, and 0.070% and 0.037% increases in CO_2 emissions per capita is predicted for high and very high-income countries, respectively, per 0.01 unit increase in the regional democracy index, holding all other variables constant.

5.2 Robustness testing

5.2.1 DQs and CO2

For robustness, I run the same models as shown above with a balanced dataset. The balanced dataset runs from 1995 to 2014 and contains 142 countries.

Table 8. Relationships between democratic qualities and the CO^2 per capita. Balanced panel.

	Model 1	Model 2	Model 3	Model 4	Model 5
Electoral DQ	0.123				
Liberal DQ		0.009			
Deliberative DQ			–0.044		
Egalitarian DQ				0.254***	
Participatory DQ					0.080
lnGDPpc	0.585***	0.579***	0.594***	0.577***	0.582***
$lnGDPpc^2$	–0.109***	–0.107***	–0.109***	–0.110***	–0.107***
Trend	–0.011***	–0.011***	–0.011***	–0.010***	–0.011***
Urbanization	0.025***	0.026***	0.026***	0.025***	0.025***
lnTrade	0.051***	0.051***	0.051***	0.048***	0.051***
lnOilpc	0.079**	0.067*	0.060*	0.081**	0.073**
Constant	0.765***	0.765***	0.767***	0.769***	0.762***
Observations	2 840	2 840	2 840	2 840	2 840
Countries	142	142	142	142	142
AIC	–4 020	–4 002	–3 993	–3 999	–4 004
BIC	–3 936	–3 919	–3 910	–3 916	–3 921

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. DQ: democratic quality, GDP: gross domestic product, pc: per capita, ln: natural logarithm.

Table 8 shows the relationship between the DQs and CO_2 per capita for the balanced panel. The results are similar to the results from the unbalanced panel in Table 3: The coefficients for all DQs, except egalitarian, is not significant. The coefficient for the egalitarian DQ is still positive and strong (0.254), though slightly weaker than in Table 3 (0.304). The effect of GDP per capita squared is slightly stronger, the effect of trade openness and urbanization slightly weaker and the constant has a higher value in these models compared to the models in Table 3. The turning point for the EKC in Model 1 in Table 8 is predicted to be 85 356.3 international 2005 dollars. This is lower than the estimate from Model 1 in Table 3 (110 003.8$), but still well outside 99 % of all observations in the dataset, indicating that no real turning point is observed in the balanced panel either.

5.2.2 Participatory DQ and CO_2

Table 9. Relationships between subcomponents of the participatory DQ and CO_2 per capita. Balanced panel.

	Model 1	Model 2	Model 3	Model 4
Civil Society	–0.033			
Direct		–0.061		
Local			0.064	
Regional				0.111
Observations	2 840	2 840	2 840	2 840
Countries	142	142	142	142
AIC	–3 998	–3 993	–3 971	–3 976
BIC	–3 915	–3 910	–3 888	–3 875

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered.

In Table 9, the relationship between subcomponents of the participatory DQ and CO_2 per capita are modeled. The models in Table 9 show no significant effects for the coefficients. The direction of the effects is, however, the same in models 2–4 as they were for the significant effects in models 2–4 in Table 4 with the unbalanced panel.

5.2.3 DQs and CO_2 by income group

Table 10. Relationships between democratic qualities and CO_2 per capita for different income groups. Balanced panel.

	Model 1	Model 2	Model 3	Model 4	Model 5
Electoral DQ	0.162*				
Electoral DQ * GDPpcMed	–0.097				
Electoral DQ * GDPpcHi	–0.050				
Electoral DQ * GDPpcVeryHi	0.010				
Liberal DQ		0.013			
Liberal DQ * GDPpcMed		–0.101			
Liberal DQ * GDPpcHi		0.065			
Liberal DQ * GDPpcVeryHi		0.232			
Deliberative DQ			–0.094		
Deliberative DQ * GDPpcMed			0.005		
Deliberative DQ * GDPpcHi			0.125		
Deliberative DQ * GDPpcVeryHi			0.197		
Egalitarian DQ				0.159	
Egalitarian DQ * GDPpcMed				0.090	
Egalitarian DQ * GDPpcHi				0.171	
Egalitarian DQ * GDPpcVeryHi				0.225	
Participatory DQ					0.218
Participatory DQ * GDPpcMed					–0.300**
Participatory DQ * GDPpcHi					–0.144
Participatory DQ * GDPpcVeryHi					–0.137
Observations	2 840	2 840	2 840	2 840	2 840
Countries	142	142	142	142	142
AIC	–3 987	–3 976	–3 964	–3 969	–3 978
BIC	–3 868	–3 857	–3 845	–3 850	–3 859

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. Reference group: Low-income countries.

Table 10 show the relationships between the DQs and CO_2 per capita for the different income groups shown in Table 11. In Table 5 the effect of participatory, electoral and egalitarian DQ in low-income countries were positive and significant. This is not the case with the balanced panel. The coefficient still suggests a positive relationship, but only electoral DQ (0.162) is significant, and only at the 0.1 level. In Table 5, electoral and participatory DQ showed net negative effects on CO_2 emissions per capita in very high-income countries. This effect is not visible when running the same models on the balanced panel. Instead, participatory DQ has a negative effect on CO_2 in medium-income countries (–0.300). The net predicted effect of this interaction is a decrease of 0.82 % per in CO_2 emissions per capita for each 0.01 unit increase in the participatory DQ index, holding all other variables constant.

Table 11. Income groups analysed in tables 10 and 12. Balanced panel.

Group (variable name)	Income range	Statistical range
Low income	314.9$ – 2 008.2$	Minimum – 25th percentile
Medium income (GDPpcMed)	2 008.2$ – 6 343.6$	25th percentile – median
High income (GDPpcHi)	6 343.6$ – 17 259.3$	Median – 75th percentile
Very high income (GDPpcVeryHi)	17 259.3$ – 110 379.3$	75th percentile – maximum

Income measured in 2005 international dollars (World Bank, 2019).

5.2.4 Participatory DQ and CO_2 by income group

Table 12. Relationships between subcomponents of participatory DQ and CO_2 per capita for different income groups. Balanced panel.

	Model 1	Model 2	Model 3	Model 4
Civil Society	–0.046			
Civil Society * GDPpcMed	–0.027			
Civil Society * GDPpcHi	0.036			
Civil Society * GDPpcVeryHi	0.123			
Direct		–0.132		
Direct * GDPpcMed		0.083		
Direct * GDPpcHi		0.112		
Direct * GDPpcVeryHi		0.045		
Local			0.107	
Local * GDPpcMed			–0.122**	
Local * GDPpcHi			–0.043	
Local * GDPpcVeryHi			–0.049	
Regional				0.224**
Regional * GDPpcMed				–0.193***
Regional * GDPpcHi				–0.147*
Regional * GDPpcVeryHi				–0.123
Observations	3 455	3 455	3 397	3 454
Countries	161	161	160	161
AIC	–4 238	–4 244	–4 191	–4 258
BIC	–4 115	–4 121	–4 069	–4 135

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. Reference group: Low-income countries.

Table 12 provides the results for the analysis of the relationship between the subcomponents of participatory DQ and CO_2 per capita for the different income groups shown in Table 11. The net negative effects of direct democracy and civil society participation in low-income and very high-income countries, respectively, is no longer significant. The coefficient for local democracy is no longer significant, for low-income countries, instead it is net negative (–0.015) and significant (p<0.05) for medium-income countries. The effect of regional democracy is still predicted to be positive and significant at certain levels of income. According to the model, the effect is strongest for low-income countries (0.224), while the net effect for medium income countries is 0.031% ($p<0.01$) increase in CO_2 per capita for each 0.01 unit increase in the regional democracy index, holding all other variables constant. The effect is net positive (0.077) in high-income countries as well, but only significant at the 0.1 level.

In conclusion, the robustness test show only two robust effects: The effect of egalitarian DQs on CO_2 emissions per capita for the entire datasets, and the effect of regional democracy at different levels of GDP per capita. Since the effect of egalitarian DQ is the most convincing of all the DQ effects, I disaggregate this index in the same way as the participatory DQ and run regressions on the subcomponents. The results for the unbalanced panel are shown in Table 13 and the balanced panel in Table 14.

5.3 Egalitarian DQs and CO2

Table 13. Relationships between subcomponents of egalitarian DQ and CO_2 per capita. Unbalanced panel.

	Model 1	Model 2	Model 3
Equal Protection	0.069		
Equal Access		0.118	
Equal Distribution			0.188**
Observations	3 455	3 455	3 455
Countries	161	161	161
AIC	–4 272	–4 277	–4 230
BIC	–4 186	–4 191	–4 144

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered.

Table 14. Relationships between subcomponents of egalitarian DQ and CO_2 per capita. Balanced panel.

	Model 1	Model 2	Model 3
Equal Protection	0.050		
Equal Access		0.061	
Equal Distribution			0.239***
Observations	2 840	2 840	2 840
Countries	142	142	142
AIC	–3 992	–3 999	–4 000
BIC	–3 909	–3 916	–3 916

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered.

Both Tables 13 and 14 show that the predicted effect of egalitarian DQ on CO_2 emissions per capita is most likely dominated by the equal distribution subcomponent. Still, the coefficient for equal distribution from Table 13 (0.188) is only significant at the 0.05 level, in contrast to the coefficient from Table 3, which is significant at the 0.01 level. The effect size is also not as large as the effect size of egalitarian DQ on CO_2 per capita from Table 3, indicating that the other subcomponents that makes up the egalitarian DQ is required to produce the predicted effect. The coefficient for equal distribution in Table 14 carries the same size and significance as the coefficient for egalitarian DQ in Table 8, providing a more unambiguous representation of the role of the equal distribution subcomponent in the egalitarian DQ index. All in all, it seems likely that the equal distribution subcomponent plays a defining role in the relationship between the egalitarian DQ and CO_2 emissions per capita.

5.4 Summing up

It is evident that results vary greatly from the main analysis to the robustness tests. There might be a few reasons for this. Firstly, the unbalanced panel might have inflated standard errors as a consequence of the estimation technique's calculation of degrees of freedom (see Method). Secondly, I believe that the countries and country-years that are omitted in the balanced panel are removed because they had systematically missing data and systematically worse data quality. These countries are the ones that are poor, unstable, war prone, or in transition, and make up the extreme observations and outliers in the dataset, and therefore possibly the significant effects. The good aspect of excluding these country-years, is that data reliability is improved. If the omitted observations were made in countries at times of instability and institutional unrest, data quality is quite possibly low. Therefore, the balanced panel provides estimates with higher reliability than the unbalanced panel. Conversely, omitting country-years, extreme or not, weakens inference for the population, i.e. all countries. If e.g. all observations that are measured during war are omitted, the dataset would not reflect the population, as war has traditionally been an innate part of global country development. Still, I believe that the most interesting effects are the ones that are strong enough to be visible, both with and without such a treatment. I therefore consider the chosen robustness test, although I recognize it is not without weaknesses, to be a suitable stress-test for these effects. Lastly, a reminder of the borderline high multicollinearity in the models using income groups in tables 5, 7, 10 and 12 should be given. Since the variance inflation factor showed values above 5 for certain income group dummies (see methods), the results from these tables should be interpreted with caution.

From the analysis, I can draw the following conclusions:

Egalitarian DQs increases CO_2: Starting with the DQs and their effect on CO_2 in tables 3 and 8, there seems to be only one solid conclusion to draw: that the egalitarian DQ is the only DQ with a significant effect on CO_2. The effect is positive and rather strong. The disaggregation of the egalitarian DQ in tables 13 and 14 show that equal distribution is the only significant subcomponent of the egalitarian DQ.

Participatory DQs contrasting: The participatory DQs' subcomponents in Tables 4 show contrasting effect on CO_2. While direct democracy has a negative effect, regional and local democracy has positive effects on CO_2 emissions per capita. This effect is, however, not replicated in the balanced panel in Table 9.

High and low-income countries: Dividing the country-years into income groups in Table 5 shows some interesting results: while the effect of electoral and participatory DQs are positive in low-income countries, the opposite is true for very high-income countries, indicating that these democratic qualities are associated with mitigation in countries with the highest income. Egalitarian DQ has a positive effect in low-income countries in Table 5. In the robustness tests, the effects at very high levels of income are not visible. The only significant effects are the negative effect for the participatory DQ for medium-income countries, and the positive effect for the electoral DQ in low-income countries.

Regional democracy increases CO_2 in low-income: The participatory DQs' subcomponents in Table 7 provide contrasting results, similarly to Table 5. For civil society participation, the effect is negative for very high-income countries, and for direct democracy, the effect is negative for low-income countries. Both regional and local democracy have a positive effect on CO_2 per capita in low-income countries, while regional also have a positive effect in high and very high-income countries as well. In Table 12, only regional and local democracy have significant effects. Local democracy is strangely negatively correlated with CO_2 in medium-income countries, an opposite effect to Table 7. This might be caused by the multicollinearity in the income group-models, which can alter direction of effects (Christophersen, 2013; Crawley, 2015). The result is therefore questionable. For regional democracy, the effect is positive for low, medium and high-income countries, and definitely strongest for the low-income countries.

No turning point for EKC: The results from the control variables show that urbanization, oil production and trade openness increase CO_2 emissions, while technological advancement over time decreases CO_2 emissions. The results from the GDP per capita variables show that income has a strong positive, but non-linear effect on CO_2, and that the effect is moderated at higher levels of income. I find no evidence of a possible turning point for an inverse U-shaped EKC as the predicted turning points lie beyond the observed range.

6. Discussion

In this chapter, I start by discussing the results for the control variables (section 6.1). I move on to the hypotheses which I go through in turn and discuss the mechanisms related to the observed effect and provide a conclusion for each hypothesis using a statistical significance level of 0.05 as the threshold (section 6.2). I also discuss the democratic quality (DQ) and participatory DQ subcomponent effects at different levels of income although I have not made specific hypotheses for these effects. I continue the discussion by summing up the hypotheses and conclusions (section 6.3). In section 6.4 I discuss the theoretical implications of my results, while I discuss the policy implications of them in section 6.5. Looking back at the process of executing this analysis, I discuss some aspects that could have been done differently in section 6.6. In section 6.7 I end the discussion with clear encouragements for further research based on the most important findings in this thesis.

6.1 Control variables

The results from the control variables are rather consistent throughout the models. The results from the two income variables indicate, first and foremost, that income is the most important driver of CO_2 emissions. Furthermore, GDP per capita squared, being negative, indicates that the relationship is slightly non-linear and that increasing GDP per capita to higher levels somewhat reduce the emissions per unit income. This indicates that economies change “technology” and “composition” as they develop towards higher levels, and the pressure on emissions is reduced (Grossman & Krueger, 1995). It should still be emphasized that the effect of GDP per capita on CO_2 emissions, even at higher levels of income, is very strong. Common technological advancement, operationalized by the time trend variable, is unsurprisingly associated with a reduction in emissions over time as technology leads to efficiency gains. Urbanization is positively associated with CO_2 emissions. This is probably caused by the fact that urbanization, at least in developing countries, is often accompanied by an increase in manufacturing activities in these countries (Poumanyvong & Kaneko, 2010). Trade openness is also positively associated with CO_2 emissions. This might indicate that developing countries drive this relationship. An increase in trade openness in these countries should correspond with higher emissions, according to the “pollution-displacement-hypothesis” (Cole & Neumayer, 2005), because the developed countries have moved parts of their carbon-intensive production to less developed countries. Still, since it is positive and significant for the entire panel, this might mean that developed countries only move labor-intensive production to less developed countries, while they instead expand domestic industrial production that does not require the same amount of manual labor. This indicates that the “composition” change (Grossman &

Krueger, 1995) in the economy does not necessarily involve moving away from industrial activity, but rather that the industrial activity become less labor-intensive in countries at higher levels of income. The last variable, Oil production per capita, is associated with an increase in CO_2 emissions. The variable is an operationalization of the presence of oil lobbies which should make mitigation policy a more difficult task.

6.2 Hypotheses

H_1: An increase in the level of **electoral DQs** in countries over time is associated with a ***decrease*** in per capita CO_2 emissions.

The first hypothesis is based on the empirical evidence from the last 20 years of research into the relationship between democracy and CO_2. Although several studies have concluded that increasing democracy corresponds with increasing CO_2 emissions (see e.g. Joshi & Beck, 2018; Midlarsky, 1998), it seems the majority has concluded the opposite (see e.g. Li & Reuveny, 2006; Policardo, 2016; Povitkina, 2018).

In the analysis I find some evidence of an effect of electoral DQ only at certain income levels. The results indicate that electoral DQs might be compatible with mitigation in countries with very high income, but not in low-income countries. There might be several explanations for this. Firstly, democratic leaders have to follow the will of the people and are held accountable if they do not. In developing countries, public concern for economic and societal development might outweigh the concern for climate change (Povitkina, 2018). This might force policy makers to follow the conventional carbon-intensive development path to enhance growth and job creation short-term. In very high-income countries, where material needs are more likely to be met, the public's prioritization might be opposite, forcing policy makers to focus on climate change mitigation instead of economic development. Secondly, the aforementioned mechanism ties nicely in with Bueno de Mesquita's (2003) argument that democratic leaders has to provide public goods to maintain power. In low-income countries, there might indeed be more readily available and effective public goods than climate change mitigation to provide, and it is therefore not a sensible priority (Burnell, 2012). If e.g. hunger, safety and poverty are policy areas where public goods can be provided, focusing on these might give a larger reward, in terms of acceptance rates in the public, for a democratic leader. In very high-income countries, these are not pressing concerns, and climate change mitigation policy might therefore be more favorable.

The result indicates that there is evidence supporting the hypothesis of a decrease in CO_2 emissions, i.e. for high and very high-income countries. The effects of electoral DQ in these countries are, however, not significant at the 0.05 level, and does not replicate in the robustness tests. Instead, it seems more likely that the opposite statement is true, that electoral DQs corresponds with *increased* per capita CO_2 emissions, at least in low-income countries. This result is consistent, even the robustness tests, but only at the 0.1 level. Using a significance level of 0.05 as the threshold, I therefore do not reject the null hypotheses which says that there is no relationship between egalitarian DQs and CO_2.

*H_2: An increase in the level of **liberal DQs** in countries over time is associated with an **increase** in per capita CO_2 emissions.*

The second hypothesis is based on the assumption that countries that place high value on individual rights, a key component of the liberal DQ, have a higher threshold for restricting personal behavior (de Geus, 2004). Reducing consumption, and related CO_2 emissions, is therefore particularly difficult in these countries.

In the analysis I find no evidence of an effect of liberal DQs on CO_2 emissions. They seem entirely unrelated in all models, showing no significant effects. I therefore do not reject the null hypothesis.

*H_3: An increase in the level of **direct democracy** in countries over time is associated with an **increase** in per capita CO_2 emissions.*

The third hypothesis is based mainly on research into direct democracy policy processes in Switzerland, the country with the highest level of direct democracy (Coppedge et al., 2018). The fact that voters have trouble understanding difficult issues (Bornstein & Thalmann, 2008), are mostly concerned about maximizing personal utility (Bornstein & Lanz, 2008) and act as veto players that preserve the status quo (Bornstein, 2007) lead to the hypothesis that this subcomponent of the participatory DQ is related to an increase in CO2 emissions.

The results connected to this subcomponent points in the opposite direction of the hypothesis. The effect is negative, and the analysis of GDP per capita groups shows that this effect is strongest and most significant in low-income countries, while there is no significant effect at higher levels of income. This points to the possibility that the mechanisms at play in direct democracy policy processes in a very high-income country, such as Switzerland, does not apply the same way to the same processes in low-income countries. It does not seem unlikely, at least from an intuitive standpoint, that the veto player-argument could have an opposite effect in low-income countries. Veto players, i.e. actors and institutions that has to accept a policy before it can be implemented, are generally considered to have a preserving effect on society (Lægreid & Povitkina, 2018; Paola & Jamieson, 2018). But in low-income countries, the extra veto player in direct democracy processes, the people, might not at all be interested in maintaining the status quo. Instead, this veto player might be the force that pushes new policies, including climate change mitigation, forward. The effect of direct democracy on CO_2 emissions does not replicate in the balanced panel so I do not consider it robust even though it is interesting. I do not reject the null hypothesis.

H_4: An increase in the level **of civil society participation** in countries over time is associated with a ***decrease*** in per capita CO_2 emissions.

The fourth hypothesis is based on the assumption that since civil society participation is related to the production of post-material values such as mitigating climate change (Inglehart & Welzel, 2005; Putnam, 2016), it should correspond with lower CO_2 emissions. Civil society organizations also play a crucial part in environmental policy processes and a high level of participation should therefore be associated with a decrease in CO_2 emissions.

In the main analysis I find evidence for this hypothesis in very-high income countries. Considering that post-material value formation requires a certain material threshold to be reached, it makes sense that this effect would only be observed in very high-income countries. The result does not replicate in the balanced panel, so it is not considered robust. I do not reject the null hypothesis based on the lack of significance in the robustness test.

H_5: An increase in the level of **local democracy** in countries over time is associated with a ***decrease*** in per capita CO_2 emissions &

H_6: An increase in the level of **regional democracy** in countries over time is associated with a ***decrease*** in per capita CO_2 emissions.

The fifth and sixth hypothesis are based on the same theoretic argument: Since many of the mitigation efforts has to be taken at the local and regional level (Collier, 2007), countries with strong local and regional governments perform better at reducing emissions.

From the main analysis, I find evidence of a similar effect between the two levels of government and CO_2 emissions per capita. They are both associated with increasing CO_2 emissions, opposite of the hypotheses. The effects are strongest and most significant in low-income countries. The effect of regional democracy replicates in the balanced panel for low-, and high-income countries while it becomes significant for middle-income countries as well. The effect of local democracy changes direction from positive to negative and is only significant in medium-income countries. The change in effect direction is indeed confusing and are most likely contributed to the multicollinearity between the income group dummies in the models, as mentioned in the previous chapter (section 5.4). I therefore do not reject the null hypothesis for the effect of local democracy on CO_2 emissions per capita. Still, the effect of regional democracy is consistently positive and significant at the 0.05 level in low-income countries, and strongly significant in middle-income countries in the balanced panel. This means that strong, autonomous regional governments in these countries have a negative effect on mitigation. One plausible, though speculative explanation is that regional governments in developing countries more often than not lack the bureaucratic capacity to implement and enforce mitigation policy. Instead, the regional governments are characterized by a high degree of corruption that can be utilized by anti-environmental interests. The fact that corruption as a control variable was not significant (see section 3.4) would in this case mean that the corruption is only visible at this level of government and not registered on the corruption index. This might explain why a more autonomous regional government in these countries corresponds with higher emissions. At the 0.05 level, I can reject the null hypotheses that there is no relationship between regional democracy and CO_2 emissions per capita in low-income countries as this result replicates in the balanced panel. However, contrary to what I expected, regional democracy is associated with increased CO_2 emissions in low-income countries.

H_7: *An increase in the level of the **deliberative DQs** in countries over time is associated with a **decrease** in per capita CO_2 emissions.*

The seventh hypothesis is based on a rather large theoretic environmental literature (Drews & van den Bergh, 2016; Dryzek & Pickering, 2017; Renn & Schweizer, 2009; Stave, 2002) that argues that the deliberative process should provide the best policy solution, increased legitimacy of the chosen policy and additional resources for implementation of the policy.

In the analysis I find no evidence for an effect of deliberative DQs on CO_2 emissions. I do not reject the null hypothesis.

H_8: An increase in the level of the **egalitarian DQs** in countries over time is associated with a ***decrease*** in per capita CO_2 emissions.

The last hypothesis is based on mainly three arguments: The first is that educational equality might reduce voter ignorance and increase trust in climate change science and consequently pressure for mitigation policy (Paola & Jamieson, 2018). The second is that equal distribution of resources should promote the production of post-material values such as environmental concern (Inglehart & Welzel, 2005). The third is that gender equality is good for the environment because women are considered more concerned than men about climate change (Burnell, 2012).

The evidence for this effect points to a very clear conclusion: egalitarian DQs increase CO_2 emissions, contrary to what was expected. This holds true for both the balanced and unbalanced panels. The effect is only significant for the low-income countries in the income group models, but it is significant for the entire range of GDP per capita in all other models. This is, in my opinion, the most striking effect uncovered by this analysis. The fact that increasing egalitarian democratic qualities, i.e. equal access to power, equal distribution of resources and equal protection of rights and freedoms, corresponds with a rather strong increase in CO_2 emissions per capita indicates a direct trade-off between increasing equality and mitigating climate change.

The analysis of the subcomponents of the egalitarian DQ shows that the equal distribution subcomponent most likely dominates the effect of egalitarian DQs on CO_2 emissions per capita. I find no satisfying explanation for this effect using the mechanisms mentioned above. I therefore turn to the mechanisms that explain the relationship between income inequality, an omitted variable, and CO_2 emissions. The equal distribution subcomponent does not measure income equality directly, it measures instead equal distribution of food, water, housing, education and healthcare, but it is plausible that income equality is highly correlated with these benefits. I imagine this working one of two ways: Either food, water, housing, education and healthcare are distributed equally through social policies freeing up disposable household income for everyone, thereby indirectly redistributing income, or income is distributed equally through social policies giving everyone equal opportunity to access food, water, housing, education and healthcare, thereby indirectly redistributing these benefits. One of the few large-N studies looking at the relationship between income equality and CO_2 emissions in nations (Grunewald et al., 2017), found that increasing income equality indeed leads to more CO_2 emissions, especially in low- and middle-income countries. When income is distributed equally in these countries, the threshold for a carbon-intensive lifestyle, e.g. affording cars for transport and modern energy sources for heating and cooking, is reached for a larger number of households, and consequently, total CO_2 emissions are increased. A rather banal example of this mechanism can be given: Jeff Bezos, the richest man alive (Kroll & Dolan, 2019), has approximately ten million times the amount of income as this author. Still, it is hard to image his carbon footprint being ten million times as large as mine. If we split the income between us, my ability to consume carbon-intensive goods and services would increase immensely while his ability to do the same would be practically unchanged as his income would still be above a reasonable threshold for how much emissions a person can possibly produce. Similarly, if his fortune was split evenly with one thousand people, or even one million people, it would largely increase everyone else's ability to consume more, while his own ability might be reduced only slightly. The potential total emissions produced by redistributing Jeff Bezos' fortune is therefore much higher than letting him keep it for himself. Still, it is not entirely clear if this is the governing mechanism in the relationship between egalitarian DQs and CO_2 emissions, and the need for further research (and better data for income inequality) is large. At the 0.05 level, I can reject the null hypothesis. The effect is, however, opposite of what was anticipated.

6.3 Summing up

The research question stated for this thesis is as follows:

How does different democratic qualities relate to CO_2 emissions in countries over time?

I answer this question by constructing directional hypotheses for the effect of each DQ, operationalized by Varieties of Democracy (Coppedge et al., 2018), on CO_2 emissions per capita and test them on a large number of countries using more than two decades of annual data. There are two robust findings in this thesis:

- An increase in regional democracy, i.e. the autonomy and relative strength of a regional government, is associated with an increase in CO_2 emissions in low-income countries.
- An increase in egalitarian DQs, i.e. equal access to power, equal distribution of resources and equal protection of rights and freedoms, is associated with a rather strong increase in CO_2 emissions per capita.

Table 15 gives an overview of all the hypotheses and conclusions drawn from the analysis.

Table 15. Hypotheses and conclusions.

Hypotheses	*Conclusion*	*Justification*
H₁*:** *Increasing electoral DQs c.w.* ***decreasing *CO_2 emissions*	I do not reject H0. No robust relationship found.	Evidence from the main analysis points to an opposite effect for very high- and low-income, but the effect is not robust.
H₂*:** *Increasing liberal DQs c.w.* ***increasing *CO_2 emissions.*	I do not reject H0. No robust relationship found.	No significant effects.
H₃*:** *Increasing direct democracy c.w.* ***increasing *CO_2 emissions.*	I do not reject H0. No robust relationship found.	Direct democracy corresponds with decreasing CO_2 in low-income countries according to main analysis, but the effect is not robust.
H₄*:** *Increasing civil society participation c.w.* ***decreasing *CO_2 emissions.*	I do not reject H0. No robust relationship found.	Civil society participation corresponds with decreasing CO_2 in very high-income countries according to the main analysis, but the effect is not robust.
H₅*:** *Increasing local democracy c.w.* ***decreasing *CO_2 emissions.*	I do not reject H0. No robust relationship found.	Local democracy corresponds with increasing CO_2 in low-income countries according to the main analysis, but the effect is not robust.
H₆*:** *Increasing regional democracy c.w.* ***decreasing *CO_2 emissions*	I reject H0. Increasing regional democracy corresponds with **increasing** CO_2 emissions in low-income countries.	Regional democracy corresponds with increasing CO_2 in low-income countries. The effect is robust.
H₇*:** *Increasing deliberative DQs c.w.* ***decreasing *CO_2 emissions.*	I do not reject H0. No robust relationship found.	No significant effects.
H₈*:** *Increasing egalitarian DQs c.w.* ***decreases *CO_2 emissions.*	I reject H0. Increasing egalitarian DQs corresponds with **increasing** CO_2 emissions.	Electoral DQs corresponds with increasing CO_2 emission in the entire sample. The effect is robust.

Hypotheses are shortened. c.w.: corresponds with.

6.4 Theoretical implications

The fact that the two robust results in this thesis have a different direction than what was hypothesized might be viewed as somewhat unenviable considering that a random draw should have provided at least one correctly stated hypothesis. Still, the point of constructing them is, in any case, not to be correct. A random draw might have produced more correct directional hypotheses, but it would not have provided much insight. In the process of constructing these hypotheses, a large amount of theoretical and empirical literature has been linked to the different relationships. Without this literature, I would not be able to explain the observed effects, even though the same literature lead to disproved hypotheses to begin with. Still, it is interesting to investigate why the hypothesis did not hit the mark:

Firstly, many of the observed effects in the main analysis, although not robust, were only found in certain income groups, typically low-income countries, often with contrasting effects for very high-income countries such as the effect of electoral and participatory DQ in the main analysis. Although these effects were not robust, and the null hypotheses could not be rejected, the content of them might still provide some insight into why the hypotheses for regional democracy and egalitarian DQs stated a different direction that what was observed. The Intergovernmental panel for climate change (IPCC) points to the fact that "authorship of climate change publications from developing countries (…) still represents a small fraction of the total" (IPCC, 2014b). Similarly, it is reasonable to believe that the bulk of the mechanisms identified in this thesis comes from high and very high-income countries while a gap in the literature exists for the same effects in low and middle-income countries. For instance, the hypothesis for the effect of regional democracy is based on a study from the European Union (Collier, 2007) and might therefore not reflect the particular realities in developing countries. If this is the case, it points to a larger structural challenge in the literature. The role that institutions and DQs play at lower stages of development is just as important as it is at higher levels of development. One could even argue that it is more important to understand the mechanisms at play in developing countries as most of the future CO_2 emissions are expected to come from within these countries (IPCC, 2014a). One important realization from this thesis is therefore that the mechanisms that explains the statistical relationships between DQs and CO_2 emissions might be different or even have contrasting effects in developed and developing countries.

Secondly, it is possible that some of the indices do not measure what I expect them to measure. One example is the egalitarian DQ, which I intuitively understand as a measure of mostly non-material equality but end up arguing conversely that it could be interpreted as an indirect measure of income equality within the context of this thesis. Thirdly, I write in the Theory chapter that only some of the subcomponents of each DQ have documented or theoreticized direct or indirect effects on CO_2 emissions or other environmental outcome. It is therefore entirely possible that important mechanisms governing these relationships have been overlooked. In any case, since this thesis takes place in rather uncharted waters, I believe that the mechanisms identified in this thesis provides an important framework for future research.

6.5 Policy implications

The regional democracy result indicates that strong and autonomous regional governments pose a problem for mitigation in low-income countries. One possible explanation for this effect is that these institutions are characterized by a relatively high degree of corruption in these countries, and the more autonomous they are, the more lenient they are towards profitable anti-environmental interests. One solution to this is to increase the state presence at regional levels and alter the relative power dynamic. Furthermore, the mechanisms governing this relationship should be investigated in closer detail.

I write in the introduction to this thesis that the research question is important to investigate in a sustainable development context. In the context of the Agenda 2030, the roadmap for global development the coming decade containing the Sustainable Development Goals (SDGs) (United Nations, 2015), the fact that egalitarian DQs lead to increased CO_2 emissions is particularly important. The result indicates that several of the societal SDGs and corresponding indicators are in direct opposition to the goal of mitigating climate change. For instance, the goals for "inclusive and equitable quality education" (SDG 4) and reducing "inequalities within and between countries" (SDG 10) are trade-offs, it seems, to reducing CO_2 emissions. If it is true that countries have to choose between reducing inequalities and mitigating climate change, how do you prioritize? Considering that a large amount of literature have argued consistently since the 1970s that economic growth is not compatible with mitigating climate change either (Daly, 2007; Georgesçu-Roegen, 1971; Lenzen, Malik, & Foran, 2016; Meadows, Meadows, Randers, & Behrens, 1972; Spangenberg, 2010; Ward et al., 2016), the whole development discourse seems questionable. The need for research into policy options to navigate these unpleasant relationships is large. Additionally, if the general view on the mechanisms governing the relationships between certain DQs, with corresponding SDGs, and CO_2 emissions are based mainly on evidence and perspectives from very-high income countries, as I mention above, we might indeed experience undesirable development in other income groups if the DQs have contrasting effects on CO_2 emissions at different levels of income.

In light of these unpleasant trade-offs, the fact that six out of eight hypotheses were disproved could be regarded as good news for global development. Since there is no robust relationship between electoral DQs, liberal DQs, deliberative DQs, direct democracy, civil society participation and local democracy on the one side, and CO_2 emissions per capita on the other, means that we can indeed increase all these institutional properties and the potential co-benefits that come with them, intrinsic or otherwise, without the unpleasant negative feedbacks.

6.6 Weaknesses

The unexpected finding that egalitarian DQs corresponds with increased CO_2 emissions per capita somewhat overshadows the other results from this thesis because of its potential implications for global development. In retrospect, more resources could therefore have been spent on investigating this relationship in closer detail. One control variable that could have made a significant impact on this result is income inequality. If the relationship between egalitarian DQs and CO_2 is governed mainly by the effect of income distribution, as I argue above, a proxy for income inequality would have removed the connection between the aforementioned and provided a more correct picture of the relationship. This variable was omitted because of severe lack of data for a large number of countries. Still, sophisticated algorithms and estimation techniques that can fill in missing data in such datasets exist (Grunewald et al., 2017) and redirecting my time into such a task could have produced a consistent data material that could be used in the analysis. Another control variable that could have been interesting to include is the presence or legacy of communism in countries. At its core, communism is about redistribution, and it is therefore plausible that countries with a certain degree of communist influence might score higher on the egalitarian DQ index. If including this as a control variable affected the result, the mechanisms explaining the relationship might be different, and instead in some way related to communist or post-communist development.

Another weakness with this thesis, is that I only use one type of model throughout, a random intercept and slope model with temporal correction. I justify my choice of method quite comprehensively with clear reference to current statistical literature, but the arguments I use would have carried stronger conviction if I could show the actual result from other types om models as well. More importantly, if I could show that the effect of egalitarian DQs on CO_2 emissions were consistent across several types of models, the result would have been even more robust.

Lastly, one apparent weakness with the theoretical foundation of this thesis is that I have not succeeded in identifying any mechanisms that convincingly explain the relationship between regional democracy and CO_2 emissions in low-income countries. The fact that I only provide one study to base the hypothesis on makes the task of retrospectively speculating very difficult considering the direction of the effect.

6.7 The need for future research

This research question chosen for this thesis is a result of a call in the literature for more research into the mitigation potential of institutional qualities that go beyond the narrow definition of democracy. I would, likewise, encourage future scholars to grapple at this question, with particular emphasis on developing countries. There seems to be a large gap in the empirical and theoretical understanding of several aspects of development at lower levels of national income. Additionally, the evidence that reducing inequalities is in conflict with climate change mitigation constitutes a rather unexpected blow to the 2030 Agenda. This trade-off will complicate the progress of many countries the coming decade if good policy options are not identified. It will certainly require countries to do more than anticipated in some policy areas to weigh up for the negative feedbacks of reducing both inequality and CO_2 emissions. Most strikingly, it might also inhibit country's abilities to uphold the emission reduction trajectories required to avoid dangerous and irreversible climate change. I end this discussion with a second important encouragement: Find a way to navigate this.

7. Conclusion

This thesis is the first study to my knowledge that comprehensively examines the relationship between democratic qualities and mitigating climate change. In the analysis of 161 countries over 23 years, I find that increasing regional democracy corresponds with increasing CO_2 emissions per capita in low-income countries. Most interestingly, I also find that increasing electoral democratic qualities corresponds with a rather strong increase in CO_2 emissions per capita in the entire sample. The latter carry great importance for global development, as both increasing egalitarian democratic qualities and mitigating climate change is part of the global agenda through the Sustainable Development Goals (United Nations, 2015). It also shows that widening scope of research beyond a narrow definition of democracy provides important insight into the role of institutions in mitigating climate change.

I also find evidence pointing to a gap in the literature of the impacts of democratic qualities in developing countries. The mechanisms at play in developing countries are quite possibly different from the ones in developed countries, and a knowledge basis based mainly on the effects in developed countries could lead to unexpected and undesired development in the future.

The fact that I find no robust relationships between electoral democracy, liberal democratic qualities, deliberative democratic qualities, local democracy, direct democracy and civil society participation on one side, and CO_2 emissions per capita on the other, means that they are not in conflict with mitigating climate change.

I encourage future research to continue investigating the wide spectrum of institutions and democratic qualities with special emphasis on developing countries. Furthermore, the fact that egalitarian democratic qualities, with corresponding SDGs, seems to be direct trade-offs to mitigating climate change should encourage sustainable development research to focus aggressively on policy options to navigate this unpleasant relationship.

8. References

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9. Appendix

9.1 Descriptive statistics

Table 16. Descriptive statistics of all variables. Unbalanced panel.

Variable	*Mean*	*SD*	*Min*	*Max*
CO_2pc	4.58	6.72	0.01	70.13
Electoral DQ	0.52	0.27	0.02	0.94
Liberal DQ	0.60	0.27	0.03	0.98
Deliberative DQ	0.64	0.26	0.01	0.99
Egalitarian DQ	0.62	0.21	0.09	0.98
Participatory DQ	0.46	0.19	0.02	0.89
Civil Society	0.67	0.24	0.03	0.99
Direct	0.10	0.12	0.00	0.78
Local	0.57	0.37	0.00	0.99
Regional	0.40	0.39	0.00	1.00
GDPpc	10668.60	13104.20	175.40	110379.30
$GDPpc^2$	285500000	729240822	30770	12180000000
Trade	83.34	50.22	0.02	442.62
Urbanization	54.50	22.79	6.29	100.00
Trend	2003	6.63	1992	2014
Oilpc	1.72	6.55	0.00	65.19

9.2 List of countries in the unbalanced panel (N=161)

Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burma/Myanmar, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Democratic Republic of Vietnam, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Ivory Coast, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Macedonia, Madagascar, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Republic of the Congo, Russia, Rwanda, Saudi Arabia, Senegal, Serbia, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, South Korea, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syria, Tajikistan, Tanzania, Thailand, The Gambia, Togo, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, Uzbekistan, Venezuela, Zambia, Zimbabwe.

Countries omitted in the balanced panel (N=19):

Afganistan, Bahrain, Burma/Myanmar, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Ivory Coast, Laos, Lesotho, Liberia, Maldives, Montenegro, Papua New Guinea, Serbia, Somalia, Syria, United Arab Emirates, Uzbekistan.

9.3 Results from pooled OLS

Table 17. Relationships between democratic qualities and CO^2 per capita. Pooled OLS. Unbalanced panel.

	Model 1	Model 2	Model 3	Model 4	Model 5
Electoral DQ	–0.441***				
Liberal DQ		–0.404***			
Deliberative DQ			–0.347***		
Egalitarian DQ				0.389***	
Participatory DQ					–0.794***
lnGDPpc	0.993***	0.992***	0.965***	0.899***	0.998***
lnGDPpc^2	–0.115***	–0.113***	–0.115***	–0.136***	–0.121***
Trend	–0.014***	–0.014***	–0.014***	–0.013***	–0.013***
Urbanization	0.013***	0.013***	0.013***	0.012***	0.013***
lnTrade	0.188***	0.200***	0.203***	0.201***	0.171***
lnOilpc	0.104***	0.119***	0.136***	0.232***	0.099*
Constant	0.633***	0.658***	0.664***	0.696***	0.674***
Observations	3 452	3 445	3 455	3 455	3 455
Countries	161	161	161	161	161
R^2	0.86	0.86	0.86	0.86	0.86
Adjusted R^2	0.86	0.86	0.86	0.86	0.86

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. DQ: democratic quality, GDP: gross domestic product, pc: per capita, ln: natural logarithm. Standard errors not clustered.

9.4 Model validation graphs

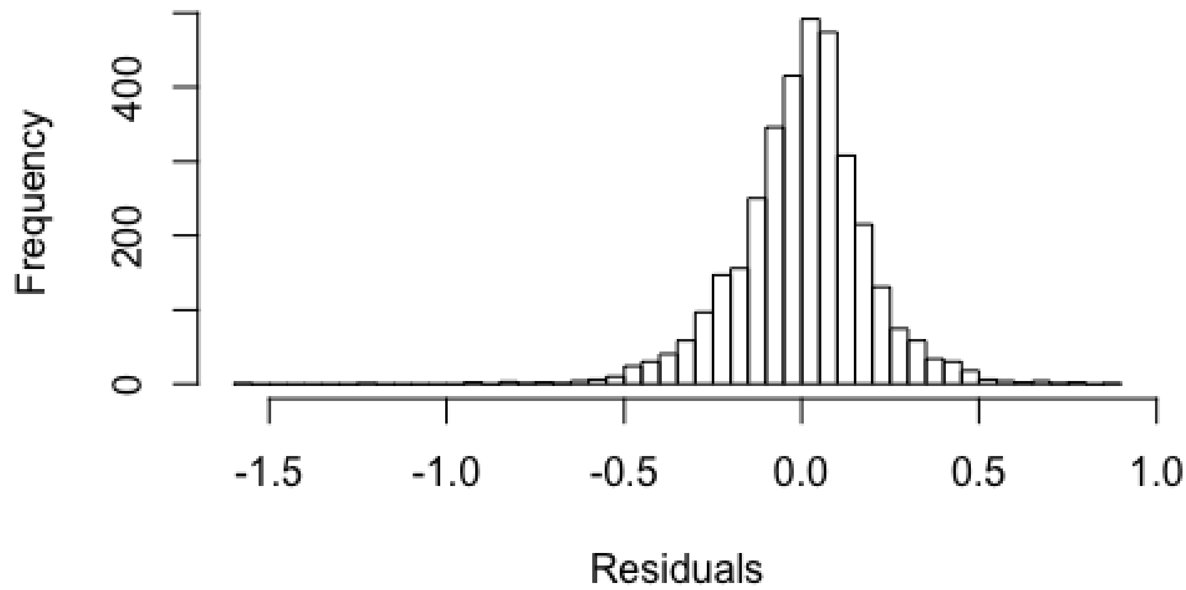

Figure 3. Histogram of residuals from Model 1 in Table 3.

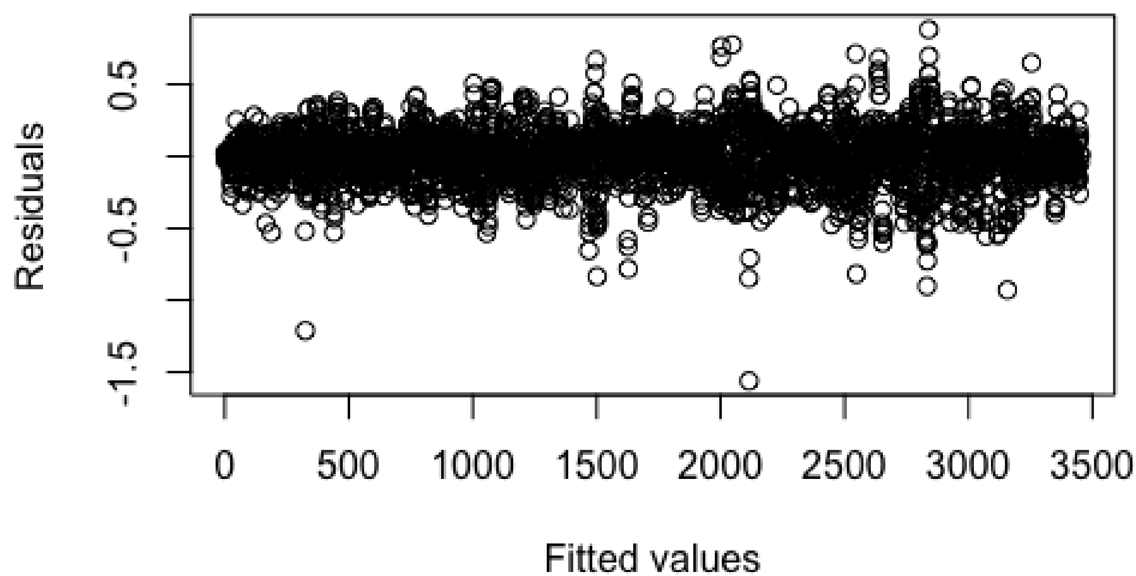

Figure 4. Scatterplot of residuals against fitted values from Model 1 in Table 3.

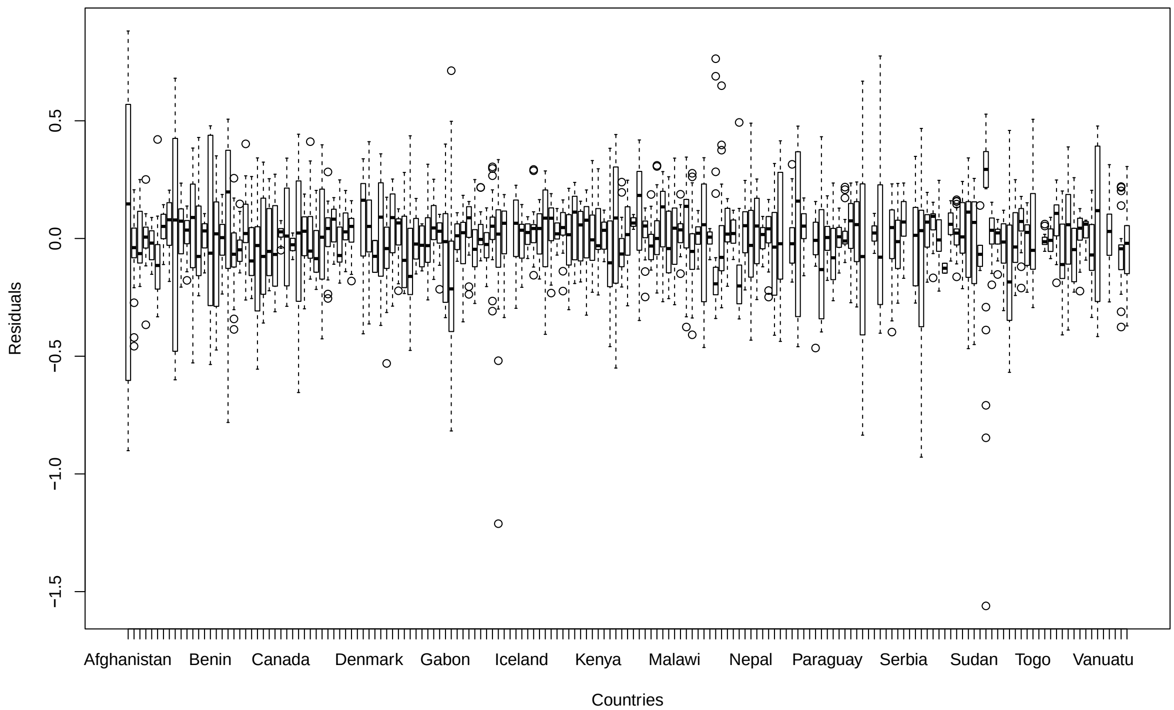

Figure 5. Plot or residual variance from Model 1 in Table 3 against countries.

9.5 Full tables with all results from control variables

Table 18. Full Table 4. Relationships between subcomponents of participatory DQ and CO^2 per capita

	Model 1	Model 2	Model 3	Model 4
Civil Society	0.024			
Direct		–0.154*		
Local			0.109**	
Regional				0.122**
lnGDPpc	0.591***	0.588***	0.575***	0.582***
$lnGDPpc^2$	–0.098***	–0.095***	–0.098***	–0.096***
Trend	–0.011***	–0.010***	–0.010***	–0.011***
Urbanization	0.028***	0.028***	0.028***	0.027***
lnTrade	0.058***	0.062***	0.061***	0.059***
lnOilpc	0.055	0.071*	0.062	0.079**
Constant	0.640***	0.637***	0.632***	0.636***
Observations	3 445	3 455	3 397	3 454
Countries	161	161	160	161
AIC	–4 272	–4 277	–4 230	–4 294
BIC	–4 186	–4 191	–4 144	–4 208

* p<0.1, ** p<0.05, *** p<0.01. Dependent variable: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered.

Table 19. Full Table 5. Relationships between democratic qualities and CO^2 per capita for different income groups

	Model 1	Model 2	Model 3	Model 4	Model 5
Electoral DQ	0.186**				
Electoral DQ * GDPpcMed	–0.062				
Electoral DQ * GDPpcHi	–0.199*				
Electoral DQ * GDPpcVeryHi	–0.239*				
Liberal DQ		0.092			
Liberal DQ * GDPpcMed		–0.111			
Liberal DQ * GDPpcHi		–0.076			
Liberal DQ * GDPpcVeryHi		–0.088			
Deliberative DQ			0.043		
Deliberative DQ * GDPpcMed			–0.031		
Deliberative DQ * GDPpcHi			–0.037		
Deliberative DQ * GDPpcVeryHi			–0.075		
Egalitarian DQ				0.314***	
Egalitarian DQ * GDPpcMed				0.046	
Egalitarian DQ * GDPpcHi				–0.022	
Egalitarian DQ * GDPpcVeryHi				–0.198	
Participatory DQ					0.331**
Participatory DQ * GDPpcMed					–0.154
Participatory DQ * GDPpcHi					–0.236
Participatory DQ * GDPpcVeryHi					–0.358*
GDPpcMed	0.001	–0.009	0.002	0.012	–0.008
GDPpcHi	–0.008	0.002	0.011	0.017	–0.009
GDPpcVeryHi	–0.007	–0.001	0.010	0.037	0.004
lnGDPpc	0.596***	0.582***	0.590***	0.576***	0.581***
$lnGDPpc^2$	–0.093***	–0.095***	–0.095***	–0.097***	–0.095***
Trend	–0.011***	–0.011***	–0.011***	–0.010***	–0.010***
Urbanization	0.028***	0.028***	0.028***	0.027***	0.028***
lnTrade	0.059***	0.059***	0.057***	0.057***	0.057***
lnOilpc	0.069*	0.068*	0.052	0.080**	0.066*
Constant	0.650***	0.642***	0.633***	0.634***	0.643***
Observations	3 452	3 445	3 455	3 455	3 455
Countries	161	161	161	161	161
AIC	–4 240	–4 229	–4 243	–4 245	–4 274
BIC	–4 117	–4 106	–4 121	–4 122	–4 151

* p<0.1, ** p<0.05, *** p<0.01. Dependent variables: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. Reference group: Low-income countries.

Table 20. Full Table 7. Relationships between subcomponents of participatory DQ and CO^2 per capita for different income groups

	Model 1	Model 2	Model 3	Model 4
Civil Society	0.132			
Civil Society * GDPpcMed	–0.092			
Civil Society * GDPpcHi	–0.160			
Civil Society * GDPpcVeryHi	–0.276**			
Direct		–0.353**		
Direct * GDPpcMed		0.290*		
Direct * GDPpcHi		0.282		
Direct * GDPpcVeryHi		0.189		
Local			0.165**	
Local * GDPpcMed			–0.076	
Local * GDPpcHi			–0.081	
Local * GDPpcVeryHi			–0.108	
Regional				0.196**
Regional * GDPpcMed				–0.037
Regional * GDPpcHi				–0.126*
Regional * GDPpcVeryHi				–0.159*
GDPpcMed	–0.002	0.007	0.005	0.005
GDPpcHi	–0.003	0.013	0.015	0.008
GDPpcVeryHi	–0.001	0.016	0.018	0.004
lnGDPpc	0.592***	0.588***	0.569***	0.583***
$lnGDPpc^2$	–0.095***	–0.094***	–0.096***	–0.094***
Trend	–0.011***	–0.010***	–0.010***	–0.011***
Urbanization	0.028***	0.028***	0.028***	0.028***
lnTrade	0.058***	0.062***	0.060***	0.058***
lnOilpc	0.058*	0.070*	0.060	0.075**
Constant	0.643***	0.626***	0.624***	0.633***
Observations	3 455	3 455	3 397	3 454
Countries	161	161	160	161
AIC	–4 238	–4 244	–4 191	–4 258
BIC	–4 115	–4 121	–4 069	–4 135

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Dependent variables: natural logarithm of CO_2 emissions per capita. All right-hand side variables centered. Reference group: Low-income countries.

9.6 List of countries by income group

From Table 6 (unbalanced panel) for the year 2003:

Low income:

Haiti, Senegal, The Gambia, Mauritania, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Mali, Ivory Coast, Burkina Faso, Ghana, Togo, Niger, Benin, Sao Tome and Principe, Chad, Democratic Republic og Congo, Central African Republic, Lesotho, Zambia, Burundi, Rwanda, Zimbabwe, Sudan, Uganda, Mozambique, Malawi, Kenya, Ethipoia, Eritrea, Tanzania, Comoros, Somalia, Madagascar, Tajikistan, Afghanistan, Nepal, Bangladesh, Burma/Myanmar, Laos, Cambodia, North Korea.

Medium income:

Guatemala, Honduras, Nicaragua, Bolivia, Guyana, Paraguay, Cape Verde, Morocco, Nigeria, Cameroon, Angola, Republic of the Congo, Namibia, Bosnia and Herzegovina, Albania, Modlova, Ukraine, Swaziland, Egypt, Palestine/West Bank, Jordan, Syria, Djibouti, Yemen, Iraq, Armenia, Georgia, Azerbaijan, Turkmenistan, Uzbekistan, Pakistan, Maldives, Kyrgyzstan, India, Sri Lanka, Bhutan, Democratic Republic of Vietnam, Indonesia, Mongolia, China, Philippines, Papua New Guinea, Solomon Islands, Vanuatu, Fiji.

High income:

El Salvador, Costa Rica, Cuba, Panama, Ecuador, Peru, Jamaica, Colombia, Chile, Diminican Republic, Venezuela, Argentina, Uruguay, Suriname, Brazil, Algeria, Equatorial Guinea, Gabon, Tunisia, Libya, Croatia, Slovakia, Montenegro, Serbia, Poland, Macedonia, Bulgaria, Latvia, Estonia, Lithuania, Botswana, Romania, Belarus, South Africa, Turkey, Lebanon, Russia, Iran, Mauritius, Kazakhstan, Thailand, Malaysia.

Very High income:

Norway, Sweden, Denmark, Germany, Ireland, United Kingdom, Iceland, Finland, France, Spain, Italy, Portugal, Slovenia, Switzerland, United States of America, Canada, Trinidad and Tobago, Barbados, Belgium, Netherlands, Luxembourg, Czech Republic, Austria, Hungary, Greece, Cyprus, Israel, Saudi Arabia, Kuwait, Bahrain, Qatar, United Arab Emirates, Seychelles, Oman, Singapore, Hong Kong, South Korea, Japan, Australia, New Zealand.