Even Isungset

State Ownership and Climate Change

Can State Ownership of the Economy Reduce Greenhouse Gas Emissions? A Quantitative Study

Master's thesis in Political Science
Supervisor: Indra de Soysa
June 2022

Master's thesis

NTNU
Norwegian University of Science and Technology
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Abstract

This thesis is a quantitative analysis of whether the state or the market is best suited to deal with climate change. The state versus market debate is relevant as there have recently been debates over which is best to deal with environmental issues such as climate change or over which side has the most severe problems; are market failures or state failures most severe? This thesis is the first quantitative study investigating state ownership and climate performance on a global scale on a state level, as most previous research focuses on China and the firm level. State ownership will also be conditioned by good institutions and electoral democracy

The thesis uses time-series cross-sectional (TSCS) methods and random effects to research the impact of state ownership on greenhouse gas (GHG) and related indicators. 164 countries are included. The state versus market division is represented by a novel variable from the V-Dem dataset measuring the degree of state ownership of the economy. The dependent variables include CO_2 per GDP produced, CO_2 per capita, GHG per capita, renewable energy consumption as a percentage of total energy consumption, and eco-innovation. Ecological footprints are also used as an alternative independent variable and as a robustness check. The emissions measurements are relevant to capture the amount of GHG emissions of each country which are direct measures of how much they contribute to climate change. CO_2 is measured both per GDP produced and per capita to capture both the weak and the strong sustainability. Renewable energy consumption as a percentage of total energy consumption and eco-innovation are included to shed light on some of the underlying mechanisms that might reduce GHG emissions.

The findings of the thesis are mixed. Some state ownership of important sectors reduces CO_2 per GDP produced and CO_2 per capita. More state ownership only increases general GHG emissions per capita. More state ownership also increases eco-innovation and reduces renewable energy consumption. Introducing the interactive effect of good institutions and democracy on state ownership of the economy variable makes the interactive effect increase both measures of CO_2 emission. However, the interactive effects of good institutions and democracy do decrease general GHG emissions per capita in developing countries. Meanwhile, the interactive effects still increase GHG emissions in western industrial democracies. The conditional effects of good institutions and electoral democracy on state ownership lead to mixed results for eco-innovation while reducing renewable energy consumption.

Sammendrag

Masteroppgaven er en kvantitativ analyse som undersøker om staten eller markedet er best egnet til å forebygge klimaendringer. Det har i det siste foregått en debatt om hvorvidt staten eller markedet kan håndtere miljøsaker best, slik som klimaendringer. En annen måte å se debatten på er at den handler om hvilken av sidene som har de mest alvorlige feilene; er det markedssvikt eller statssvikt som er det mest alvorlige problemet? Mye av den tidligere forskningen på statlig eierskap av økonomien og klima er fokusert på Kina og på et bedriftsnivå. Denne masteroppgaven er det første kvantitative studiet som undersøker disse spørsmålene på en global skala og med et fokus på det statelige nivået. Den statlige eierskapsvariabelen blir også testet i samspillsledd sammen med indikatorer på gode institusjoner og på demokrati.

Oppgaven tar i bruk time-Series Cross-Sectional (TSCS) metode og random effects for å undersøke effekten av statlig eierskap av økonomien på drivhusgasser og relaterte indikatorer. Statlig eierskap blir målt på en original måte ved hjelp av statlig eierskap av økonomivariabelen fra V-Dem datasettet, 164 land er med i analysen. De avhengige variablene er karbondioksidutslipp per bruttonasjonalt produkt som blir produsert, CO_2 per innbygger, klimagasser per innbygger, fornybar energi som en prosent av den totale energibruken og eco-innovasjon. Økologisk fotavtrykk blir brukt som et alternativt mål og for å forsikre om robusthet. Utslippsmålene er relevante ettersom de måler direkte hvor mye utslipp hvert enkelt land bidrar til klimaendringer. CO_2 blir målt både per bruttonasjonalt produkt produsert og per innbygger, dette blir gjort for å fange opp både svak og sterk bærekraft. Fornybar energi som en prosent av den totale energibruken og eco-innovasjon er inkludert for å fange opp noen av mekanismene som kan redusere klimagassutslipp.

Analysen i oppgaven fører til blandede resultater. En viss grad av statlig eierskap i viktige sektorer bidrar til en reduksjon i både CO_2utslipp per bruttonasjonalt produkt som blir produsert og CO_2 per innbygger. Mer statlig eierskap øker også mengden eco-innovasjon mens det har en negativ effekt på alle de andre avhengige variablene. Når samspillet mellom statlig eierskap av økonomien og gode institusjoner eller demokrati blir tatt med i modellen fører det til at begge samspillene øker begge former for CO_2 utslipp. Samtidig fører samspillene til en reduksjon i generelle klimagassutslipp per innbygger i utviklingsland. Det samme samspillet fører til en økning i generelle klimagassutslipp i vestlige industrialiserte demokratier. Statlig eierskap i samspill med gode institusjoner og demokrati har blandede resultater for eco-innovasjon, mens det reduserer fornybar energi som en prosent av den totale energibruken.

Forewords

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Even Isungset

Trondheim, June 5, 2022

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List of Abbreviations

ASEI – ASEM Eco-Innovation Index

ASEM – Asia-Europe Meeting

CO_2 – Carbon Dioxide

ECF – Ecological Footprint

ECK – Environmental Kuznets Curve

Eco-IS – Eco-Innovation Scoreboard

EPI – Environmental Performance Index

EU – European Union

GCII – Global Cleantech Innovation Index

GHG – Greenhouse gas

IPCC – Intergovernmental Panel on Climate Change

MBI – Market-Based Instruments

OECD – Organization for Economic Co-operation and Development

R&D – Research and Development

SOE – State-Owned Enterprise

TSCS – Time-Series Cross-Sectional

WDI – World Development Indicators

1. Introduction

According to the most recent IPCC reports, climate change leads to multiple risks for human and natural systems, and if we do not stop global warming at 1.5°C above pre-industrial levels, it can lead to even more severe risks for both human and natural systems (H.-O. Pörtner et al., 2022). Further policies must promote GHG reduction if we are to stop global warming 1.5 or 2°C above pre-industrial levels. If we continue with the policies that were in place at the end of 2020, the median outcome will be 3.2°C warming above pre-industrial levels by 2100 (IPCC, 2022, p. 21). There are many debates on how the problem is best solved. This thesis, however, focuses on one of these debates: whether the state or the market is best suited to deal with climate change (Dryzek, 2021; Riedy, 2020). The debate, in part, is over whether market failure and state failure are the most significant problems (Helm, 2010; Hepburn, 2010).

Similarly, researchers disagree on whether market mechanisms or state interventions and policies can reduce greenhouse gas (GHG) emissions and move us towards a sustainable future. Neoclassical economists and Prometheans have argued that the free market is the most efficient way to deal with climate change (Carter, 2018; Dryzek, 2021). Others have recently argued that the state can or should take on a larger role in solving the climate problem (Duit et al., 2016; Eckersley, 2004; Mazzucato, 2021). State ownership of the economy is used as a proxy indicator for measuring to which extent the free market or the state has performed best in reducing GHG emissions and preventing GHG emissions. So, is the market the best solution, or is it the state? [1] The research question is, therefore:

How does state ownership of the economy affect greenhouse gas emissions?

The research question is relevant as debates about the state's role in dealing with climate change are considered in relation to contemporary issues such as the potential of a Green New Deal in the US (Mastini et al., 2021) and the launch of a European Green Deal in the European Union (EU) in December 2019 (Skjærseth, 2021). The EU green deal can potentially bring in the state to intervene and lead the green transition. It might even have the potential to transform capitalism for sustainability (Mazzucato, 2022). It is, therefore, relevant to see how such state intervention has performed in the past.

The debate is also relevant for developing countries – especially in the global south – to see in what direction they should develop their economies while having as little climate impact as possible. It has been argued that emerging economies, which generally have even more state ownership, need their own context-specific solutions to climate change. These emerging economies are now attempting to tackle the climate problem (Mayer & Rajavuori, 2017).

The research question is also academically relevant as the state versus market issues lack academic consensus. There is a significant theoretical and empirical disagreement about whether the market or the states are best to solve the climate change problem. For example, Mazzucato (2014, 2021) argues that the state can fix market failures and take on a leading role in dealing with climate change which means going beyond fixing

[1] The research question and the research design are based on a research design I created for the course POL3004.

market failures. Mazzucato thinks the state should invest in long-term projects like renewable energy and climate-related research. The state must do this because the markets lack the incentive to take the high risk and pursue long-term interests instead of the short-term interests of shareholders. Mazzucato still argues that the market has a role, but the state must take the lead.

There seem to be limitations in what market-based mechanisms can do. Therefore, there are also areas where the government can make significant changes (Hepburn, 2010; Mayer & Rajavuori, 2017); this has also been implied by the Paris Agreement and IPCC reports. The state has the potential to make such a change since States often own the central economic actors of carbon-intensive economies. The state has an especially prominent potential with the fossil fuel and the power generation industry (Mayer & Rajavuori, 2017).

The other side of the debate includes those who argue that the market is the solution. This discourse might be called Promethean. Prometheans might say that government involvement will lead to government failures or other problems. When it comes to specific authors who argue for this, one of the most prominent ones is Bjørn Lomborg (Dryzek, 2021). Lomborg (2020) argues that the market and continuous economic growth is the solution.

Different theories and schools of thought sit at various places on the axis between the two poles. One side sees the state as the problem, and the other side considers the market the problem. A political axis can be used to conceptualize this spectrum of belief (Boyce, 2002, p. 126).

This thesis will try to come to some answers in the debate on the balance between state and market in solving the climate problem. The state is also of particular interest as the state as a unit of analysis has been overlooked recently as the focus has turned to the international level (Duit et al., 2016). And even if it is a global issue, lots can happen on a state level (Dryzek et al., 2011, pp. 479-489).

Interestingly, there seems to be a lack of quantitative research on the topic, even if the market versus state debate is much debated. There is some related research on the firm level, but this is the first quantitative analysis on the state level. The focus on government ownership can lead to new evidence of what structure states economies should have to prevent climate change, for example, through the renewable energy transition, innovation, or just a general reduction in greenhouse gas emissions. The state ownership of the economy variable will contribute by showing some statistical results in precisely this area. The novel state ownership of the economy variable is from the V-dem dataset and measures how much capital the state owns (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Altman, et al., 2021).

I employed multiple dependent variables to measure aspects of national climate performance. As the dependent variables, I use various measurements of greenhouse gas emissions and two performance measures: renewable energy and eco-innovation. State ownership of the economy is the main independent variable. State ownership will also be tested in interaction with less corruption and electoral democracy. I use a combination of other variables as control variables, and to ensure robustness.

The findings of the thesis are that the results are mixed. A general conclusion is that some state ownership of important capital reduces emissions measured as both CO_2 per GDP produced and CO_2 per capita while only increasing GHG per capita. When conditioned by democracy or good institutions, state ownership reduces GHG emissions per capita in developing countries, but not elsewhere. The conditional effects of democracy and good institutions increase both types of CO_2 emissions regardless of the division of samples of countries as developed and developing. State ownership also increases eco-innovation, but the result for the conditional effects is mixed. Lastly, more state ownership reduces renewable energy consumption as a percentage of total energy consumption.

The thesis proceeds as follows; First, a literature review will discuss and provide an overview of the current literature, presenting the major arguments and theories. Three hypotheses are developed based on the literature review and theory. Then, the data and section will explain the choice of variables. The methodology section follows this. Next, in the analysis and discussion part, the data is used to conduct a regression analysis, presenting the findings. Based on this, the discussion part will analyze the results based on the theory and previous findings in the literature. Lastly, the conclusion summarizes the findings and develops suggestions for future research.

2. Literature Review and Theory

There is extensive literature on state ownership versus the free market. The debate is one of the most significant in politics and economics (Tanzi, 2011). However, this thesis only focuses on one part of the debate: if the state or the market is best fitted to deal with climate change – or which one is worse. Still, this is no small topic. The focus on the state as the unit of analysis allows me to borrow from the extensive literature on states (Duit et al., 2016). The literature will outline the theories and findings on the state's role in dealing with climate change.

The literature review starts with a short general history of the state's role in environmental issues. Followingly, I discuss the divide between those that think that the free market is generally the solution; and those who see that more state intervention is needed; this divide will be based on discourses. The different strands of the arguments will be discussed and based on this. Lastly, I develop three hypotheses based on the discussion.

2.1. Historical Background of the State and the Environment Issues

The history of approaching environmental problems starts with the state. The state conducted the initial efforts at tackling environmental problems, and most of the measures for climate policy occur within the nation-state. Governments often use Environmental policy integration (EPI) to deal with environmental issues. EPIs are strategies for environment protection both for general sectors like climate change and for specific resources such as water management. There are two general integration mechanisms, organizational reforms, e.g., environment ministries (a classic measure to deal with environmental issues) and administrative techniques. Administrative techniques include techniques such as cost-benefit analysis and risk assessments (Carter, 2018).

From the beginning of the 1970s, many countries created ministries of the environment as an initial attempt at EPI. Later, some countries promoted the position of environment ministries by combining them with other ministries. Many EPI institutions have failed, as their ministries have not accomplished much. Contrarily, some countries like Sweden and Norway have been relatively successful. However, the more specific national green plans and specific climate policy integration have seen some success (Carter, 2018).

Even if the state has a central role – and another reason why it is relevant to have the state as the unit of analysis – as Duit et al. (2016) argue, studies on environmental politics have focused less on the state, undermining its role on the issue. In an issue of the Environment Politics journal, Duit and others aimed to set a new research agenda in this area. They use the concept of the environmental state to do this, defined as: "a state that possesses a significant set of institutions and practices dedicated to the management of the environment and societal-environmental interactions" (Duit et al., 2016, p. 5). Duit et al. (2016) argue that the environmental state emerged in the last third of the 20th century, around the time countries started creating ministries of the environment. The concept of the environmental state has been developed further and identified in both western countries and non-western countries, and the states that do not yet have environmental states seem to be converging (Sommerer & Lim, 2016). The environmental state is, therefore, an issue of increasing relevance.

Duit (2016) argues that this environmental state has four ways to deal with environmental issues: regulation, redistribution, organization, and knowledge generation. Similarly, how the state traditionally has dealt with environmental issues, is according to Carter (2018), through four general categories of policy instruments that states can use to promote sustainable development: "regulation, government expenditure, voluntary action, and market-based instruments (MBIs) – sometimes called economic instruments" (Carter, 2018, p. 332). Regulation is the most utilized instrument (Carter, 2018). States, therefore, have historically had multiple mechanisms through which they have attempted to deal with environmental issues.

Based on the history of the role of states in environmental issues and the rise of the environmental state, it seems that the state today has an essential role in dealing with environmental issues. Still, there is no agreement on how much the state should be involved and how it should intervene in different areas. Therefore, the following section will discuss the environmental discourses and approaches used to answer these questions.

2.1.1. Environmental Discourses

Dryzek (2021) divides the environmental discourses into four categories based on their approach to tackling environmental issues. Firstly, the *environmental problem-solving* discourse sees adjusting the current system – often through public policy – as the best solution. Secondly, the *sustainability* discourse argues that the current system must be reformed to ensure growth and development are made sustainable and do not contradict environmental protection. These first two discourses see that the current system can be reformed to deal with environmental issues, while the next two find that a more radical approach is needed. The third approach – the discourse of *limits and survival* posits that centralized control by elites is required to stop driving climate change factors such as economic and population growth. Lastly, *green radicalism* aims to change the relationship between humans and nature and make structural changes to the current industrial system.

There are two supplemental discourses in addition to these four approaches. They both also argue that climate change is real, but no drastic solutions are needed. The most radical one is *gray radicalism*. The grey radicalism discourse is not attempting to deal with environmental issues as it does not want to try to solve the climate problem, and they do not believe in markets as the solution. Instead, grey radicals want to return to the past energy sources, like coal, even if the market has shown that this is not a viable solution. Grey radicalism has ties to right-wing ideologies, and an example is that Trump campaigned on his support of the coal sector in the US. Grey radicalism can be seen as a reaction to environmentalism. However, grey radicalism will not be discussed much here as they do not take the issue of climate seriously and do not try to come up with a solution. However, a more skeptical discourse is relevant, the *Promethean* one. Unlike the gray radicals, Prometheans agree that there is an environmental problem. But what makes them different is that the Prometheans argue that the current system can deal with the environmental issues by itself. Prometheans say that the free market and human progress can deal with environmental problems (Dryzek, 2021).

Dryzek (2021) sees the Promethean discourse as especially prominent among economists and traces it back to Harold Barnett and Chandler Morse’s 1963 book *Scarcity and Growth*. Barned and Morse based their argument on the traditional concept in the economics of price as a measurement of scarcity. So, when prices go up, that is because scarcity increases.

A historical example of scarcity and growth is how society changed since wood was the primary energy resource (1500-1700 in Europe). People then feared running out of energy when wood became scarce. But a solution arrived when they started using coal. This pattern has continued until today, and so have the Promethean arguments, as prices keep decreasing when humans find new solutions. Julian Simon was, for example, a prominent Promethean in the 1980s. Simon argued that human ingenuity is the ultimate resource. Thus, if markets are free, the profit motive will powerfully drive innovation and change. After him, Bjørn Lomborg took up the Promethean torch (Dryzek, 2021). The Promethean discourse represents the side that argues against state involvement in dealing with environmental issues.

Dryzek (2021) argues that the Prometheans are leading over the *Limits to growth* regarding evidence. He suggests that this might be because they sometimes use oversimplified statistics but are also based on the phenomenon of displacement. The phenomenon of displacement is that developed countries exports their pollution sources to developing countries; this then shows up as emission reduction when one looks at the statistics since pollution is simply moved elsewhere. Therefore, Promethean statistics need to use global trends to be trustworthy – according to Dryzek. Still, one often loses out when arguing about trends with a Prometheans, as many global trends are positive; still, according to Dryzek, these current trends are no guarantee for the future.

Even if Prometheans argue that there is no need for more state involvement, their argument does imply involvement by the state. Bjørn Lomborg argues that large-scale technological solutions and bioengineering are the more cost-efficient ways to deal with climate change. Dryzek argues that these initiatives will be so ambitious that governments will have to become involved to make them happen (Dryzek, 2021, p. 58). Next, I detail further the arguments of Prometheans and related discourses critical to understanding how governments may or may not be better for leading in the solving the climate change problem driven by global warming.

2.1.2. The Market as the Solution (Prometheans/Neoliberalism/Economic Rationalism):

Prometheans are not the only ones who argue that the market is the best solution to climate change. Still, Prometheans are the only ones that say that the market should be left to itself (Dryzek, 2021). The following section will be structured by starting with those who only argue that the market is the solution, then gradually moving toward those that see the state as the solution to climate change. It, therefore, makes sense to start with Bjørn Lomborg himself.

Based on the most recent book from Lomborg (2020), False Alarm, it is not clear that he thinks the market can solve the problem all on its own as the Promethean discourse would. There is some more nuance to Lomborg's argument. He argues that we need to deal with climate change actively, but the current approach is too expensive. Lomborg further argues that the current approach also puts too much pressure on the general population, who are unwilling to pay, and it makes the poor have to take on more of the burden. Placing the responsibility on the people is making the solutions to climate change unpopular and leads to unrest, exemplified by the yellow vest protests in France

Lomborg (2020) argues that climate change should be dealt with through more cost-efficient solutions such as green innovation and carbon tax. A general approach should focus on long-term development and cheaper options such as geoengineering and adaptation to climate change instead of panicking and applying expensive short-term solutions. Still, Lomborg is not as ambitious as others. He thinks the zero-emission goal should be abandoned as it is too costly. He argues that climate change is not that much of a problem and that what he calls climate hysteria does more damage than good.

Additionally, Lomborg argues that the consequences of climate change will not be as severe as many thinks. If the market is left to itself, it is estimated that climate change will reduce global GDP by 3.6 percent by 2100; this is nothing to the estimated 450 percent estimated growth in GDP during the same period. And the current improvement in income and life expectancy outweighs all the negative effects of climate change.

There are, according to Lomborg, more dire issues that we should worry about, such as health and poverty. Therefore, we should stop climate hysteria and start thinking of the problems that we benefit from dealing with based on a cost-benefit perspective (Lomborg, 2020).

Not all the discourses that advocate markets as the solution are as uncompromising as the Prometheans in that there should be no involvement in the market. The *economic rationalist* discourse argues that the state may create conditions for the market to work better Economic rationalism is one of three environmental problem-solving discourses that Dryzek builds on (Dryzek, 2021).

The three environmental problem-solving discourses are administrative rationalism, democratic pragmatism, and economic rationalism. These are pragmatic approaches that are also carried out by governments today. Administrative rationalism is the most common approach of governments and is the basis of the much-discussed approach in China. The *administrative rationalism* discourse argues that experts and bureaucracies are needed to create solutions as the climate issue is complicated. *Democratic pragmatism* argues that solutions must be reached through broad participation and interactive problem-solving in liberal democracies (Dryzek, 2021).

In contrast to these two discourses, *economic rationalism* is an alternative market approach to the Promethean approach. What differentiates economic rationalism is that it argues that the state may deal with environmental issues when market failures occur. Management should be done with as little involvement by the state as possible by providing the incentives for new environment-friendly markets and sometimes even taxes. This approach is the opposite of administrative rationalism as it posits that states should only create the basic conditions for markets (Dryzek, 2021).

Many argue similarly to economic rationalism that environmental issues should be dealt with within the current free-market capitalist system; one of these groups is neoclassical economists (Dryzek, 2021, p. 142). Neoclassical economics contend that the smaller the amount of intervention in the market is, the better. The reason is that the free market is the most efficient economic system. Neoclassical economics argue that this is also the case in dealing with climate change. Taxes might only be used when there is a market failure, and even then, only reluctantly so. Neoclassical economists only see GHG emissions as an unintended externality of production. As no one pays the cost of the externality of GHG emissions, neoclassical economists see this as a simple market failure that is solved by setting a price on GHG emissions and then letting the market reduce emissions to avoid extra costs. Still, the issue of GHG as a market failure is not agreed upon among neoclassical economists. Conservative neoclassical economists might argue that it should be left completely to the market to solve or to a carbon tax. In contrast, more liberal neoclassical economists might argue that more interventionist corrections to GHG market failures are needed, such as carbon tax or tradeable carbon permits (Atkinson & Hackler, 2010). Some neoclassical economists are not far from the Promethean discourse in their skepticism of state intervention.

Neoclassical economics finds government intervention to deal with market failures problematic because the market makes fewer mistakes than the government. Put differently, according to neoclassical economists; state failures are a more common and a more severe problem than market failures. So, even if the government might be able to reduce GHG externalities short term with a carbon tax, the free market, if left alone long term, will make fewer mistakes (Atkinson & Hackler, 2010).

Although neoclassical economists prefer to let the market self-regulate, many are still unhappy with the current system. Important sectors of GHG emissions, such as the energy emissions, have traditionally had high levels of state ownership and have been subsidized by governments, even when they are less cost-effective than renewable energy (Mayer & Rajavuori, 2017; Mildenberger, 2020). Neoclassical economists argue that states should remove such interventions and subsidies to make energy production more efficient. The removal of interventions and subsidies would incentivize private energy businesses and consumers to become more efficient and conservative with their energy use. They would have to take the energy cost themselves without any support from the government (Atkinson & Hackler, 2010)

Carbon tax and cap and trade are the leading solutions to climate change for neoclassical economists. Cap and trade are systems constructed by governments based on market mechanisms. A cap-and-trade system allows one to pollute a certain amount based on a national cap that is reduced over time and is bought and sold by companies. Pigouvian tax (a tax on the goods that might cause emissions as a negative externality) is often supported by neoclassical economists such as Noble Laureate William Nordhaus (Atkinson & Hackler, 2010). In addition to a carbon tax Nordhaus (2019) also argues that an international climate club that sets ambitious goals for GHG reduction is needed; this club would also sanction those who do not follow their initiatives. Additionally, Nordhaus argues that innovation is essential. Governments should therefore support the private sector in climate-related innovation.

Others also maintain that these market-based systems are a good solution, but slightly more is needed. For example, Acemoglu et al. (2012) find that an optimal carbon tax can reduce emissions but that it must be accompanied by subsidies to drive innovation (similarly to Nordhaus, who argues that the state should assist the market in innovation). Newell and Paterson (2010) maintain in *Climate Capitalism* that there are problems with capitalism. Still, since the response to climate change needs to come now, the only solution might be to act within the capitalist system. They come up with different scenarios on how climate can be dealt with within the capitalist system. Their scenarios are climate capitalism utopia, stagnation, decarbonized dystopia, and climate Keynesianism.

So, there are multiple arguments and solutions to how the market can deal with climate change, both preventing it and dealing with its consequences. There are also arguments for why the state is not suited to the task. As already mentioned, the problem is that a fully free market is the most efficient solution according to neoclassical economists, and efficiency is the crucial point in neoclassical economics, and state intervention will obscure this efficiency. Secondly, there is the issue of government failure. There are two broad categories of government failure: those related to rent capture and those related to voting. Rent capture includes states being captured by interest groups and vested interests, such as the fossil fuel industry or labor (Mildenberger, 2020; Stern, 2015). Coal miners, for example, are often working against reforms towards renewable energy and away from coal as an energy source as they want to keep their jobs (Mildenberger, 2020). Politicians might also make more short-term choices on environmental protection as they want to keep their position during the next election cycle (Cole, 2002, p. 39). Politicians might also pursue minority interests to gain electoral support (Helm, 2010)

There is also the issue of picking the wrong winners. When states choose to subsidize a form of innovation or business, they might choose the wrong one as they lack the information to make fully informed decisions. If they pick the wrong winner, they might therefore be subsidizing something that has less potential than an alternative. Picking winners is especially prominent in research and development (R&D). Subsidizing R&D is required to fund the research needed to deal with climate change because risks disincentivize the market from investing in climate R&D, and it is, therefore, a market failure. These risks are, among other things, a lot of uncertainty about whether such research will pay off, sunk costs, and positive externalities. As government subsidies are required in this sector, states must pick winners. The process has a high risk of being captured by interest groups as researchers and firms have a considerable advantage when on information over governments in this area. Lastly, the voting issue is that governments want to be elected again (Helm, 2010).

That the market approach has advantages in efficiency over the state approach does not mean the market approach is perfect, even if there are many potential ways to critique the government approach. Free market economists have been accused of being slow in acting on climate change. For example, Nordstrom and the neoclassical tradition have been criticized for drastically underestimating the effect of climate change on growth while dismissing other consequences of climate change (Keen, 2021). Further, even if government failure is an issue, so are market failures, as already mentioned. So, as both sides of the argument have their downsides, it might be best to find a balance between the two. However, the balance might be hard to find as government and state failure and their solutions are context-specific (Hepburn, 2010). The following section will turn to the discourses and theories that view state intervention as the solution and market failure as the main issue.

2.1.3. The State as the Solution (Progressive Statism/Administrative Rationalism/New Economics):

Administrative rationalism necessitates more state involvement as the solution. Still, Dryzek (2021) says that another discourse he does not discuss is progressive statism, a pro-state discourse developed by Stevenson (2019). Statist progressivism differs in some ways from the discourses developed by (Dryzek, 2021). As:

> Statist Progressivism doesn’t share either the wholehearted rejection or support for economic growth, but rather questions the desirability of an economic system oriented so exclusively towards economic growth. The state is seen to have a fundamental role to play in moving society towards a new green economic order that pursues wellbeing over growth. (Stevenson, 2019, p. 541)

Thus, statist progressivism sees the state as an important actor that should take responsibility for creating a sustainable society; this would require a drastic increase in state intervention and steer society away from what is common in today's liberal market capitalism. Statist progressivism also has numerous overlaps with the limit to growth discourse (Stevenson, 2019). Many such discourses are arrayed against the current neoliberal order.

Riedy (2020) calls the discourses that want to change the neoliberal economic system to some extent *new economics* discourse. New economics includes statist progressivism and other ideas like the Green New Deal and *doughnut economics*.

Doughnut economics is a concept developed by Kate Raworth (2018). There are seven ideas in her book, but foundationally, she argues we must think of the economy like a doughnut. We want to stay along the ring of the doughnut and keep out of the hole in the middle and the outside. The hole in the middle represents social shortfalls, including issues like lack of food, electricity, and education. The outside of the doughnut represents ecological overshoot; ecological overshoot includes issues like climate change, different types of pollution, and biodiversity loss. So, the economy must be balanced between the social foundation and the ecological ceiling. We must go beyond markets and recognize the importance of other actors, like the state (Raworth, 2018).

However, these new economics discourses – that the concept of doughnut economics is part of – do not necessarily all advocate for more state involvement. Nevertheless, they all argue that the economy needs to be deliberatively governed to reach sustainability. To sum up: all the new economics discourses oppose what Riedy calls the current neoliberal free-market system. The neoliberal free-market side of the discourse includes other discourses and theories, such as the Promethean discourse and neoclassical economics (Riedy, 2020). Based on Riedy's division, this thesis can be seen as a debate between neoliberalism and the new economics debate, at least to some extent.

As multiple analyses identify different discourses (Riedy, 2020; Stevenson, 2019, p. 542), it is unreasonable to base the hypothesis on all of them. Instead, the critical point for this thesis is that multiple discourses argue that the state needs to take a more prominent role in the economy to deal with environmental issues in opposition to market-based approaches. These discourses might be seen as spread out through the state-marked axis on the environmental-political compass (the other axis of oligarchy and democracy will be discussed later) (Boyce, 2002, pp. 126-128). Further, the recent concept, the environmental state, will inform the main theoretical focus and the empirical analyses.

2.1.3.1 The Environmental State

As mentioned earlier, the environmental state is "a state that possesses a significant set of institutions and practices dedicated to the management of the environment and societal-environmental interactions" (Duit et al., 2016, p. 5). Duit and others want to bring attention back to the state because it still has a vital role in acting on climate, as it is a powerful entity with encompassing power over society. States control areas like property rights, fiscal policy, and coercive power. Even if international and supranational factors impact the state, the state has considerable autonomy to act. Focusing on the state also makes it possible to incorporate the vast academic literature on the state. They identify the four ways the environmental state can impact the environment, "as a system of regulation, and administrative apparatus, a corpus of ideas and expert knowledge, and a site of contestation and decision" (Duit et al., 2016, p. 7).

Sommerer and Lim (2016) identify the same environmental state in 37 non-western countries. These countries have also seen regulatory expansion into the area of the environment. Further, it seems that the expansion of the environmental state is converging between countries, as there appears to be a trend where non-western countries are catching up with the West in creating environmental states (Sommerer & Lim, 2016).

Duit et al. (2016, pp. 15-16) also outline a research agenda for the environmental state. One of the issues is the relationship between economics and the environmental state. This includes whether the state will abandon free-market principles to deal with environmental issues and whether states can overcome the structural barriers that economic interests pose. This thesis will contribute to these issues.

Duit (2016) expands on the four ways the state can deal with the environment. Two of these aspects of the environmental state are directly related to this thesis's analysis, as it will mainly focus on the economic aspects of the environmental state as this is what the state ownership of the economy carriable captures. Firstly, the regulatory element is important, where more ownership of the economy might mean that the state has greater control and autonomy and thereby greater potential for more ambitious initiatives. Secondly, it is relevant for the ideational aspect, especially in funding research and public agencies for addressing environmental issues.

Pointing out some of the environmental state's overlaps with other concepts can help highlight why the state ownership indicator can capture this. There are, for example, parallels between the rise of the environmental state and the rise of the welfare state. In both instances, the state significantly expanded its regulatory role to deal with issues not adequately dealt with by markets, local governments, or voluntary action (Duit et al., 2016, p. 9). Here, the state must also act on climate beyond what the current market-based or neoliberal economy provides. Therefore, the environmental state overlaps with what Riedy (2020) calls new economics. Mol (2016) and Gough (2016) expand on the political economy of the environmental state. Gough (2016) (building on Meadowcroft (2005)) argues that the function of the welfare state and the environmental state is similar, as they act on the logic that they can deal with negative market externalities. To summarize, Gough concludes:

> Common drivers include globalisation and internationalisation, the rising power of capital and business over other classes, and the continuing dominance of neo-liberal ideas. International economic and political linkages favour the environmental state but weaken the welfare state. Business power promotes inequality and weakens welfare, and in many countries blocks climate mitigation programmes; but its impact on the environmental state depends on the balance of carboniferous and Green business interests. (Gough, 2016, p. 43)

However, one significant difference between the welfare state and the environmental state is that the environmental state is more regulatory than redistributive. In contrast, the welfare state is primarily redistributive (Duit et al., 2016). The environmental state as a concept and its political economy parallels to the welfare state are relevant to see how governments might use control over the economy and policies to deal with environmental issues. However, the environmental state is not the first theory on the state and the environment. Others had also theorized on this issue before.

Eckersley (2004) envisages a new green state as well (she also adopts the concepts of the environmental state later (Eckersley, 2021)). Eckersley develops a concept of a green democratic state based on critical theory. She says this differentiated her from others who had tried to find the state's role in the limits-to-growth debate, as they answered that there needed to be an eco-authoritarian state to manage the limited amount of resources available (Eckersley, 2004). Paehlke and Torgerson (2005) also argue in their book *Managing Leviathan: Environmental Politics and the Administrative State* that a narrative has emerged that views the technocratic administrative state as the solution to environmental problems. They argue, similarly to Eckersley, that a democratic environmental state is needed.

Still, not everyone thinks that the environmental state is capable of dealing with environmental issues. Hausknost (2020) contends that there is a structural glass ceiling in the way of states becoming environmentally sustainable as states have fulfilled the role of being sustainable for their citizens (lifeworld sustainability) but have not done the same for the environment. It may even worsen environmental sustainability (system sustainability). Hausknost differentiates between two types of sustainability to explain the glass ceiling, life world- and system sustainability. The first type is based on the concept of the lifeworld. The lifeworld is the everyday world we live in, the world of experience. Lifeworld sustainability would be to maintain a comfortable lifeworld. Contrarily, system sustainability is a system-focused approach instead of experience-based sustainability. System sustainability would, for example, keep global warming under 1.5C. States have, according to Huasknost, been successful with lifeworld sustainability as it is politically important. System sustainability has been less successful as it can be less politically attractive. Hausknost finds three potential outcomes that can break the glass ceiling regarding solutions.

Firstly, as the effects of climate change, such as increased natural disasters, start to hurt the population, environmental sustainability will become included in the welfare of the people, and the state will potentially have to become sustainable. Yet, it could be that states will try to adapt to these changes instead of dealing with the root of the problem. Secondly, one could improve the lifeworld in non-growth ways. However, a non-growth lifeworld is quite radical as it might lead to the abolition of wage labor and other essential concepts in the capitalist system. Thirdly, an alternative democratic system that could legitimize efforts by the state to pursue system sustainability by, for example, stopping the use of resources that are not sustainable (Hausknost, 2020). In a similar vein, Hausknost and Hammond (2020) argue that the environmental state is limited to ecological modernization. In the same way, the welfare state is limited to capitalism and might even have helped the capitalistic system stay intact.

There is also the international area of the environmental issue (Duit et al., 2016). For example, environmental regimes are agreements between states for achieving common objectives, such as reducing greenhouse gases. Still, these agreements must take civil society into account. Some countries might not have sufficient state capacity to make agreements come to fruition. Thus, the state is also an essential factor in international environmental regimes (Carter, 2018, p. 272). So, even if this thesis does not focus on the international aspects, it still has implications for how stronger state control translates into better environmental outcomes.

The work of the economist Mariana Mazzucato (2014, 2021) relates to the administrative rationalism discourse, new economics discourse, and the concept of the environmental state. Mazzucato’s ideas have been relevant for the real-world development of the state's role. She has advised the EU, international organizations, and governments (Mazzucato, 2018, 2019). A recent example is that Mazzucato contributed to The Green Giant strategy for the Norwegian think tank Manifest. The Green Giant strategy argued that Norway needs the state to take the lead in “investing and coordinating the shift from a fossil-driven to a green engine in the Norwegian economy” (Mazzucato et al., 2021, p.

4). The report has many recommendations on how the Norwegian government can do this.

These recommendations include creating two new banks, a new green industrial investment bank and a Norwegian bank for sustainable international cooperation. Further, it recommends changing to a new fiscal rule so that government expenditures go toward green industries and relevant institutions. There are also two recommendations related to state ownership of the economy. Firstly, Norway should use and create new state-owned enterprises (SOEs) to be used in green industrial development. Secondly, Equinor should be used for green value creation by taking it off the stock market and placing it in state ownership category 3. Lastly, and related to state ownership, Norway should create a Green Industrial State Holding Company that actively takes a leading role in "strategic industrial coordination and development" (Mazzucato et al., 2021, p. 10) to make Norwegian state ownership more efficient (Mazzucato et al., 2021, pp. 9-10). These arguments on state ownership as a solution to climate problems are precisely what this thesis will test broadly. Examining how state ownership has recently helped or harmed green objectives should be the best guide to thinking about the issue.

Dent (2018) has also investigated existing examples of states taking on a leading role in dealing with environmental issues. They coined the concept of new developmentalism as a form of environmental statism. New developmentalism is specifically for East Asia, where states such as South Korea and Singapore have taken a more statist approach to environmental issues. New developmentalism is a more authoritarian top-down approach to environmental issues, made possible by strong state ownership of the economy. New developmentalism leads more towards the authoritarian side than other concepts like the environmental state; Dent argues that authoritarian China has succeeded in this area. The issue of whether China is successful is, however, controversial. And it is not agreed upon whether statist China is performing well (Harris et al., 2013).

Mayer and Rajavuori (2017) discuss state ownership's climate change mitigation role and potential. Mayer and Rajavuori document that carbon-intensive sectors are often state-owned, such as the fossil fuel industry. They find that the state's role in these state-owned enterprises (SOEs) is regulatory; however, they argue that the state has the potential to take a leading role instead. Even if states generally have not taken on leading their SOEs towards lower emissions, there are some promising developments. Such as Saudi Arabia's plans to reform its economy and the Norwegian Sovereign Wealth Fund (SWF), which has taken action to reduce climate change.

The research of Mayer and Rajavuori (2017) is closely related to my research. Still, the difference is that I will comprehensively assess the effects of state ownership using a large-N approach with quantitative data. The empirics will evaluate how state ownership does relative to non-state ownership systematically. Potentially conditioning factors that might make state ownership more environmentally friendly, such as good institutions and democratic governance, will also be investigated. The conditioning factors are relevant as there could be significant differences in state ownership since some governments that are, for example, corrupt could use their power to ensure political survival. In contrast, governments with good institutions could focus on using this power to reduce climate change—through mechanisms such as technological innovation.

Sagstad and Schiefloe (2019) researched state ownership on a business level. They examined how state ownership of enterprises influences Environmental, Social, and Governance (ESG) scores as a measurement for sustainability. Their research focused on the EU and some EEA countries. Sagstad and Schiefloe found that the higher the firm's state ownership levels, the better the ESG score proportionally. My thesis also researches the levels of state ownership but looks at the state's economies instead of individual firms. The dependent climate variables are also different. Sagstad and Schiefloe were particularly interested in firm sustainability and state ownership mechanisms, a scarcely researched topic. They conducted interviews with Norwegian state-owned enterprises to attempt to reveal some of these mechanisms. One mechanism might be that states take a more long-term view of their interests. Another mechanism is that SOEs also have to consider higher expectations from the state.

Mazzucato also discusses general mechanisms as to how the state can increase sustainability. In her most recent book, Mazzucato (2021) argues that the approach to solving the environmental problem (and other issues) should be similar to how the US approached their moon landing. She argues that the state needs to set an ambitious goal but work with the private sector and other non-governmental actors to reach these goals. The reason for doing this is that markets alone are not enough to deal with large issues such as climate change. There needs to be a central state that gathers the efforts of all parts of society to deal with fundamental issues. Examples of such goals are the Green New Deal in the US and the European Green (Mazzucato, 2021).

For the specific mechanisms, Mazzucato (2014) focused primarily on supply-side policies rather than demand-side policies. The supply side is where she sees the greatest potential, even if the demand side is essential too. The supply side will also be the focus of this thesis. An important supply-side mechanism, according to Mazzucato, is:

> Supply-side policies are important for putting money "where the mouth is", by financing firms directly or indirectly through the subsidy of long-term market growth, in the hope that it will accelerate the formation of innovative companies that can deliver a green industrial revolution. (Mazzucato, 2014, p. 115)

Some positive areas where states have already started to act include funding R&D of clean technologies, subsidizing and supporting leading manufacturers, and stabilizing the developments of renewable energy markets with policy and finance. Private companies only start to develop in these new areas once the government has absorbed the associated risk. As there are also other barriers like embedded energy infrastructure, nudging by governments is not enough, long-term policies and a strong "push" are needed (Mazzucato, 2014, p. 119).

Further, state investment banks can take a leading role in some countries, as seen in China (Mazzucato, 2014, p. 122). State investment banks can intervene beyond fixing market failures as they have the potential to invest in the reduction of greenhouse gas emissions, for example (Mazzucato & Penna, 2016). Related to state investment banks is the literature on sovereign wealth funds (SWFs) and how state ownership of the economy in the form of SWFs can be used to reduce GHG emissions. The Norwegian SWF, for example, has the opportunity to take on such a role. Reiche (2010) did a case study of the Norwegian SWF and concluded that Norway could become a pioneer in its use of the SWFs through initiatives such as ethical guidelines on where to invest its funds. Similarly, SWFs could also direct investments to environmental and climate interests through fiduciary law (Richardson, 2013). The impact of SWFs and state investment banks is outside the scope of my thesis and will only be discussed as a relevant related issue.

Mazzucato sees China as an example of what to do as they have set ambitious goals on clean technologies and invested in related areas in their 2011-2015 5-year plan. They have set ambitious long-term goals like having 1000 GWs of wind power by 2050. Further, Mazzucato argues that even if the US has a high share of the venture capital investment in clean energy, it lacks in the most high-risk areas, as venture capitalists generally are not willing to invest in these high technological risk areas. It seems that venture capitalists go to clean technology precisely because the government has subsidized this area (for example, First Solar). Mazzucato gives examples like the Department of Energy in the US, as to how government investment can lead to risky but necessary research. Mazzucato argues that patient capital is needed. State development banks can provide patient capital to support innovation. State development banks are willing to give longer-term and more risky loans based on other conditions, such as high social value. The productive use of patient capital has occurred, especially in developing countries like China. Patient capital allows the government to go beyond correcting market failure and instead foster innovation (Mazzucato, 2014, pp. 122-140).

Thus, according to Mazzucato, it is not enough with just R&D to solve the climate problem. Governments need to reduce risk, invest, and make long-term commitments. The state also needs to help clean energy compete with the well-established energy sector of fossil power (Mazzucato, 2014, pp. 158-163). Additionally, the state should profit when the innovation is booming to reinvest, not just throw money at risky businesses and R&D (Mazzucato, 2014, pp. 196-198).

It is worth discussing innovation more in-depth as both sides of the market versus state argument (including Mazzucato and Lomborg) agree that innovation is essential to solving the climate problem. However, they disagree on how one increases innovation. Does the state have to take on a leading role to make innovation happen, or can the market do it through investments? The following section discusses previous research on the determinants of innovation and specific climate innovation.

2.2. Technology and Innovation

It is important to promote technology and innovation as it has the potential to reduce GHG emissions without necessarily sacrificing economic growth. New technologies could, for example, make renewable energy more efficient and more sustainable lifestyles based on new technologies (Albino et al., 2014; Barbieri et al., 2016; Elia et al., 2021; McJeon et al., 2011). Previous research has shown that promoting more R&D can reduce GHG emissions (Fernández Fernández et al., 2018). The IPCC report on the mitigation of climate change also finds that innovation has led to low-emission technologies and that it can be said with high confidence that innovation made it possible to reduce emissions (IPCC, 2022).

It has been argued that States have an opportunity to take a leading role in technology and innovation. States can back "large-scale deployment of new technologies, resulting in economies of scale or simply reducing the risks of private investments" (Mayer &

Rajavuori, 2017, p. 224). Others, nevertheless, argue that free-market capitalism is best suited for innovation (Baumol, 2002). However, it is important to differentiate the literature on standard innovation and eco-innovation as the two types of innovations have different drivers (Hojnik & Ruzzier, 2016).

The specific focus here will be on eco-innovation (also known as green or environmental innovation), as eco-innovation is more directly related to GHG emissions. There are many different definitions of eco-innovation, but they mostly overlap and can therefore be used interchangeably (Schiederig et al., 2012). A recent literature review by Hojnik and Ruzzier (2016) found that there is no agreement on a definition but that:

> [A]ll definitions embrace the environmental component and reflect the two main consequences of eco-innovation: fewer adverse effects on the environment and more efficient use of resources. However, while eco-innovation can be realized in many forms (e.g., product, process, and organizational and/or marketing methods), the effect of a diminishing environmental burden is not the primary reason for the deployment of eco-innovation. (Hojnik & Ruzzier, 2016, p. 32)

The specific concept of eco-innovation is differentiated from the broader concept of sustainable innovation, which also includes social dimensions (Schiederig et al., 2012).

Literature reviews of eco-innovation and technology, such as Hojnik and Ruzzier (2016) and Barbieri et al. (2016), have focused primarily on the business level. Hojnik and Ruzzier (2016) found that the literature is often focused on regulations and market pull factors. They also found that regulations are the leading driver. Other important drivers include cost savings, increased company size, and environmental management systems. Barbieri et al. (2016) literature survey found that most of the research is on OECD countries and recommends, among other things, that future research focus on non-OECD countries and-country level investigation to better understand the macro perspective. My thesis aims to fill this gap by focusing on a global sample of countries using a macro perspective. Neither of these literature reviews mentions state ownership or SOEs.

Much of the literature on state ownership and innovation focuses on China. Wang and Jiang (2021) investigated state ownership and green innovation. They did not measure broad state ownership of the economy like my thesis does. Instead, they investigated state ownership of specific firms. Wang and Jiang found that state ownership of firms improves their green innovation, measured as green patents. Some of their findings and hypotheses were based on mechanisms relevant to the discussion in this paper and explain green innovation on a firm level. Another caveat is that this is based on the specific conditions in China and emerging economies, so this might not be the case everywhere. Additionally, the mechanism might not be present outside of China because they are quite specific. Nevertheless, these mechanisms are relevant to understanding the relationship between state ownership and innovation.

Firstly, state-owned enterprises (SOEs) are more likely to be compelled to follow government mandates and expectations on green innovation, as the government is more involved in these businesses, and they are less focused on profit maximization than fully private firms. Secondly, SOEs might get easier access to scarce resources controlled by the government, leading them to access resources needed for green innovation, such as green subsidies. Wang and Jiang found supporting results for both of these mechanisms (Wang & Jiang, 2021).

Other relevant research on China includes Bai et al. (2019), who found that government subsidies to R&D increase green innovation in energy-intensive firms. Further, Zhou et al. (2017) found that in emerging economies (using China as their case), state ownership increases R&D through access to resources. At the same time, state ownership makes firms less efficient in the same area, as government interference in private business reduces efficiency. Therefore they found minority state ownership to be the best form of ownership. Pan et al. (2020) found a U-shaped relationship between state ownership of firms and green innovation in China.

Since state ownership of the economy seemingly increases eco-innovation in China, the question becomes if this eco-innovation positively impacts the climate. As mentioned earlier, we see this pattern in the literature globally. Zhang et al. (2017) found that innovation reduces CO_2 emissions primarily through energy efficiency and resources for innovation and knowledge innovation. Innovation, therefore, seems to have a positive role in sustainability. Cheng et al. (2021) also found that eco-innovation does reduce CO_2 emissions in China. Nevertheless, Wang et al. (2019) found that even if China is doing well on innovation, they might not rely on this technology in the foreseeable future, as reliance on labor, production capital, and natural capital.

Broader, relevant literature on state ownership and innovation does exist, although it is often heavily China-oriented. It has also been found that firms' state ownership positively affects eco-innovation in Russia (Roud & Thurner, 2018). However, there is a lack of quantitative research on the effect of state ownership outside of China and this one study on Russia.

Much of the research on eco-innovation focuses on the firm level. The literature review by Tõnurist and Karo (2016) also finds this to be the case. Tõnurist and Karo say that the macro perspective on SOEs and innovation has mostly been neglected, and they say that the recently renewed attention to this from people like Mazzucato needs more attention in research as SOEs might have a potential for making a difference here. In this thesis, I will purposefully look at the larger trends at the state level. As a result, I will not be able to look at the specific firm-level variables that might also impact eco-innovation. However, this approach will give a broad view of the global trends on state ownership of the economy and environmental performance (including eco-innovation). Future research might then scrutinize the results by going into the specifics of the mechanisms.

Another mechanism where state ownership plays a role is controlling the powerful vested interest of existing sectors. Because as Stern (2015) argues, existing business interests, like the oil sector, might try to block innovative structural changes. Established businesses might want to do this as structural changes towards sustainability will hurt their economic interests as they profit from the current system where they profit on oil, which causes GHG emissions. The state might play a role in suppressing these interests and allowing the structural reforms to happen. Structural reforms are essential to reduce climate change. They might lead to "discovery, innovation, investment, and growth, much as we have seen in other waves of technological change over the last 250 years" (Stern, 2015, p. 304).

Important to these structural changes is the Schumpeterian concept of creative destruction. Creative destruction moves society forwards when innovation and entrepreneurship are allowed to replace and improve upon previous practices and transform the economy. Stern argues that we can apply creative destruction to climate change as well. Creative destruction caused, for example, by renewable energy can replace current practices such as fossil fuels. In the Schumpeterian view of history, policies have the potential to accelerate the process of innovation and creative destruction (Stern, 2015, pp. 95-129). Still, the establishments and businesses that profit from the current order may be incentivized to block creative destruction. Therefore inclusive institutions are also needed to prevent these actors from blocking innovation and creative destruction (Acemoglu & Robinson, 2012). Based on the concept of creative destruction and the inclusive institution, it might be that just state ownership is not enough to be able to transform the economy into an industrial one. There is also the need for good institutions that can suppress powerful vested interests.

The findings of Kulin and Johansson Sevä (2019) support the arguments of inclusive institutions to some extent. They found that higher quality of the governmental institutions in a country makes the population more inclined to back government spending on climate when they have a "high quality" government they trust.

There are also other ways that states potentially can increase eco-innovation. Ouyang et al. (2020) find a U-shaped relationship between environmental regulations and innovation. The U-shaped relationship suggests that regulation can be positive for regulation in a way that can promote more climate-related innovation. Breetz et al. (2018) argue that politics are an essential aspect of the energy transition to renewable energy. Researchers found that public environmental policies increase the number of renewable energy-related patents in OECD countries (Johnstone et al., 2010). Public environmental policy has also boosted innovation in environment-related technology in a larger sample of 77 countries (Johnstone et al., 2012). There is also support for the much-debated Porter hypothesis, which claims that environmental regulation might make firms more competitive (Ambec et al., 2020).

Another mechanism governments can use to increase eco-innovation is fiscal decentralization. As: "to employ eco-innovative methods, countries need continuous investment in R&D. Central governments play an important role in allowing fiscal decentralization to protect the environment with rightly formulated policies in this regard" (Iqbal et al., 2021, p. 8). Taxes are another mechanism as higher environmental taxes lead to more environment-related technological innovations (Karmaker et al., 2021).

Lastly, the existence of the green industry in itself can improve eco-innovation. The promotion of green industries has made it more relevant for the state to promote their domestic firms and industries' position in global value chains. The increase of both geopolitical and economic relevance of green industries might make states accelerate eco-innovation and the move towards renewable energy (Allan et al., 2021).

Related to technology and innovation is another essential aspect, renewable energy. Through innovation and research, renewable energy can become cheaper (Elia et al., 2021) and more efficient (Albino et al., 2014). The latest IPCC reports find with high confidence that reducing fossil fuel use and alternative energy sources are needed to reduce GHG emissions. Further investments into fossil fuels will also lock in the infrastructure, making it hard to reduce GHG emissions. The alternative energy sources include renewable energy sources such as wind and solar power (IPCC, 2022). Therefore, renewable energy is an important part of states' reduction of their GHG emissions.

2.3. Transition to Renewable Energy

State ownership might have an essential role in transitioning to renewable energy. Renewable energy consumption is relevant as many new economics discourses argue that the energy transition is happening too slowly because there are structural and vested interests in the oil and coal sector. Government intervention is needed to get away from this. Still, this is not enough, as a government might be captured by the traditional energy business (Mildenberger, 2020; Moe, 2015; Stern, 2015). Still, Prag et al. (2018) find that state ownership of enterprises increases investments in renewables. They argue that two potential mechanisms can explain the enhanced performance of SOE. First preferential treatments to SOEs, such as lower capital cost, might give an advantage in investing in renewable energy as it can require a lot of capital. Secondly, the government might use its SOEs to implement renewable energy policies

That states an important role in the energy transition is nothing new. States' have long been important actors in the energy sector. According to the International Energy Agency, state ownership is already widespread in the energy sector. SOEs own half of the world's power generation assets and an estimated 71% of oil and gas reserves. States' ownership of power generation assets is even higher in emerging economies (Mayer & Rajavuori, 2017).

States can use regulation of the supply side to trigger "global processes of economic adjustments incentivizing investments in alternative sources of energy" (Mayer & Rajavuori, 2017, p. 224). Therefore, state ownership can be a mechanism that states can use to get out of the "carbon curse." States can also use their tools to invest in renewable energy directly. Other potential mechanisms involve the state taking a leadership role. SOEs can make their current operations more sustainable by changing to more sustainable activities, preferably through diversification. State ownership can also assist firms in changing to a new economic model based on less carbon and more sustainability (Mayer & Rajavuori, 2017). Other research that supports the importance of state ownership in the transition to renewable energy is that SOE is a driver of wind power in China (Zhu et al., 2022). Public investments also indirectly affect investment in renewable electricity, as public investments in this area mobilize private investments into the same area (Deleidi et al., 2020). Another reason involvement by the state might be needed is that even if several major oil-producing firms have adopted a rhetoric of a transition to more renewable energy. Financial analysis shows that this is mostly empty rhetoric and that no such voluntary transition is taking place. Instead, this rhetoric is mostly a sign of greenwashing by these firms (Li et al., 2022).

There is, as already mentioned, generally high public ownership of the energy sector, but this public ownership can take many different forms, and state ownership is only one of them. Haney and Pollitt (2013) argue that mixed ownership might be the best form for the energy sector. Mixed ownership allows states to get the advantages of both forms of ownership. Sometimes it might not even be an option to have it fully one way when it comes to ownership form, as contemporary issues such as climate change require that the sector reach social goals such as dealing with climate change while delivering new investments. Mixed ownership is best suited to deal with this as the state-owned part promotes climate change while the private part promotes investments.

Some issues with state involvement in the renewable sector are not directly related to state ownership but are still relevant for the discussion. Hao and Shao (2021) detail the drivers of renewable energy transitions and previous literature on the topic and found that carbon tax has an insignificant effect on renewable energy deployment.

Setting a high carbon tax for one country may have negative consequences, like the flight of capital to other countries. The reason is that the cost of doing business within the country becomes uncompetitive internationally due to the increased tax. There are, however, some policies in the works that might tackle this problem. Other obstacles like the lack of economy of scale compared to established energy sources like fossil fuel, barriers to trade, path dependency, and externalities make it hard for renewable energy to develop itself in a free market. According to institutional theory, bureaucracy is another obstacle, as they are often slow-moving and "conservative." Vested interests are also an issue globally. So, the energy transition cannot be done by technological progress alone (Moe, 2015).

The main discussion has been of discourses or theories that argue that environmental and climate issues can be dealt with while growth in both wealth and population terms continues. Therefore, it is relevant to turn to a discussion of sustainability to see if such sustainable growth is possible or if a reduction in growth is needed to deal with climate change.

2.4. Sustainability

Ecological Modernization and Sustainable Development (and Green Growth) are part of the sustainability discourse (Riedy, 2020, p. 103). The Brundtland report popularized and made this argument of sustainability the standard approach (Dryzek, 2021). Sustainable development is now on the global agenda for both companies and governments (Shi et al., 2019). There is still no shared definition of sustainable development (Atkinson et al., 2014). However, to get an overview of what the definitions have in common, Carter (2018, pp. 222-229) identified five core principles of sustainable development: equity, democracy and participation, the precautionary principle, policy integration, and planning.

Another popular sustainability approach is ecological modernization (Dryzek, 2021). Ecological modernization, founded by Joseph Huber, argues that capitalism can become green while making profits (Carter, 2018, p. 232; Huber, 2004) (also see (Hajer, 1995)). Meanwhile, the state also takes on a new role of steering the economy in a positive-sum game where economic growth can improve environmental performance (Carter, 2018, p. 233). There are, however, problems with ecological modernization; it does not necessarily include social justice. It focuses on the prosperous north, and there are mixed results on how well states have done on ecological modernization. The same goes for companies. Green growth became prevalent as an answer to the 2008 financial crisis and the stern review (Carter, 2018, pp. 237-242).

Some argue that the developed world needs to stop its economic growth and only let developing countries see growth, as continuing growth in the developed world is unsustainable (Victor, 2018). This is what Dryzek (2021) calls the limit to growth discourse as it argues that continuous economic growth and stopping climate change or other environmental issues are mutually exclusive issues.

In theory, Hickel and Kallis (2020) find that green growth is possible, but it is impossible to prevent global warming at 1.5C or 2.5C only with green growth. Still, politicians base their plans on the sustainability assumption; this is probably because anything but green growth is politically impossible to get through democratically. People are not willing to sacrifice economic growth to reduce global warming. The Environmental Kuznets Curve (EKC) is a counter-argument to the limits to growth discourse.

The concept of an EKC is that when countries' economies start to grow, they increase the environmental deterioration. Still, once they get to a certain level, the environmental deterioration will decrease. This relationship looks like an inverted U-curve, similar to the original Kuznets curve (Shahbaz & Sinha, 2019). The original article that found an EKC was by Grossman and Krueger (1995). This environmental Kuznets curve (EKC) has been investigated many times in the literature, but there is still no conclusive answer on whether it exists (Shahbaz & Sinha, 2019).

One example of research on the EKC is Joshi and Beck (2018). They found no evidence for a CO_2 EKC in OECD – divided into subcategories based on political freedom –or non-OECD countries. They do find that a rise in income monotonically increases CO_2 emissions. Political freedom has a different effect in OECD countries and non-OECD countries, as it seems to increase pollution in OECD countries, maybe because interest groups capture the political process to stop emission cuts that hurt them. Still, in non-OECD countries, however, political freedom does not have much impact on CO_2 emissions. The findings on economic freedoms and the EKC were mixed, but they found that more economic freedoms lead to business expansion, leading to more emissions. Joshi and Beck see more economic regulation by the government as the solution to this increase.

Others have investigated the EKC with other measurements of climate performance, such as ecological footprint. But studies have found different results here as well. Sarkodie (2021) found that instead of an EKC, there is a scale effect. Here, growth leads to more ecological destruction, but rich nations move this to developing countries, so it looks like a Kuznets curve on a graph. It also seems to lead to environmental convergence eventually. The solution appears to be more renewables. Others have found an environmental Kuznets curve using ecological footprint (Al-mulali et al., 2015). Kate Raworth (2018) criticizes the basis of the EKC. She argues the graph is incorrect in its prioritization. Currently, the EKC prioritizes growth first, then the climate, while she believes climate should be prioritized first as this is the critical issue.

So far, most of the theories and discourses that have been discussed are part of the sustainable discourse, as none of them have a reduction of growth as their goal. Still, the *new economy* side is probably more willing to sacrifice growth to reduce emissions. However, other theories, like the limit to growth, argue that no matter what, the world will have to reduce emissions to save the planet as continued or unlimited growth is not sustainable (Dryzek, 2021). Previous research has found support for the limits to growth theory as economic growth leads to a race-to-the-bottom in terms of environment (Aşıcı, 2013). The basic assumptions of this thesis, however, rely on sustainability, but if the analysis results in this thesis are that neither help reduce emissions, it might support the limit-to-growth discourse.

Lastly, before the hypotheses, the next section outlines the general findings on how different factors impacts state environmental performance.

2.5. Indicators for Environmental Performance

Another related measurement of state involvement is research that has used government spending to see if it impacts environmental performance. This proxy is quite different from the state ownership variable in this thesis, as state ownership and government spending are not related in many instances (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Altman, et al., 2021). Still, it is interesting as Galinato and Galinato (2016) found that government spending harms the environment short term as it leads to deforestation and higher CO_2 emissions based on the expansion of the social security net. Fan et al. (2020) investigated this on a regional level in China. They found that increasing government spending does not in itself reduce emissions. Still, it can help "optimizing the expenditure structure and improving energy-saving, and the emissions reduction efficiency of environmental protection expenditures can effectively reduce emission inequality" (Fan et al., 2020, p. 13). However, in the US, increased government spending reduces production and consumption-based CO_2 emissions (Halkos & Paizanos, 2016).

There is also extensive literature on other factors that impact states' performance on climate-related issues. Christoff and Eckersley (2011) looked at the different factors that influence state responses to climate change and found no single explanation, as every state is in a different situation. Still, some generally essential factors include having: "an advanced economy, a strong civil society, a strong and respected tradition of scientific research, and a diverse media" (Christoff & Eckersley, 2011, p. 445). Further, they found that democracies and non-democracies are not good predictors of emission performance. Meanwhile, good governance and corruption are good predictors of the reduction of CO_2 emissions (Christoff & Eckersley, 2011).

So many factors can affect state performance, but "climate change is shaped, in part, by their location in the global capitalist economy, their relative material capability, and their general status as a developed or developing country" (Christoff & Eckersley, 2011, p. 443). When it comes to the top performers, "most of the climate leaders are social democracies with a corporatist style of interest group intermediation, with the exception of the United Kingdom" (Christoff & Eckersley, 2011, p. 443). Domestic veto groups are another obstacle that causes hurdles for some countries, but not so much for others. (Christoff & Eckersley, 2011, p. 445).

For climate change policies: "Macro level economic and political structures, such as the economic weight of fossil fuel industries, play an important role in shaping these policies. So do the national science community and the national culture of science" (Ylä-Anttila et al., 2018, p. 258). Income levels and EU membership are the best predictors of climate policies (Schmidt & Fleig, 2018). According to the IPCC, GDP per capita, population, GHG intensity, and energy intensity are the immediate drivers of GHG emissions (Blanco et al., 2014).

Stern (2015) has a more eclectic approach to identifying barriers and solutions to dealing with climate change. He argues that not enough is being done to stop climate change. The obstacles that cause the slow response include psychological barriers to appreciating such a complex problem and the analytical problems that come with analyzing such a large and complex issue in economics. Public understanding has also been reduced as there has been a failure in communicating solutions. There are also the structural barriers of vested interest, as already mentioned. Stern's approach to solving the issue of climate change also argues that many incremental approaches at the same time can together deal with the issues that delay a response. For the state specifically, he finds there are multiple mechanisms it can use to play a role. Governments should use various policy tools, such as nudging, carbon taxes, and interventions to phase out coal, among other things. However, there are also barriers that can block governments from acting, such as structural forces in the economy and the short-term interests of both the government and factions within society (Stern, 2015).

Reviewing the literature on political economy hurdles to climate policy progress. Lamb and Minx (2020) found that:

> Identified constraints include (but are not limited to) exposure to fossil fuel extraction activities, supply-side coal dependency, a lack of democratic norms, exposure to corruption, a lack of public climate awareness, and low levels of social trust. Correlation and principal component analysis of these variables demonstrates strong co-dependencies, including a North-South divide in institutional quality, trust and climate awareness that limits full participation in climate legislation and the removal of fossil subsidies. Recent trends indicate stability in corruption across the whole sample, and the continued durability of autocratic and extractivist states. (Lamb & Minx, 2020, p. 1)

These political and economic factors are also mutually reinforcing, so they must be investigated together (Lamb & Minx, 2020).

Another barrier to acting on climate change is the politicization of science. Politicized science means it is not enough to leave it to the experts; a political consensus must be created (Sarewitz, 2004). Kahan et al. (2012) support this argument and posits that scientific literacy does not lead to a consensus on climate change. Instead, the more science-literate population is, in fact, highly polarized on the climate issue. These issues might make it hard to deal with climate change through a democratic process.

Another issue is the international aspect of climate change. As GHG emission is a global issue that affects the whole world and requires the entire world to act on it, some have argued that it is almost pointless to deal with it locally (Anderson & Leal, 2015). Developing countries blame developed countries as the developed countries have been allowed to grow and pollute without thinking of the consequences until now. Therefore, some developing countries argue that it is their turn to develop now (Carter, 2018). The growing economies of China and India were responsible for 35% of global CO_2 emissions in 2017. Both countries' populations and economies are still growing rapidly. So if these countries are to continue to support their growth, an unprecedented large-scale transition to renewable energy is required (Warner & Jones, 2019).

To summarize: the literature review has shown that most of the immediately related literature focuses on SOE and the firm level instead of the state level. The regional focus of the literature is also biased toward China. The focus is mostly on the firm level, and China has therefore been identified as a gap in the literature. This thesis will therefore attempt to fill this gap in the literature in two ways. Firstly, by focusing on the state level instead of the firm level. Secondly, by taking a global approach of 164 countries instead of focusing on specific countries. Still, there is extensive literature on what factors impact states' climate performance, which the thesis will rely on in its analysis.

The following section develops three theories based on the identified gaps in the research and the relevant theories.

2.6. Hypotheses

The theory and discussion part has shown that there is a divide between those who argue that the state is the problem and that the market is the best way to deal with environmental issues (Prometheans and economic rationalists); against those who find that the state needs to take a more assertive role in dealing with market failures and to lead the world towards a sustainable future (new economics). The divide between the two sides is stylized and broad and not always very stark. Theories about markets versus states generally are on two opposite ends of a spectrum, but most states' policies and processes are blended. The analysis in this thesis will control for this as the main independent variable—state ownership of the economy—measures the extent of state ownership of the economy on an interval scale. Thus, it is ideally suited to capture the ambiguities that exist along the spectrum of fully private to full state ownership. MBIs and regulations are not mutually exclusive in praxis either, and policymakers often use both to come to the most effective solution. There are also low-cost and high-cost policies, which might be a good measurement of how committed governments are to finding solutions to environmental issues. So, the state versus market issue is not mutually exclusive. Still, there is a divide here (Carter, 2018). However, all these arguments share that they fit within the sustainability discourse. Based on the discussion on whether the state or the market is the solution to climate change, I derive hypothesis 1 as:

> **H1:** *State ownership of the economy reduces greenhouse gas emissions and improves emission prevention*

The hypothesis is tested quantitively on countries with time series data and multiple dependent variables related to the different mechanisms in these "theories." Still, it is not necessarily the answer to only increase state ownership of the economy. Because as Mayer and Rajavuori (2017) pointed out, state ownership has the potential to be used to deal with environmental issues. Still: "This is not to say that State ownership policies are a silver bullet solution to climate change mitigation. In many parts of the world, State ownership continues reflect and perpetuate rent seeking, elite expropriation, crony capitalism and geopolitical interests" (Mayer & Rajavuori, 2017, p. 232). These issues might be the result of what has been called "extractive institutions."

Extractive institutions can cause such problems as the institutions within the state are set up to benefit those in power and their interests while excluding the rest of the population. In contrast, the solutions to problems like rent seeking, elite expropriation, and crony capitalism might be "inclusive institutions." Inclusive institutions grant access to the economy to all actors, which benefits all of society through mechanisms like creative destruction (Acemoglu & Robinson, 2012). Stern (2015), as mentioned earlier, argues that creative destruction is one of the important mechanisms that can move society towards sustainability with innovation that improves or replaces current highly polluting industries, such as fossil fuel. Established industries, however, have vested interests in keeping their current business practice and stopping the process of creative destruction that might replace them with new and sustainable industry. One of the arguments of hypothesis 2, is therefore that good and inclusive institutions are needed to keep suppress these vested interests and allow creative destruction.

It is not only through allowing creative destruction that states might deal with environmental issues and market failures. As Mazzucato (2014, 2021) argues, the state might take a leading role in the effort toward the goal of sustainability. And as the other new economics discourses argue, the state might take a leading role through policies. Here institutions are important as well. Sometimes the hurdle is a struggle to implement the policies/instruments; this might be caused by institutional issues, like a lack of personnel, a lack of budget, and dysfunctional bureaucracy (sometimes intentionally) (Carter, 2018, pp. 335-339).

These arguments for institutional quality are not directly related to how state ownership of the economy is used. Still, as the factors like rent-seeking, elite expropriation, and crony capitalism might make state ownership mismanaged (Mayer & Rajavuori, 2017). These issues might be suppressed by high institutional quality, as argued above. Based on the argument that good institutions might manage issues by using state ownership toward environmental goals directly and through other mechanisms like creative destruction, leadership, and policies, hypothesis 2 is that:

H2: *State ownership´s effect on greenhouse gas emissions and emission prevention is conditioned by good institutions*

There is also the related but separate issue of democracy. Many of these concepts have in common the focus on democracy as the solution (for example (Eckersley, 2004; Hausknost, 2020; Paehlke & Torgerson, 2005). Therefore, democracy will be controlled for. Democracy might also be needed to legitimize the policies, and feedback and plural decision-making might make the policies better (Carter, 2018, p. 323). So, governments need support from the population to deal with climate and sustainability, but the measures often lack support. People can be seen as the biggest obstacle to sustainability (Carter, 2018, p. 374). Wilkinson and Pickett (2009) argue that climate policies must be linked with other popular policies that will benefit most people, like social reforms, to make climate reforms possible. The argument has recently been supported by research in the US (Bergquist et al., 2020).

Previous research on democracy in climate performance has found that democracy (and corruption) affects how an increase in GDP per capita impacts CO_2 emissions (Lægreid & Povitkina, 2018). Democratic, inclusive systems might also lead to better climate policies, but they might not reduce GHG emissions (Böhmelt et al., 2016).

Even if democracy might be a hurdle to dealing with climate change in some instances, it might also be needed. As Boyce (2002) puts it:

> Democratic accountability grounded in an equitable distribution of power and wealth is the only reliable way to channel government interventions towards the public interest [on the environment] rather than private interests, and toward correction of market failures rather than their further exacerbation. (Boyce, 2002, p. 128)

Based on the arguments that democracy is needed to legitimize government intervention and to ensure the quality and productivity of environmental policies, hypothesis 3 is:

H3: *State ownership´s effect on greenhouse gas emissions and emission prevention is conditioned by democracy*

The next section will present and discuss the variables that are used in the analysis based on these three hypotheses and other relevant factors identified in the literature review.

3. Data

The hypotheses cover three main areas: climate gas emission, innovation as a solution to climate change (both hypotheses include innovation, but the Promethean one is based almost entirely on innovation), and general environmental performance. Multiple datasets will be used to measure these climate-related outcomes. Firstly, however, the methodology will be outlined.

Quantitative methods are used to identify patterns by manipulating data. More specifically, inferential statistics will be used as they use statistics to look at relationships between variables, not just in a descriptive way. A multivariate regression will be used to simultaneously investigate the impact of multiple independent variables that might have an impact on the dependent variables (Moses & Knutsen, 2019). The specific statistical method used is the time-series cross-section (TSCS) method. TSCS is a type of panel data that investigates fewer units over a more extended period (Mehmetoglu & Jakobsen, 2017). First, however, the dependent variables will are accounted for.

3.1. Dependent variables

There are many ways to measure state performance on climate change. Perhaps the most common and accurate are GHG emissions or specific CO_2 emissions. GHG emissions directly measure how much each country contributes and might be the best estimate of the state's climate performance. Other indicators also measure everything from past performance, present performance, climate-related policy aspirations, and national factors and material capabilities. Some indices combine multiple indicators to measure the state's overall performance (Christoff & Eckersley, 2011).

According to Christoff and Eckersley (2011), the best way to compare states is by emission. Still, this does not say anything about why there is a difference. It could be a result of intentional government policy or if it is an unintended consequence. And even if it measures performance, it is not necessarily a perfect measure of the states' effort, as it is easier to reduce emissions for some and harder for others. No measure is, however, completely fair in this way. So, one always has to consider other factors to try to compare the performance of different states. Lamb and Minx (2020) also argue that CO_2 emissions are not necessarily the best way to compare state performance. The reason is that current levels of CO_2 emission can be the result of path dependencies that go back to before climate change became an issue. Therefore, the current emissions are not necessarily a good measurement of the performance of the state Lamb and Minx (2020, p. 3).

Another downside of GHG emissions is that they can not measure how much effort states put in against their capacity to reduce emissions, as some countries have an easier time reducing their emissions than others. The emission measure also punishes the producers countries as the countries that import the goods won't increase their emissions, even if they create the demand that leads to pollution. National factors like energy configuration are another way to measure state performance on climate change (Christoff & Eckersley, 2011, p. 433). Emissions are still widely used and will be used here as a basic measurement as it is a direct driver of climate change (Blanco et al., 2014), but other indicators also supplement them.

Strezov et al. (2017) looked at nine different indices and compared what they did and how well they performed. The categorization was based on three different types of sustainability; the economic, environmental, and social aspects. SSI and GSI were the only two that included all these measurements, and the rest had some combinations of the different elements. Even if the literature on sustainability indices is sizable, it lacks any consensus on which to use. Some of the literature has been highly critical of such indices.

One example of these indices is Yale's Environmental Performance Index (EPI). The EPI is used to measure how well countries perform on environmental issues. The EPI datasets provide additional measures beyond emission. It includes 32 measures such as CO_2 pollution and other indicators, including tree coverage and air quality (Wendling et al., 2020).

Importantly, the EPI dataset is not suited for the time series analysis in this paper. As they themselves pointed out: "[W]e repeat our admonition that subsequent versions of the EPI should not be appended to these series – nor should users attempt to assemble time series from multiple versions of the EPI, as methodological changes between reports make these scores incomparable" (Wendling et al., 2020, p. 43). If one wants to use the data for time series data, one should use some of the individual variables suitable for this (Wendling et al., 2020, p. 174). Some have employed specific variables as measurements of environmental performance. Morse (2018) uses 16 EPI indicators in a time-series regression to measure the effect of income and income inequality on nation-states' environmental performance.

The problem of years not being comparable is common for environmental indices. It is, at least, also the case for the Green Growth Index, the Human Development Index, and the SDG Index (L.A. Acosta, 2020, p. 7). The lack of comparable time-series data excludes many indices as an option for this analysis as it is based on time-series data.

Another problem with using these indices is that this thesis is focused specifically on climate change. However, many of these indices measure more general sustainable development like the nine indices analyzed by Strezov et al. (2017). So, instead of using some measurements from the EPI, measurements that are more focused on climate change performance will be employed.

To summarize, I will use emissions data in this thesis. Given that most countries have an even starting point, at least to some extent, emissions are good for comparing performance. In contrast, the global ecological footprint index, for example, measures aspects of sustainability based on, for example, countries' biocapacity, where the countries' starting point differs quite drastically (Wackernagel & Beyers, 2019). There are also many other indices and no consensus on which one to use, and it might therefore be better to go with the commonly accepted measure of GHG emissions. Another reason not to use indices is that many indices are not suited for time-series analysis.

In addition to emissions use, I will also utilize other measurements of environmental performance: renewable energy consumption and eco-innovation. These are included to investigate as they might reveal some of the mechanisms as to how state ownership can impact climate performance. As shown in the literature review, part of the argument is that state ownership can positively affect the countries' innovation, positively affecting their climate performance. These are also interesting as they measure the current performance on the underlying factors that affect emissions and climate performance. Renewable energy consumption and eco-innovation are discussed in more detail, but first, the emissions measurement will be discussed.

3.1.1 Emission

For specific measurements of GHG emissions, I will refer to general GHG emissions in addition to pure CO_2 emissions, following others who have done similar research (Nong et al., 2021; Roeland & de Soysa, 2021). Controlling for both types of emissions is relevant. Depending on which measurement is used, the result might differ when including other greenhouse gasses with the general greenhouse gas variable. Researchers, therefore, suggest that both are included when researching climate change policies (Nong et al., 2021).

First, starting with only CO_2 emissions. Two different measurements of CO_2 emissions are used. "CO_2 emissions (metric tons per capita)". And "CO_2 emissions (kg per 2015 US$ of GDP)" (The World Bank, 2022).

Two measures of CO_2 emissions are used since CO_2 emissions per GDP measure weak sustainability, and CO_2 emissions per capita measure strong sustainability. Weak sustainability is the sum of economic and natural capital, while strong sustainability requires that economic and natural capital are maintained independently (Atkinson et al., 2014, pp. 43-44). So, in this case, CO_2 per GDP can measure weak sustainability as this measures how wealth production becomes more sustainable. CO_2 per GDP produced is a standard measurement of environmental productivity (Barbieri et al., 2016, p. 616). In contrast, CO_2 per capita measures strong sustainability as GDP per capita measures emissions per capita measure the overall pollution of each person in the population on average. This means that a decrease in this value will lead to an overall reduction in emissions per capita (de Soysa, 2022). Greenhouse gas emissions are only measured with the strong sustainability measurement of per capita.

Strong sustainability is arguably more relevant than weak sustainability. Weak sustainability alone might not be enough as it only makes production more efficient and increases environmental efficiency. States, and the world, in general, must also reduce their overall emission, and to reduce overall emissions in absolute terms, environmental efficiency might not be sufficient. CO_2 per capita captures the emissions in absolute terms (or strong sustainability). Still, weak sustainability is relevant as a measure of increased environmental efficiency, for example, when measuring the effect of innovation on reducing emissions (Barbieri et al., 2016). This is because innovation and increased environmental efficiency may reduce emissions without reducing consumption or economic growth (Albino et al., 2014; Elia et al., 2021; McJeon et al., 2011). Still, economic and natural capital must be decoupled to reach carbon neutrality, as proponents of strong sustainability argue (Atkinson et al., 2014). This decoupling is essential to ensure emissions are reduced in absolute terms and not that there is merely an increase in environmental efficiency.

Another reason it is relevant to include both strong and weak sustainability is that political and economic factors might impact weak and strong sustainability differently. Liberal democracy improves weak sustainability, and on strong sustainability, stable core autocracies do worse than stable democracies (Ward, 2008).

When it comes to the definition of the CO_2 variable, The World Bank Developing Indicators (WDI) defines it as: "Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring" (The World Bank, 2022). While greenhouse gas emissions are defined as:

> Total greenhouse gas emissions in kt of CO_2 equivalent are composed of CO_2 totals excluding short-cycle biomass burning (such as agricultural waste burning and savanna burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires and decay of drained peatlands), all anthropogenic CH4 sources, N2O sources and F-gases (HFCs, PFCs and SF6). (The World Bank, 2022)

The GHG per capita variable was created by dividing the value by the population of each country in any given year. The population variable is also taken from The WDI. The creation of the GHG per capita was done as there are no variables measuring this in the WDI dataset. All the emission variables are also log-transformed as they are skewed. Log-transforming is done to make the distribution of the variable more symmetrical, as a skewed variable can be problematic in the regression analysis (Mehmetoglu & Jakobsen, 2017, pp. 326-329). There were some negative values of emission, and some at 0. The negative values were set to zero. Then all these values of 0 are changed to 0.000001 for all the emissions variables before they were log-transformed. Changing the negative and 0 values is important as log-transformed variables cannot have negative values or values of 0 (Mehmetoglu & Jakobsen, 2017, p. 329).

As these three emission indicators are similar, I have estimated to what degree they correlate with each other to ensure they all measure distinct aspects. Pairwise deletions are used to avoid information loss (Mehmetoglu & Jakobsen, 2017, p. 39). The results show that the two CO_2 emissions have a correlation of 0.6125. CO_2 per capita and greenhouse gas per capita have a correlation of 0.6388. Lastly, CO_2 per GDP and greenhouse gas per capita have a correlation of 0.2350. As already mentioned, previous research also finds that these indicators capture different aspects.

3.1.2. Renewable energy

Controlling for renewable energy (and eco-innovation) in this thesis is important as the research on state ownership is so new. Including these indicators as dependent variables make it possible to potentially reveal some of the underlying mechanisms that cause GHG emissions. As discussed earlier, renewable energy is important as it is needed to reduce global GHG emissions (IPCC, 2022).

The operationalization of renewable energy will follow others who use the measure of renewable energy as a percent of total energy (Danish et al., 2020; Hao & Shao, 2021). Renewable energy as a percentage of total energy consumption from the WDI is used like many others have used this measurement from the World Bank (Anton & Afloarei Nucu, 2020). The WDI indicator measures "Renewable energy consumption is the share of renewable energy in total final energy consumption" (The World Bank, 2022).

The renewable energy variable was also log-transformed as it was skewed.

3.1.3. Eco-innovation

According to both the market and the state arguments, eco-innovation is one of the main solutions and mechanisms for reducing GHG emissions, as exemplified by Lomborg (2020) and Mazzucato (2014, 2021). Notably, both have different prescriptions on how to get it. Lomborg supports the free market, whereas Mazzucato prefers a "mixed" solution where the state invests and takes the lead in promoting innovation. Whether more or less state ownership fosters more eco-innovation is therefore highly relevant to reveal which side of the argument is correct.

Innovation is a more complicated concept to measure than the previous variables. Nevertheless, patents are arguably the best measurement of eco-innovation as:

> Patent data have been used as a measure of technological innovation because they focus on outputs of the inventive process […] This is in contrast to many other potential candidates (e.g. research and development expenditures, number of scientific personnel, etc.) which are at best imperfect indicators of the innovative performance of an economy since they focus on inputs. Moreover, patent data provide a wealth of information on the nature of the invention and the applicant, the data is readily available (if not always in a convenient format), discrete (and thus easily subject to statistical analysis). Significantly, there are very few examples of economically significant inventions which have not been patented […]. (Johnstone et al., 2012, p. 2159)

Patents are also the standard way to measure innovation (Griliches, 1998). Many others have also used patent data to measure eco-innovation, like Costantini and Mazzanti (2012), who used patent data from the OECD. So Following previous research, patent data will be used as a dependent variable (Cho & Sohn, 2018; Costantini & Mazzanti, 2012; Fabrizi et al., 2018).

There are also indices for eco-innovation. Park et al. (2017) discuss the potential of such indices. They compare the ASEM Eco-Innovation Index (ASEI), which covers Asia and Europe, and the Eco-Innovation Scoreboard (Eco-IS), which only covers European countries. Eco-IS seems, however, to have good data from 2012 to 2021. The ASEI was established in 2011, and the 2018 data is not comparable to the rest. It also only includes 51 countries (Jeong et al., 2018). Some have used it in comparative research (Urbaniec & Tomala, 2021). Kemp et al. (2019) identified a third eco-innovation index on top of ASEI and Eco-IS called the Global Cleantech Innovation Index (GCII). The GCII, however, only includes 40 countries (Cleantech Group, 2022). Given the uneven availability of data on years and countries of these indices, it seems like patents are the best, most long-running, and only global measurement available.

The patent data that will be used to account for eco-innovations is OECD data. Like Fabrizi et al. (2018), others use OECD data to measure green patent data and use it in a hierarchical way, following an OECD guide. It is common to use the OECD guide ((Haščič and Migotto (2015)) to justify the use of patents as a proxy for innovation and explain how it is done (see Urbaniec et al. (2021) Cheng et al. (2019) Karmaker et al. (2021)). My research, therefore, follows many others who have used similar techniques following Haščič and Migotto (2015) when using green patents as a proxy for eco-innovation/green innovation (for example (Fabrizi et al., 2018)). However, I will instead follow the more recent 2020 OECD patent classifications strategy (OECD, 2020) that is used in the OECD Environment Statistics database on the indicators of "Patents in environment-related technologies: Technology indicators" (OECD, 2022). The explanation for the variables used there is:

> The number of environment-related inventions is expressed per million residents (higher-value inventions/million persons).
>
> Indicators of technology development are constructed by measuring inventive activity using patent data across a wide range of environment-related technological domains (ENV-TECH, see link below), including environmental management, water-related adaptation, and climate change mitigation technologies. The counts used here include only higher-value inventions (with patent family size = 2).
>
> Data are obtained from the Patents: Technology development dataset of the OECD Environment Database. Detailed information on the methodology used to compute the patent counts is in the associated metadata. (OECD, 2022)

Still, patents as a measurement of innovation have some shortcomings. These shortcomings can be dealt with through different tools (Haščič & Migotto, 2015, p. 16). Such as fractional count and priority date as a proxy for the date on the invention (p. 25). The OECD dataset helps tackle some of these issues, as can be seen in the metadata:

> Inventor country - fractional counts by country of residence of the inventor(s); e.g. for a patent listing inventors from two different countries, each country will obtain a count of 0.5, to avoid double-counting of inventions;
>
> Priority date - the first filing date worldwide, under the Paris Convention. The priority date is considered to be closest to the actual date of invention;

> Family size - the size of an international patent family (including the first 'priority' filing and its equivalents deposited at other patent offices) has been found to be correlated with the value of the invention: Family size "1 and greater" (i.e. all patent priorities) will yield figures based on all available data worldwide, including many low-value inventions; family size "2 and greater" (i.e. 'claimed' priorities) will count only the higher-value inventions that have sought patent protection in at least two jurisdictions; etc.;
>
> Technology domain - based on the ENV-TECH [...] definitions. (OECD, 2021)

These techniques overcome many of the problems with patent data. There is also the issue of patent family size. The patent variable will only use patents with a family size of two or greater. The reason for this is that this might help reduce some issues like strategic patenting. The OECD guide also argues that excluding patents with a family size of one is better when comparing countries as:

> "high-value" priority applications are counted without placing an excessive constraint on 'narrow' technological fields (which is often the case when using e.g. the triadic patent family indicator). The reason that claimed priorities can be viewed as representing inventions of higher value is that patenting is costly (e.g. translation and maintenance fees). (Haščič & Migotto, 2015, p. 23)

Therefore, only eco-patents with a family size of 2 and higher will be used.

The population is used as a control variable in the eco-innovation regression, following previous research (Di Cagno et al., 2014; Fabrizi et al., 2016, 2018). The population can be relevant to control for, especially when looking at issues related to green growth (Haščič & Migotto, 2015). Lastly, the eco patent variable is log-transformed as it is skewed.

3.2. Independent Variables

The primary independent variable of interest is the state ownership of the economy variable from the V-dem, which is based on the question, "Does the state own or directly control important sectors of the economy?" (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, et al., 2021, p. 184). V-Dem defines state ownership as:

> This question gauges the degree to which the state owns and controls capital (including land) in the industrial, agricultural, and service sectors. It does not measure the extent of government revenue and expenditure as a share of total output; indeed, it is quite common for states with expansive fiscal policies to exercise little direct control (and virtually no ownership) over the economy. (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Altman, et al., 2021, p. 184)

The response to this question is from 0 to 4. 0 means "Virtually all valuable capital belongs to the state or is directly controlled by the state. Private property may be officially prohibited" (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, et al., 2021, p. 184). And 4 means "Very little valuable capital belongs to the state or is directly controlled by the state" (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, et al., 2021, p. 184). So, the closer the number is to 4, the lower the level of state ownership in the country. These ordinal values of 0-4 are then made into a standardized interval scale (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, et al., 2021). The standardized interval scale for the state ownership of the economy variable is from negative 4 to positive 4. There are also 3 decimals to the score, so it is more nuanced than just 8 values.

While labeled state ownership, the V-Dem variable measures private ownership as lower values represent state ownership and higher values represent private ownership. Thus, I invert (flip) the interval level scale. The variable has data from 1789 to 2020 (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Altman, et al., 2021).

It is crucial to account for the validity of the indicator as validity captures whether one measures what one intends to measure (Drost, 2011). The validity of the state ownership of the economy variables for this thesis is solid. It captures both sides of the debate over whether the market or the state is the solution to climate issues, as state ownership of the economy measures how much control the state has compared to the market's control. The state ownership variable also captures, at least partly, the broader concept of statism. Statism has traditionally meant the state's control over the economy and also the extent of economic interventions by the state, such as controlling the market, nationalization, and state planning over the economy. However, some argue that statism is evolving into a system where the state more so assists firms that now occupy the role of the traditional statist state (Levy, 2006). Still, state ownership captures many of these traditional aspects of statism and state ownership as it captures the extent of state ownership of capital. Therefore, that state ownership of the economy has good validity as it captures the extent of state ownership of the economy in general in contrast to the free market.

The V-dem is a solid dataset as more than 3500 country experts code it. Each indicator (variable) for each country is based on the coding of at least five country experts to provide the best estimate possible. However, to avoid biases and control for the difference in opinion between experts, the V-Dem dataset employs a Bayesian Item-Response Theory (IRT) estimation strategy. The IRT estimation strategy controls for multiple issues that might emerge when using expert-coded data. Among other things, it controls for expert rating thresholds and the difference in the reliability of the coders (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Marquardt, et al., 2021; V-Dem Institute, 2022).

The other main independent variables are those related to institutions and democracy. Hypotheses 2 and 3 states that these institutional factors are needed for higher state ownership to be used to reduce GHG emissions. Less corruption is used as a proxy for good institutions. The use of corruption as a proxy follows previous research on climate and related issues such as renewable energy that has used corruption as a proxy for institutional quality (Arminen & Menegaki, 2019; Cadoret & Padovano, 2016).

Corruption in itself has been shown to impact emissions (Akhbari & Nejati, 2019; Christoff & Eckersley, 2011; Lamb & Minx, 2020). Although there have been varied findings on the relationship, Akhbari and Nejati (2019) found that a decrease in corruption leads to less carbon emission in developing countries, but that has no effect in developed countries. Developed countries already have regulatory institutions that reduce emissions, so decreasing corruption won't change much. Meanwhile, developing countries have not established regulatory institutions and have higher corruption. Therefore, reducing corruption in developing countries has a higher potential for decreasing emissions. Therefore, Akhbari & Nejati argue that policies that reduce corruption should be put in place in developing countries, making them get to the other side of the environmental Kuznets curve quicker. This might also mean that decreasing corruption in developed countries won't do as much in an interactive effect with state ownership. As these countries already have established regulatory institutions.

Political corruption from the VDEM database is used as the indicator. The VDEM codebook defines political corruption as how pervasive political corruption is. The variable is an index of six different types of corruption. The six types are at both what they call "petty" and "grand" levels, it covers both bribery and theft, and it covers both the implementation and the making of laws. It is, therefore, a measurement of general corruption. The description of how the variable was constructed is:

> The index is arrived at by taking the average of (a) public sector corruption index (v2x_pubcorr); (b) executive corruption index (v2x_execorr); (c) the indicator for legislative corruption (v2lgcrrpt); and (d) the indicator for judicial corruption (v2jucorrdc). In other words, these four different government spheres are weighted equally in the resulting index. We replace missing values for countries with no legislature by only taking the average of a, b and d. (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Altman, et al., 2021, p. 297)

The data is available from 1789 to 2020. And it goes from 0, which is the least corrupt, to 1, which is the most corrupt (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, et al., 2021). As hypothesis 2 is that good institutions are needed, I invert the corruption variable so that the higher the value, the lower the corruption.

Democracy is another variable that might influence how state ownership impacts GHG emissions, as stated in hypothesis 3. A central argument for why this is the case is that the feedback and participation of all the actors in a democracy are better at making good decisions when it comes to climate policy (Carter, 2018, p. 323). The previous empirical findings on democracies' impact on environmental performance are mixed. Some have found support for the claim (Lamb & Minx, 2020; You et al., 2015), while others have not (Christoff & Eckersley, 2011). And others have found conditional results, like Povitkina (2018) (see also (Farzin & Bond, 2006)), who found that democracy only reduces emissions if the country also has low corruption. So, in countries with significant levels of corruption, authoritarian governments and democratic governments perform no different. Lamb and Minx (2020, p. 4) find broad support in the literature for democracy positively affecting environmental policy. As democracies have a larger electorate, they need to please, while autocracies serve the interests of the elites.

The data on democracy is also gathered from the V-dem dataset. The V-dem has multiple different measures of democracy. The polyarchy variable from the VDEM to test control for electoral democracy is defined as:

> The electoral principle of democracy seeks to embody the core value of making rulers responsive to citizens, achieved through electoral competition for the electorate's approval under circumstances when suffrage is extensive; political and civil society organizations can operate freely; elections are clean and not

> marred by fraud or systematic irregularities; and elections affect the composition of the chief executive of the country. In between elections, there is freedom of expression and an independent media capable of presenting alternative views on matters of political relevance. In the V-Dem conceptual scheme, electoral democracy is understood as an essential element of any other conception of representative democracy — liberal, participatory, deliberative, egalitarian, or some other. (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Altman, et al., 2021, p. 43)

Electoral democracy is, therefore, the most basic and essential measure of democracy, as all other measures of democracy incorporate electoral democracy. The variable is measured from low to high on a scale of 0 to 1 with decimals on an interval scale. The variable is an index created by the weighted average of 5 indices and the five-way multiplicative interaction between those indices. The data is available from 1789 to 2020 (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Alizada, et al., 2021, p. 43).

Thus, the main independent variables are state ownership of the economy and then different measures of institutional quality as conditioning variables. Next, relevant control variables are discussed.

3.2.1. Control Variables

Multiple control variables are also included based on previous research and theory. These control variables are important as other factors that might theoretically affect the dependent variables should be included in multivariate regression analyses. The inclusion of control variables is to remove the effect of other potential factors that might impact the dependent variable; this makes it possible to look at the pure effect of the main dependent variable(s) (Mehmetoglu & Jakobsen, 2017).

First, GDP per capita is a crucial control variable. According to the IPCC, GDP per capita is one of the immediate drivers of greenhouse gas emissions (Blanco et al., 2014). Growth is important to control for as there is considerable debate on whether there are limits to growth or if the economy can grow while reducing environmental impact (Dryzek, 2021). The effect that GDP increases pollution is called the scale effect (Iqbal et al., 2021, p. 2). The "GDP per capita growth (annual %)" variable measures economic growth. The WDI calculates this variable as the "[a]nnual percentage growth rate of GDP per capita based on constant local currency" (The World Bank, 2022). The estimate is based on the country's midyear population (The World Bank, 2022). The GDP per capita variable was skewed and was therefore log-transformed.

International trade will also be controlled for as it can impact emissions. Peters et al. (2011) found that international trade impacts consumption and production-based CO_2 emissions. Trade as a percentage of GDP is the last variable from the WDI. Trade is defined as "the sum of exports and imports of goods and services measured as a share of gross domestic product" (The World Bank, 2022). This is then calculated as a percentage of GDP. The international trade variable is skewed and was therefore log-transformed

The next natural resource rents are included as a control available. Natural resource rents increase long-run CO_2 emissions (Bekun et al., 2019). But Nwani and Adams

(2021) found that this might be mitigated with high quality of government. Natural resource rents significantly increase both consumption-based, and production-based CO_2 produces in countries with low quality of government. At the same time, it was insignificant for consumption-based CO_2 in countries with a high quality of government and reduced production-based CO_2 emissions. Countries with high natural resource rents might also pollute more based on the natural resource curse (Roeland & de Soysa, 2021).

The "total natural resource rents as a percentage of GDP" variable from the WDI measures the price of the natural resources that a state extract. Then the average cost of extracting or harvesting the resources is subtracted from the value of the resources to calculate the rents. Then these rents are multiplied by the amount of the resource a country is extracting and harvesting. Then this is calculated as a percentage of the total GDP. Some states have a high share of resource rents, which often come from minerals and fossil fuels (The World Bank, 2022).

Natural resource rents can also control for authoritarian oil states as states with high levels of natural resource rents are oil states. The resource curse can hide the effect of democracy as oil countries tend to be autocracies, as oil a country's oil exports might be strongly related to authoritarian rule (Lamb & Minx, 2020; Oskarsson & Ottosen, 2010; Ross, 2001). The natural resource rents variable is skewed and was therefore log-transformed.

The relative size of the country's urban population is also included. The urban population is a relevant variable as multiple theories assert that there is a connection between urbanization and emissions. Urban environmental transition theory finds that urbanization initially increases pollution as manufacturing increases. Still, later in development, this trend turned around as the country saw advanced environmental regulations. The economy of scale theory also finds hold cities are more efficient on emissions. Lastly, urbanization can play a role in ecological modernization (Abdallh & Abugamos, 2017). There are mixed empirical results on the effect of urbanization. Martínez-Zarzoso and Maruotti (2011) found an inverted U-shaped relationship supporting the EKC theory between urbanization and CO_2 emissions in developing countries.

In contrast, Zhu et al. (2012) found a more complex non-linear relationship and no evidence for the EKC. The IPCC report on climate change mitigation also found that urban areas can make net-zero emissions possible through urban development (IPCC, 2022, p. 39). So, the urban population as a measurement of urbanization will be included, as the variable is often used and significantly impacts the emissions and environmental performance.

I control for urbanization with the urban population as a percentage from the WDI. The "urban population as a percentage of the total population" variable from the WDI is collected from the United Nations Population Division. This measurement is based on the national statistical offices' definition of people living in urban areas. This is calculated with population estimates from the WDI and urban ratios from the United Nations World Urbanization Prospects. The measurements might vary between countries, as different countries define their urban population differently. And the description of the variable highlight why it is a relevant control variable

> Explosive growth of cities globally signifies the demographic transition from rural to urban, and is associated with shifts from an agriculture-based economy to mass industry, technology, and service. In principle, cities offer a more favorable setting for the resolution of social and environmental problems than rural areas. Cities generate jobs and income, and deliver education, health care and other services. (The World Bank, 2022)

The urban population variable is skewed and was therefore log-transformed.

The population of countries will be used as a control variable when using green innovation as the dependent variable. It was also used to construct the greenhouse as a per capita variable. According to the IPCC, the population is also one of the immediate drivers of greenhouse gas emissions (Blanco et al., 2014). The population variable is gathered from the WDI, and it is defined as: "Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates" (The World Bank, 2022).

The same control variables will be used in the model's renewable energy and eco-innovation. Even if these are different types of indicators, many of the commonly used variables overlap. And most importantly, the renewable energy and eco-innovation measurements are included to attempt to clarify the underlying mechanisms that impact GHG emissions. Therefore, it is relevant to use the same independent variables when investigating factors that impact GHG emissions.

Most of the control variables have also been used to control for eco-innovation and renewable energy in the literature. The three first independent variables of state ownership, corruption, and electoral democracy are relevant as these are mechanisms that might improve these factors, as discussed in the literature and theory section. When it comes to the control variables, these have also been shown to be relevant in the literature.

For renewable energy, previous research shows mixed results on the impact of GDP per capita (Hao & Shao, 2021). Trade might also impact renewable energy consumption (Omri & Nguyen, 2014; Wang & Zhang, 2021). Natural resource wealth, especially petroleum rents, can decrease renewable energy production and also potentially consumption (Ahmadov & van der Borg, 2019). Lastly, urbanization has also been found to impact renewable energy consumption (Yang et al., 2016)

When it comes to eco-innovation, most of the previous research has investigated the drivers on a firm level (Bossle et al., 2016; Hojnik & Ruzzier, 2016). However, previous research on innovation in the renewable energy industry has controlled for GDP per capita but found that it is an ineffective driver (Aflaki et al., 2021). Still, there is research on general innovation. Trade can have a positive spillover effect on innovation (Gorodnichenko et al., 2020). Resource rents are relevant to control for when it comes to innovation because of the Dutch disease. Dutch disease can occur when countries have an economy that is heavily reliant on booming sectors such as resource extraction of oil. This diverts other parts of the economy toward this resource extraction. (Corden & Neary, 1982). Therefore, other sectors, such as industry and innovation, might lose priority. Urban population and urbanization are relevant as cities are disproportionally innovation centers (Bettencourt et al., 2010).

Even if there is more research on general innovation, general innovation and eco-innovation are quite different (Hojnik & Ruzzier, 2016). Still, the most important part is that the literature assumes that this is one of the mechanisms by which the state can play a leading role in dealing with climate change, so the inclusion of control variables will be the same as those that might be relevant in relation to how state ownership impacts GHG emissions.

4. Methodology

Time-series cross-section methods (TSCS) can lead to issues that bias results. First of all, as TSCS includes multiple data points over an extended time period, individual units' error terms will likely correlate over time. Followingly, the error term of units correlates over time, causing autocorrelation, which might lead to false-positive results. Autocorrelation might also cause heteroscedasticity. Heteroscedasticity is a problem because some values are then predicted less accurately than others (Mehmetoglu & Jakobsen, 2017, pp. 231-234).

I use the Wooldridge test to test for autocorrelation. The null hypothesis in the Woolridge test is that there is no first-order autocorrelation (Mehmetoglu & Jakobsen, 2017). I then apply the test to the basic models in Table 2 with all the independent variables. The results for all the models are that the tests are significant, which means that the null hypothesis is rejected, and there is autocorrelation in the models. The presence of autocorrelation breaks the assumption of normal OLS regression, which assumes the absence of autocorrelation. Robust standard errors can be used instead of a normal OLS when autocorrelation is present. Robust standard errors relax the assumption of no autocorrelation or heteroscedasticity in the model (Mehmetoglu & Jakobsen, 2017, p. 235).

Spatial dependence is another issue, as one unit's data might be correlated with spatial neighbors (Hoechle, 2007; Mehmetoglu & Jakobsen, 2017, p. 150). An example of spatial dependence is that some countries' GHG emissions are affected by their neighbors' emissions or energy sources. For example, Mahmood and Furqan (2021) found that one country's spillover from oil rent increases neighboring countries' CO_2 emissions in Gulf Cooperation Council countries. I will therefore use Driscol-Kraay standard errors that are also robust to spatial correlation. At the same time, these standard errors also are autocorrelation and heteroscedasticity consistent. The updated Driscol-Kraay standard errors are robust to general temporal dependence as well. The updated Driscol-Kraay standard errors also work with unbalanced data (Hoechle, 2007), which is suitable as the dataset is unbalanced. The dataset is unbalanced as there some of the countries are missing data for some years (Mehmetoglu & Jakobsen, 2017, p. 229).

The last assumption for TSCS data is that there is stationarity. Stationarity means that the parameters of our data do not change over time. Non-stationarity means that data is not consistent over time. Non-stationarity can cause spurious results that make the results of a regression deceptive. Testing for non-stationarity can be done by running the Dickey-Fuller test. The Dickey-Fuller test is used to test whether variables in the model contain a unit root, as a unit root tests how serious the problem with non-stationarity is. The null hypothesis is that there is a unit root and that the model is therefore plagued by non-stationarity (Mehmetoglu & Jakobsen, 2017, pp. 252-258). The Fisher test for unit root, based on the Dickey-Fuller test, suggests that issues of non-stationarity do not plague the data, as the null hypothesis of the model containing a unit root is rejected.

Next, the Hausman test is used to test whether fixed or random effects are more consistent. This is necessary to test for as there might be biased coefficients if an unmeasured variable correlates with at least one of the explanatory variables. Random effect models are generally used if the covariation between the error term and the explanatory variables is either low or non-existent. The Hausman test is used to choose between random and fixed effects. If the results of the Hausman test are significant at 5%, the null hypothesis can be rejected, which means that fixed effects are consistent and therefore preferred. However, if the test is not significant at 5%, the null hypothesis can be accepted, making the random effects model consistent and efficient. Random effects should then be used instead of fixed effects as random effects are more efficient (Mehmetoglu & Jakobsen, 2017, pp. 240-251).

Running the Hausman test led to different results depending on which dependent variable was used in the model. CO_2 per capita, renewable energy as a percentage of total consumption, and eco-innovation are significant and suitable for fixed effects. Meanwhile, CO_2 per GDP produced and GHG per capita are not significant and are therefore not suited to be used in fixed-effects models.

Random effects are "a weighted average of within and between estimators" (Mehmetoglu & Jakobsen, 2017, p. 251). Random effects are chosen when omitted variables are both fixed between units but vary over time (between effects) and constant over time but vary between units (fixed or within effects) (Mehmetoglu & Jakobsen, 2017, p. 251). As the results of the Hausman test gave different results depending on the dependent variables, random effects are used as they can control for both outcomes. The outcomes of running the regression with random or fixed effects are not that large. Checking the effect of the main independent variable shows that the difference is not that big, and both models show similar results. Doing the same regressions as in Table 2 with fixed effects instead of random effects leads to no change in the direction of the main independent variable, and all the effects also remain significant. There is only a slight change in some of the coefficients. The other control variables stay mostly the same as well (see appendix 1).

One drawback of using random effects is that it makes it impossible to say whether we are measuring the change within a specific unit. Therefore, the result will be more general in that there is no certainty where the change is taking place, so it is more so a general trend (Mehmetoglu & Jakobsen, 2017, p. 252).

Next, one year of lag is added to all the independent (X) variables. The lag is added as the independent variable should come before the dependent variable in time (Mehmetoglu & Jakobsen, 2017, p. 254). Climate policies would, for example, have to come before emissions in time to make any difference to emission levels. Time-fixed effects are also included as dummy variables for each year. Time-fixed effects are included to avoid omitted variable bias from variables that might vary across time rather than units (Mehmetoglu & Jakobsen, 2017, pp. 249-250).

Related is the discussion of omitted variables that can cause a spurious relationship, as omitted variables might cause a change in both an independent variable like state ownership and the dependent variables (omission, renewable energy, and eco-innovation). There are two approaches to dealing with spurious relationships. Firstly, one can identify a variable that captures the spurious effect and includes the variable in the regression model. One approach is to use a fixed-effects model. Fixed effects, as already mentioned, can control for within-unit variation as fixed effects control for time-invariant variables, which removes some of the issues with potential spurious effects. As the random effects that I use in the models also control for this type of spurious effect as it combines within (fixed effect) and between estimators (Mehmetoglu & Jakobsen, 2017, pp. 236-252).

Another approach is to deal with the sporous effect by introducing a variable that captures the effect. Introducing such a variable requires knowing the spurious effect (which requires theory) and that a variable that captures this relationship exists (Mehmetoglu & Jakobsen, 2017, p. 236). Some spurious relationships are already accounted for by the control variables included in the model. Natural resource rents, for example, might lead to bot a change in regime towards a more authoritarian one (Ross, 2001) and more GHG emissions (Bekun et al., 2019). The literature review and identification of relevant control variables should also control for spurious effects as no such effects have been identified theoretically from the literature review.

The same goes for model specification errors. It is important not to include theoretically irrelevant variables or exclude theoretically relevant variables (Mehmetoglu & Jakobsen, 2017). There should be no issue with model specification errors as the model has based on previous literature reviews that have identified the significant drivers of CO_2 and general GHG emissions, including the major political and economic drivers (Christoff & Eckersley, 2011; Lamb & Minx, 2020). There is also the argument that one should not overfit the model with variables (Achen, 2005). Therefore, not every possible variable is included, but all the major drivers from the literature and theory are.

As both the electoral democracy variable and the good institution variable (measured as less corruption) are indicators of institutional quality, including both might overload the models. Independent variables that measure the same phenomenon should not be included in the same model, as it can lead to variables taking explanatory power from each other and to coefficients that are hard to interpret. Two variables overlapping becomes problematic when the correlation between two independent variables is over 0.8 or if they theoretically measure the same concept (Mehmetoglu & Jakobsen, 2017, p. 146). The correlation matrix in the appendix shows that no two variables correlate over 0.8. When it comes to the theoretical aspect, the two measures of institutional quality have been discussed separately in previous research, as can be seen in the literature review, so much so that they warrant different hypotheses. This can also be seen when comparing the models where they are both left in, or one is dropped models' results. They are very similar when keeping both in at the same time or dropping one of them. This is also the case when including an interactive effect between one of the institutional quality variables and state ownership of the economy. Therefore, both indicators are kept in all of the models.

Lastly, there is the issue of causal direction. Is it X that impacts Y, or is the opposite the case?. It is a crucial part of statistical research to ensure there is no reverse causality – that it is the dependent variable that impacts the independent variable. A solid theoretical foundation is essential in ensuring the causal direction (Mehmetoglu & Jakobsen, 2017). The causal direction in this model is assumed to be that economic structures and institutions impact GHG emissions, eco-patents, and energy transition. These assumptions are based on the previous literature and theory. But is there a potential theoretical impact of GHG, innovation, and renewable energy consumption on the state's economic and political structure? As far as I know, no previous research or theory would imply that this is the case. There are no findings in the literature or any mechanisms where emissions, more innovation, or renewable energy would change the economic or institutional structure of the state. There is, therefore, nothing that implies any reverse causality.

Descriptive statistics based on all included variables:

Table 1. Descriptive Statistics of the Variables

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
State ownership	9941	-0.079	1.322	-2.69	4.202
Less corruption	9855	-0.477	0.292	-0.968	-0.002
Electoral democracy	9919	0.419	0.287	0.007	0.919
GDP per capita (log)	9595	8.333	1.494	4.971	12.11
Trade % of GDP (log)	8376	4.164	0.653	-3.863	6.761
Resource rents % of GDP (log)	7976	0.388	2.474	-11.595	4.472
Urban population (log)	13106	3.767	0.655	0.731	4.605
Year	13237	1990	17.607	1960	2020
Population (log)	13195	14.761	2.452	7.949	21.068
CO_2 per GDP (log)	8492	-1.018	0.996	-13.816	1.683
CO_2 per capita (log)	10514	0.23	2.027	-13.816	4.616
GHG per capita (log)	9364	-5.416	1.113	-9.196	-1.903
Renewable energy % (log)	6071	2.667	1.487	0	4.599
Eco-patents (log)	4017	2.118	2.415	-1.966	9.249

5. Analysis and Discussion

The following section will discuss multiple regression analysis based on the variables and the assumptions and discussion in the methodology section.

5.1. Results

Table 2 includes all the dependent variables and all the basic control variables. The model includes the years 1971 to 2018 for the CO2 per GDP, CO2 per capita, and GHG per capita. 1990 to 2020 for renewable energy as a % of total energy consumption, and 1971 to 2019 for eco-innovation.

Table 2. The effect of state ownership, less corruption, and electoral democracy on GHG emissions and GHG emission prevention

VARIABLES	(1) CO_2 per GDP (log)	(2) CO_2 per capita (log)	(3) GHG per capita (log)	(4) Renewable energy % (log)	(5) Eco-innovation (log)
State ownership	0.06***	0.05***	0.10***	-0.10***	0.08**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)
Less corruption	0.10	0.11*	-0.34***	-0.08	0.07
	(0.07)	(0.06)	(0.07)	(0.07)	(0.25)
Electoral democracy	0.35***	0.33***	0.16***	-0.31***	0.54**
	(0.03)	(0.03)	(0.04)	(0.09)	(0.21)
GDP per capita (log)	-0.35***	0.62***	0.57***	-0.27***	1.28***
	(0.03)	(0.02)	(0.02)	(0.04)	(0.08)
Trade % of GDP (log)	0.07***	0.10***	0.07***	0.11***	0.50***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.08)
Resource rents % of GDP (log)	0.01	0.02	-0.03***	-0.02	-0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Urban population (log)	0.89***	0.90***	-0.14***	-0.74***	-0.07
	(0.08)	(0.08)	(0.04)	(0.08)	(0.21)
Population (log)					0.90***
					(0.11)
Constant	0.00	-8.34***	-9.73***	0.00	-26.97***
	(0.00)	(0.28)	(0.15)	(0.00)	(2.20)
Observations	5,996	6,054	6,061	4,236	3,140
Number of groups	162	164	164	164	154

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Beginning with column 1, state ownership of the economy significantly increases CO_2 per capita. Estimating the substantive effect of an increase of one overall standard deviation increase in state ownership shows that it increases the dependent variable of CO_2 per GDP by 8% of a standard deviation of the dependent variable. Next, the corruption variable is insignificant. Electoral democracy significantly increases CO_2 per GDP. The substantive effect of one standard deviation increase in democracy is 12% in terms of the impact on the standard deviation of the dependent variable. An increase in GDP per capita reduces CO_2 per GDP; the substantive effect of one standard deviation is a 64% reduction in a standard deviation of CO_2 per GDP. Trade as a % of GDP is significant and positively affects CO_2 per GDP. Resource rents as a % of GDP are insignificant, while a more urban population significantly increases CO_2 per GDP.

Column one, consequently, shows that the main independent variable of state ownership significantly increases CO_2 per GDP, independently of all the controls. The substantive effect of 8% for state ownership is comparably smaller than the effect of GDP per capita, where the substantive effect is 64%. Yet, GDP per capita is one of the immediate drivers of CO_2 emissions (Blanco et al., 2014). So that the effect is small compared to GDP per capita does not mean that it is inconsequential.

In column 2, state ownership has a significant and positive effect this time on CO_2 per capita. The substantive effect of a change of one standard deviation is 3% of a standard deviation of the dependent variable. The corruption variable is not significant here either. Electoral democracy is significant and positive. The substantive effect of electoral democracy is 5% of a standard deviation of the dependent variable. GDP per capita is again significant, but it is now positive compared to the negative effect in column one. The different direction of impact from GDP per capita for the two CO_2 measurements makes sense. Previous literature has found that an increase in GDP per capita is good for week sustainability, which CO_2 per GDP measures. At the same time, it negatively impacts strong sustainability, which CO_2 per capita measures (Roeland & de Soysa, 2021). The substantive change of one standard deviation in GDP per capita is 54% of a standard deviation of the dependent variable. Trade also has a positive and significant effect, resource rents are insignificant, and the urban population variable is significant and positive.

State ownership of the economy is also significant in column 3 and positively affects GHG per capita. The substantive effect of an increase of one standard deviation is 11% of a standard deviation in the dependent variable. The variable of less corruption is significant for GHG per capita, while it was insignificant for the two CO_2 measurements. The substantive effect of a change of one standard deviation is 11% of one standard deviation of the dependent variable. Electoral democracy is also significant and positively affects GHG per capita. The substantive effect of democracy is 5% of a standard deviation of the dependent variable. GDP per capita has a positive and significant effect, and one standard deviation increases GHG per capita by 84% of a standard deviation of the dependent variable. Trade as a % of GDP is significant and positively impacts GHG per capita. Both resource rents and urban population are significant, and both reduce GHG per capita.

Next, moving on to renewable energy as a % of total energy consumption in column 4, state ownership is significant and negatively impacts renewable energy. The substantive effect of state ownership is that an increase of one standard deviation leads to a change of 8% of a standard deviation of the dependent variable. The corruption variable is not significant. An increase in electoral democracy score is significant and negatively impacts renewable energy. The substantive effect of an increase of one standard deviation in the variable is a change of 6% of one standard deviation of the dependent variable. GDP per capita is also significant and has a negative effect. Its substantive effect on renewable energy is 30% of one standard deviation. Trade as a % of GDP is significant and positively affects the dependent variable. Natural resource rents are not significant, and a more urban population is significant and has a negative effect on renewable energy.

Lastly, in column 5, state ownership is also significant and positively affects eco-innovation. The substantive effect of an increase of one standard deviation in state ownership on eco-innovation is 3% of a standard deviation of the dependent variable. The corruption variable is not significant. Electoral democracy is significant and has a positive effect on eco-innovation. The substantive effect of an increase of one standard deviation of electoral democracy is 6% of a standard deviation of the dependent variable. GDP per capita is also significant and has a positive effect on eco-innovation. The substantive effect of an increase of one standard deviation is 66% of one standard deviation of the dependent variable. Trade as a percentage of GDP is significant and positively impacts eco-innovation. Natural resources rents are also significant and have a negative effect, while the urban population variable is insignificant

These findings are interesting as the results vary quite a lot depending on the measurement of climate performance used. However, the primary independent variable of state ownership of the economy seems to impact almost all aspects of climate performance negatively. The only exception is that more state ownership of the economy seems to increase the amount of eco-innovation in a state.

Still, the models in Table 2 might not represent the actual effect of state ownership of the economy, as few would argue that states should take complete control over the economy. Next, I will investigate whether there is a curvilinear effect of state ownership of the economy, as some literature has found that a mixed approach to state ownership is best (Haney & Pollitt, 2013; Hepburn, 2010). And as the theoretical argument is that the state only needs to take control over the market to some extent (Mazzucato, 2014; Riedy, 2020).

Testing for a quadratic effect of state ownership of the economy on the basic model in Table 2 shows a quadratic effect for some of the variables, as shown in Figures 1, 2, and 3.

Figure 1. Quadratic effect of state ownership on CO_2 per GDP produced

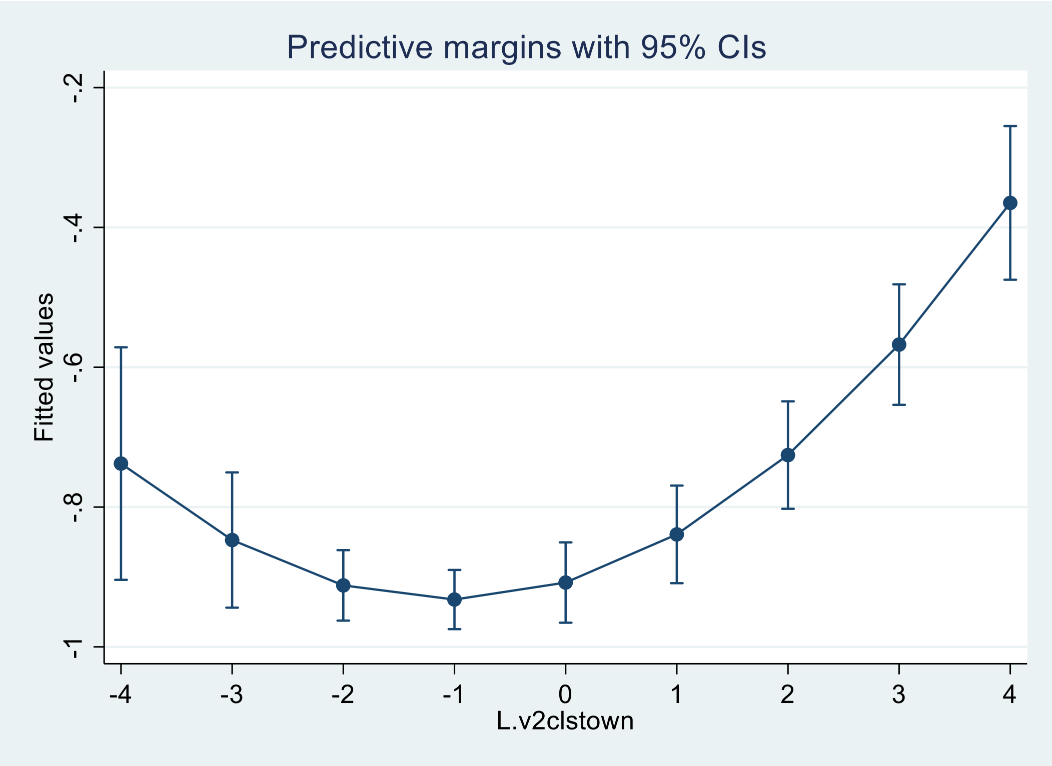


Figure 2. Quadratic effect of state ownership on CO_2 per capita

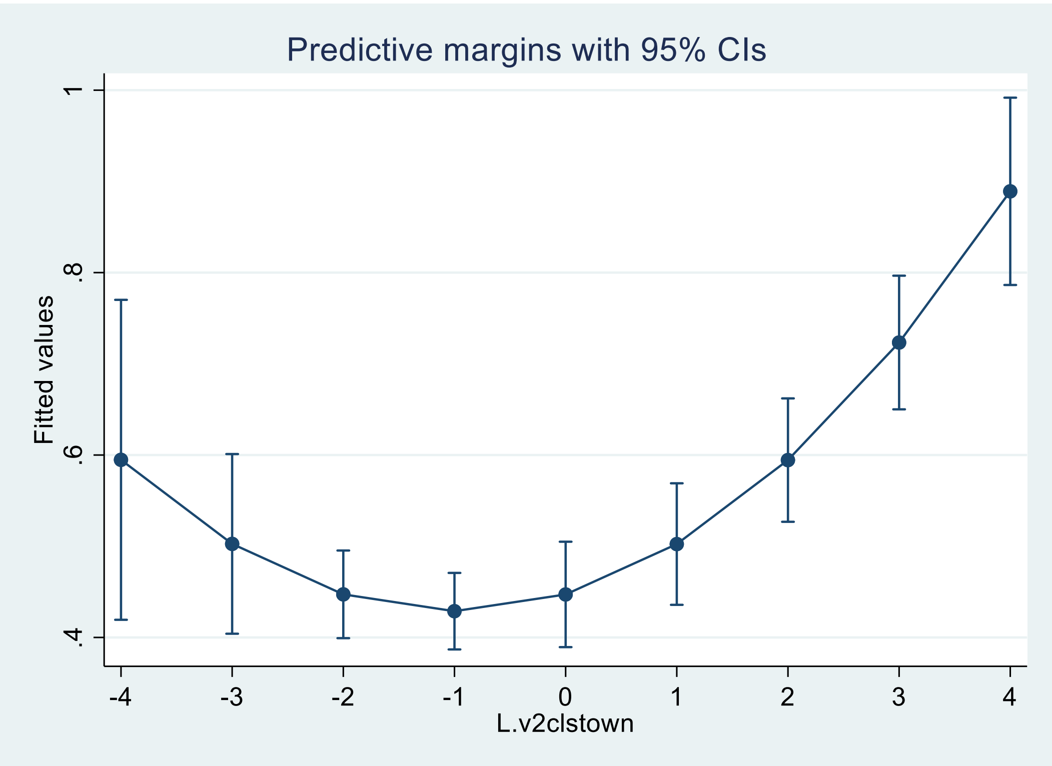
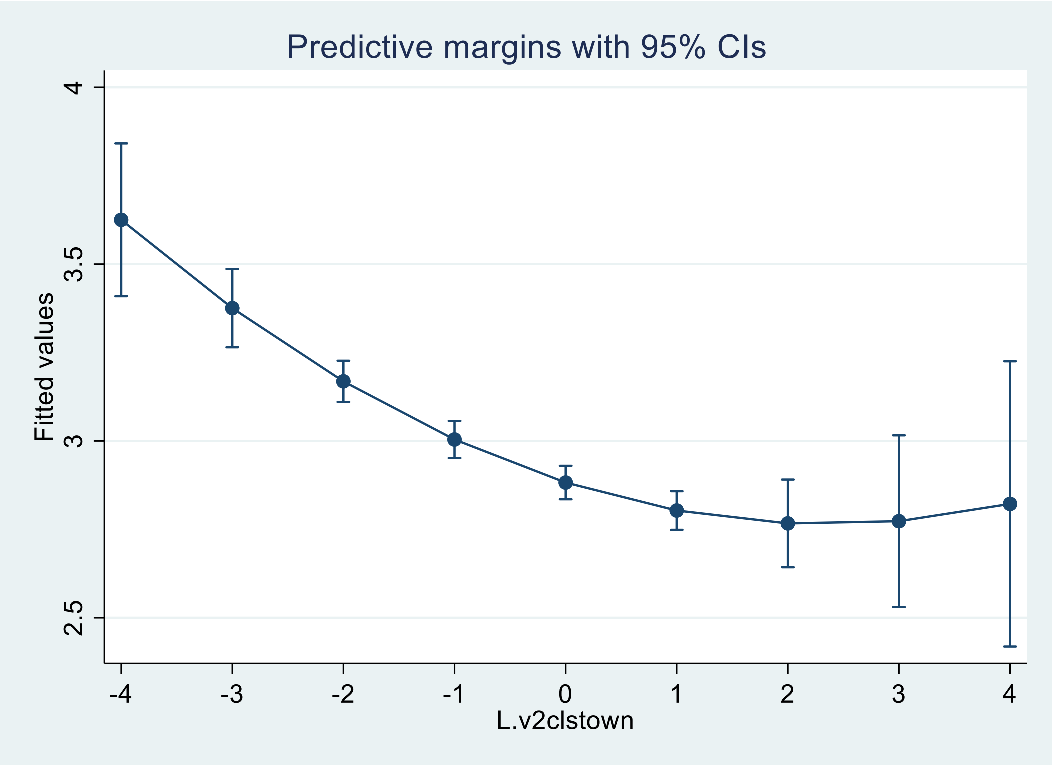


Figure 3. Quadratic effect of state ownership on renewable energy consumption



The quadratic effect is significant for the two measurements of CO_2 emission and renewable energy. Meanwhile, it is insignificant in the two other models with GHG per capita and eco-innovation.

These quadratic effects are interesting as they show that a certain level of state ownership helps decrease the state's CO_2 emissions. It seems like the optimal level of state ownership is at -1. The peak means that some level of state ownership of the economy is good for reducing CO_2 emissions. However, when state ownership of the economy gets to higher levels, it quickly increases the CO_2 emissions again. A value of -1 on state ownership does not necessarily mean that the country has high levels of state ownership. Australia, for example, had a value of -1.116 in 2020 on the interval scale used in this model. On the ordinal scale from the same year, before it was converted to an interval scale and flipped, the value was 3.15. A 3, according to the codebook, means that: "Some valuable capital either belongs to the state or is directly controlled by the state, but most remains free of direct state control" (Coppedge, Gerring, Knutsen, Lindberg, Teorell, Altman, et al., 2021, p. 184). These results support those who have found that a mix of state ownership and private ownership is optimal as one can get the best of both worlds, for example, Mazzucato (2014, 2021) and many of the new economics discourses. Still, this is only the case to some extent, as a value of -1 only entails some state ownership of valuable capital.

The results in Figure 2 go against those that have argued that mixed ownership of the energy sector can positively affect climate, such as Haney and Pollitt (2013), as it seems that state ownership decreases renewable energy from the beginning and only recovers slightly at the extreme end of state ownership.

Still, it is not necessarily enough to have more state ownership of the economy. Hypothesis 2 is that good institution has a conditional effect on state ownership of the economy. The hypothesis is tested in Table 3 with an interactive effect between state ownership of the economy and good institutions, measured as less corruption.

Table 3. The impact of the interactive effect between state ownership and less corruption on measures of GHG emissions

VARIABLES	(1) CO_2 per GDP (log)	(2) CO_2 per capita (log)	(3) GHG per capita (log)
State ownership	0.19***	0.18***	0.02
	(0.02)	(0.02)	(0.02)
Less corruption	0.09*	0.09**	-0.33***
	(0.05)	(0.04)	(0.07)
State ownership * less corruption	0.27***	0.27***	-0.16***
	(0.03)	(0.03)	(0.03)
Electoral democracy	0.35***	0.33***	0.16***
	(0.03)	(0.03)	(0.04)
GDP per capita (log)	-0.30***	0.67***	0.54***
	(0.03)	(0.03)	(0.02)
Trade % of GDP (log)	0.06***	0.09***	0.08***
	(0.02)	(0.02)	(0.02)
Resource rents % of GDP (log)	0.01	0.01	-0.02***
	(0.01)	(0.01)	(0.01)
Urban population (log)	0.81***	0.82***	-0.09**
	(0.09)	(0.09)	(0.04)
Constant	0.00	-8.39***	0.00
	(0.00)	(0.30)	(0.00)
Observations	5,996	6,054	6,061
Number of groups	162	164	164

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Column 1 of Table 3 shows that state ownership of the economy has a significant and positive effect. Since the variable is part of an interactive effect, interpreting this variable means that the other part of the interactive effect (political corruption in this case) is at zero (Mehmetoglu & Jakobsen, 2017, p. 113). Next, the corruption variable alone is not significant. However, the interactive effect between electoral democracy and state ownership is significant and positively affects CO_2 per GDP. Next, electoral democracy, GDP per capita, and trade as a percentage of GDP are all significant. Electoral democracy and trade as a percentage of GDP positively affect CO_2 per GDP, while GDP per capita has a negative effect. The natural resource rent variable is not significant. Lastly, the urban population variable is significant and positively affects CO_2 per GDP.

State ownership alone is significant in column 2 as well and has a positive impact on CO_2 per capita. The corruption variable alone is significant and positively affects the dependent variable. The interactive effect between state ownership of the economy and less corruption is significant and positively affects the dependent variable. Electoral democracy GDP per capita and trade as a % of GDP are all significant and positively affect CO_2 per capita. The resources rents variable is not significant here either. The urban population variable is significant and positively affects CO_2 per capita.

Lastly, in column 3, state ownership alone is not significant. The variable measuring institutional quality as less corruption is significant and has a negative effect on GHG per capita. The interactive effect between state ownership and less corruption is also significant and negative. Electoral democracy, GDP per capita, and trade as a percentage of GDP are all significant and positively affect GHG per capita. The natural resource rents and urban population variables are also significant but have a negative effect on GHG per capita.

Some interesting results emerge from adding the interactive effect between state ownership and less corruption to the model. While state ownership alone with the corruption value set to zero and the interactive effect increases both types of CO_2 emissions as in Table 2 (see Figures 4 and 5). The GHG per capita results change when adding the interactive effect. While the state ownership variable increased GHG emissions in Table 3 and the corruption variable was insignificant, the interactive effect of state ownership and less corruption now reduces GHG per capita (see Figure 6). These results imply that increasing state ownership or reducing corruption alone is not enough to reduce GHG emissions but increasing them together is. The negative effect of the interactive effect supports hypothesis 2 that State ownership´s effect on environmental outcomes is conditioned by good institutions.

It is, however, interesting that the opposite is the case for both measurements of CO_2 emissions. As the GHG measurements include both CO_2 emissions and other types of GHG emissions, this might imply that state ownership and less corruption together reduce other GHGs, while it increases CO_2 emissions. The reason for this might be as Akhbari and Nejati (2019) found that less corruption reduces C02 emissions in developing countries while it has no effect in developed countries. The effect could also be the opposite, as the difference between industrialized and developing countries could also be related to post-material values. Countries that have reached a level of growth where their basic material interests are fulfilled might move their politics to post-material interests such as environmental issues (Inglehart & Welzel, 2001).

Figure 4. The impact of the interactive effect between state ownership and less corruption on CO_2 per GDP

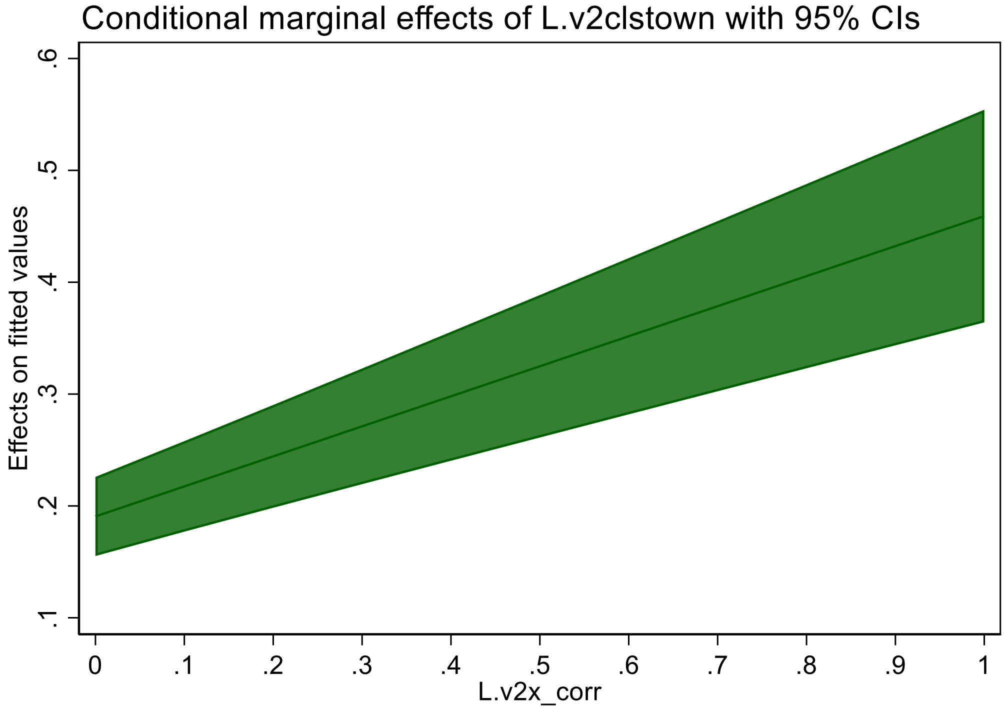


Figure 5. The impact of the interactive effect between state ownership and less corruption on CO_2 per capita

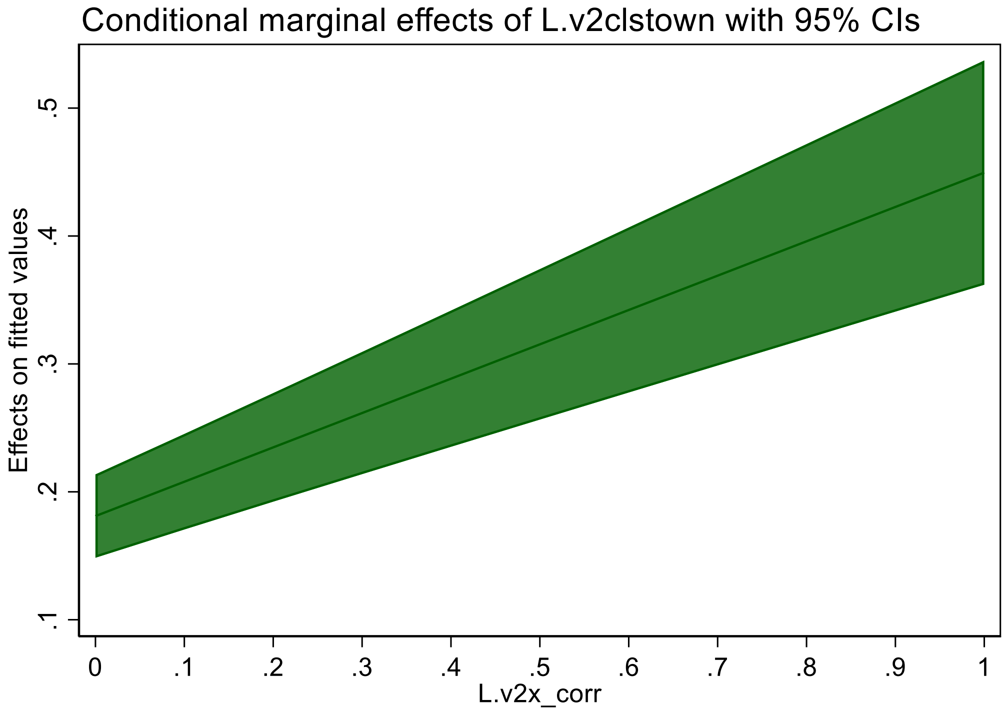
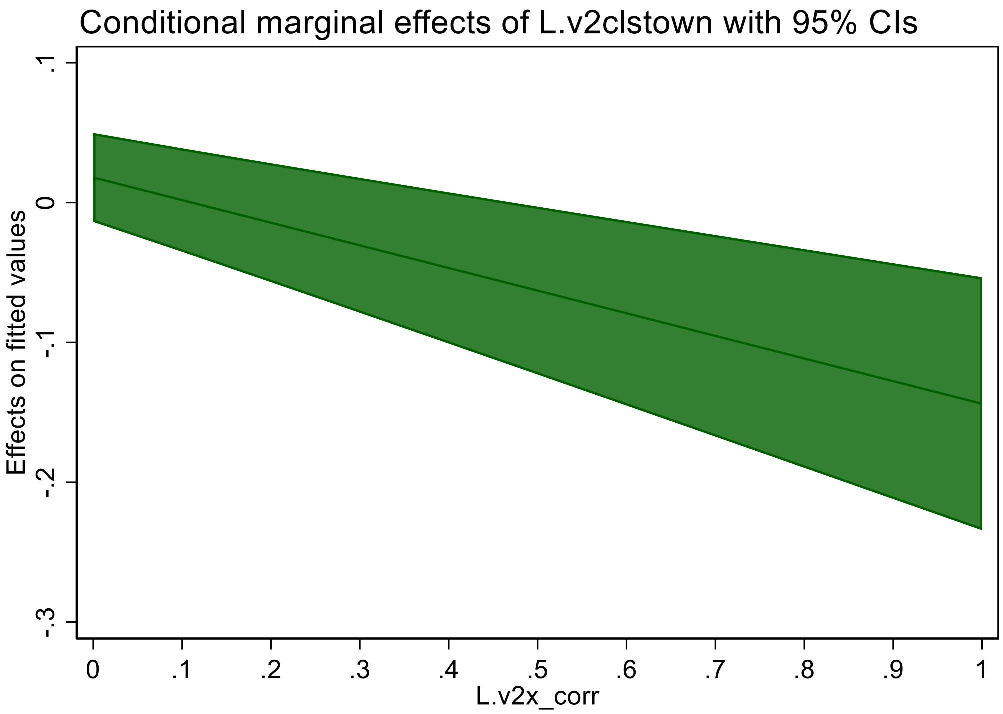


Figure 6. The impact of the interactive effect between state ownership and less corruption on GHG per capita



The findings of Akhbari and Nejati are tested here in a slightly different way by running a regression with only western industrial democracies[2]; this selection builds on similar tests in previous research (de Soysa, 2022; Roeland & de Soysa, 2021). Doing this leads to only one substantial change in the main variables of interest. The interactive effect now increases GHG per capita instead of reducing it (see Table A4 in the appendix). That means that when only keeping western industrial democracies in the model, an interactive effect between more state ownership and less corruption increase all three emission measurements. When testing for only the countries that are not western industrial democracies (developing countries), the same effect of the interactive effect from Table 2 remains; it increases both forms of CO_2 emissions and decreases GHG per capita. This indicates that more state ownership and less corruption together do help reduce GHG emissions, but not in industrialized countries. This might be because industrialized countries already have good institutions, so reducing corruption further will not change much, as Akhbari and Nejati (2019) found. However, these findings do differ from Akhbari and Nejati's in at least two ways. Firstly, here corruption is part of an interactive effect with state ownership. Secondly, Akhbari and Nejati found this to be the case for CO_2, while this model finds that it is only the case for general GHG emissions per capita and not for CO_2.

Testing for the curvilinear effect of state ownership in the models from Table 3 does not lead to any significant curvilinearity for the interactive effect.

[2] See appendix 2 for a list of the countries.

Based on the model in Table 3, there seem to be mixed results for hypothesis 2. Next, hypothesis 3 states that state ownership alone is not the solution; it must also be conditioned by functioning democracy. Hypothesis 3 is tested in Table 4.

Table 4. The impact of the interactive effect between state ownership and electoral democracy on measures of GHG emissions

VARIABLES	(1) CO_2 per GDP (log)	(2) CO_2 per capita (log)	(3) GHG per capita (log)
State ownership	0.06***	0.05***	0.15***
	(0.02)	(0.02)	(0.01)
Electoral democracy	0.35***	0.33***	0.09*
	(0.04)	(0.04)	(0.05)
State ownership * electoral democracy	-0.00	0.00	-0.17***
	(0.03)	(0.03)	(0.03)
Less corruption	0.09	0.11**	-0.41***
	(0.06)	(0.06)	(0.08)
GDP per capita (log)	-0.35***	0.62***	0.56***
	(0.03)	(0.02)	(0.02)
Trade % of GDP (log)	0.07***	0.10***	0.07***
	(0.02)	(0.02)	(0.02)
Resource rents % of GDP (log)	0.01	0.02	-0.02**
	(0.01)	(0.01)	(0.01)
Urban population (log)	0.90***	0.90***	-0.09**
	(0.08)	(0.08)	(0.04)
Constant	-1.56***	0.00	0.00
	(0.28)	(0.00)	(0.00)
Observations	5,996	6,054	6,061
Number of groups	162	164	164

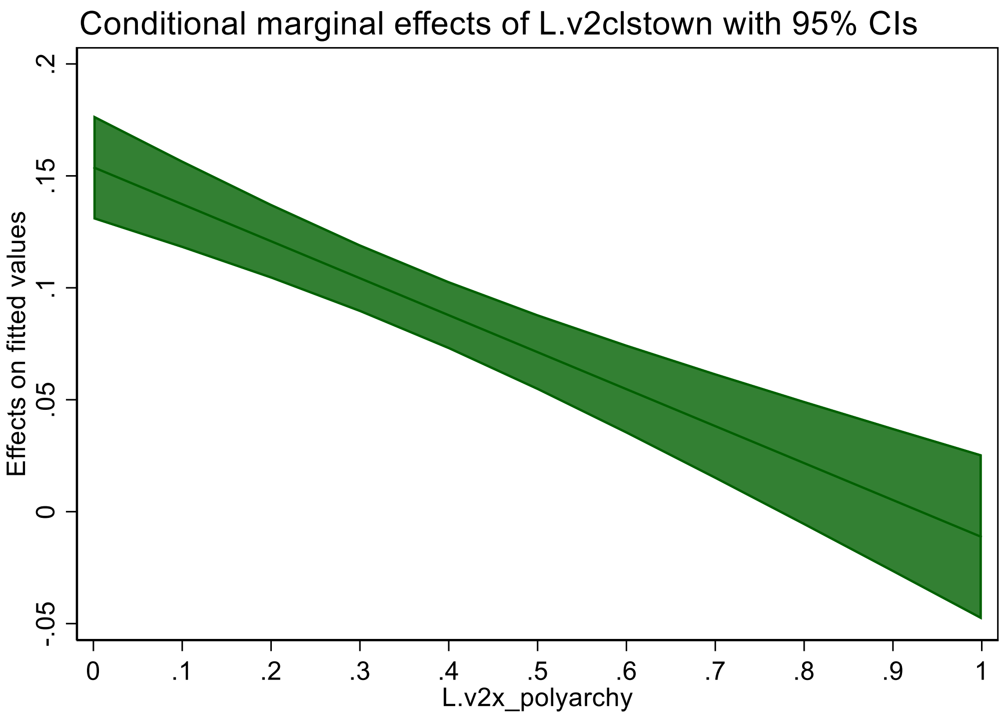
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Column 1 of Table 4 shows that both state ownership electoral democracy alone with the other variable set to zero significantly increases CO_2 per GDP. Meanwhile, the interactive effect that they both are part of is not significant. The corruption variable is also not significant. GDP per capita is significant and has a negative effect on CO_2 per GDP. Trade as a % of GDP is significant and positively affects the dependent variable. The resource rents variable is not significant. The urban population variable is significant and positively affects CO_2 per GDP.

The results for the main independent variables in column 2 are similar to those in column 1. Both parts of the interactive effect are significant and positive alone, while the interactive effect itself is not significant. However, the variables measuring less corruption are significant and positively impact CO_2 per capita. GDP per capita and trade as a % of GDP are also significant and positively impact CO_2 per capita. The resource rent variable is not significant. Meanwhile, the urban population variable is significant and positively impacts CO2 per capita.

However, the results in column 3 are quite different compared to columns 1 and 2. The state ownership variable alone with electoral democracy set to zero is significant and positively affects GHG emissions per capita. The electoral democracy variable is not significant. In contrast, the interactive effect between state ownership and electoral democracy significantly and negatively impacts GHG per capita. So, an increase in these two variables together reduces the GHG emissions per capita (see Figure 7). This supports hypothesis 3, that state ownership alone is not the solution; it must also be conditioned by functioning democracy. The variable measuring less corruption is also significant and negatively impacts GHG per capita. Both GDP per capita and trade as a % of GDP are significant and positively impact the dependent variable. Meanwhile, bot resource rents as a % of GDP and the urban population variable are significant but negatively impact GHG per capita.

Figure 7. The impact of the interactive effect between state ownership and electoral democracy on GHG emissions per capita



Testing for only Western industrial democracies in Table 4 as well makes the effect of the interactive effect on the two CO_2 emissions remain positive and significant, while it becomes insignificant for GHG emissions. At the same time, testing for only the countries that are not western industrial economies (developing countries) leads to the effect of the interactive term between state ownership and electoral democracy being insignificant for the two CO_2 emission measurements. In contrast, the effect remains significant and negative for GHG emissions per capita. So in both Table 3 and 4, it seems like the interactive effects of good institution and democracy with state ownership is only positive for GHG emissions. At the same time, it seems like this is not the case in western industrial economies. To summarize, support for hypotheses 2 and 3 is found only for general GHG emissions per capita and only for countries that are not western industrial democracies.

Therefore, there seems to be some difference in the mechanism that affects general GHG emissions and those that affect CO_2 emissions specifically. To get more clarification on how these interactions work, Tables 5 and 6 will look at the effect of the interactive effects on green innovation and renewable energy use.

Testing for the curvilinear effect of state ownership in the models from Table 4 does not lead to any significant curvilinearity for the interactive effect.

Table 5 shows the renewable energy and eco patents variables in a model with an interactive effect between state ownership of the economy and less corruption

Table 5. The impact of the interactive effect between state ownership and less corruption on renewable energy consumption and eco-innovation

VARIABLES	(1) Renewable energy % (log)	(2) Eco-innovation (log)
State ownership	-0.24***	-0.08
	(0.04)	(0.06)
Less corruption	-0.17***	-0.14
	(0.06)	(0.28)
State ownership * less corruption	-0.25***	-0.38***
	(0.05)	(0.13)
Electoral democracy	-0.32***	0.60***
	(0.09)	(0.22)
GDP per capita (log)	-0.28***	1.24***
	(0.04)	(0.08)
Trade % of GDP (log)	0.11***	0.51***
	(0.03)	(0.08)
Resource rents % of GDP (log)	-0.01	-0.06***
	(0.01)	(0.02)
Urban population (log)	-0.70***	0.05
	(0.10)	(0.22)
Population (log)		0.90***
		(0.11)
Constant	7.48***	0.00
	(0.31)	(0.00)
Observations	4,236	3,140
Number of groups	164	154

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Column 1 in Table 5 shows that the two variables that are part of the interactive effect, state ownership, and less corruption, are significant and negatively impact renewable energy. As these variables are part of an interactive effect, it means that this result is when the other part of the interactive effect is set to zero. The interactive effect itself is also significant and negatively impacts renewable energy as a % of total energy consumption. The same goes for electoral democracy and GDP per capita. Trade as a % of GDP significantly increases renewable energy. The amount of natural resource rents is not significant. Lastly, the urban population variable is significant and has a negative effect on renewable energy.

These results show that the interactive effect between state ownership and less corruption, electoral democracy, and GDP per capita all decrease the % of renewable energy consumption. As some of the countries with the highest amount of renewable energy as a % of total energy consumption are developing countries like the Democratic Republic of Congo and Somalia (The World Bank, 2022), comparing these countries to developed countries might be like comparing apples to oranges. Running the regression in column 1 for only western industrialized democracies leads to quite different results. When only western industrialized countries are included (as shown in appendix 5), the interaction between ownership and less corruption is no longer significant. More electoral democracy now significantly increases the percentage of renewable energy consumption, while GDP per capita is no longer significant. However, if I run the regression without the Western industrialized countries (so developing countries), the negative effect of the interactive effect, democracy, and GDP per capita remains. This might indicate that the negative effect of democracy and the interactive effect of state ownership and less corruption results from some countries with low democracy and high corruption having a high % of renewable energy consumption.

Moving on to column 2, both the parts of the interactive effect is insignificant on their own. At the same time, the interactive effect between state ownership and less corruption is significant and negatively impacts the amount of eco-innovation. The electoral democracy variable is significant as well and positively impacts eco-innovation. The same goes for GDP per capita and trade as a % of GDP. Natural resource rents as a % of GDP significantly reduce the amount of eco-innovation. The urban population variable is not significant. Lastly, the population variable is significant and positively affects eco-innovation.

So, the interactive effect between more state ownership and good institutions reduces renewable energy as a % of total energy consumption and eco-innovation, as seen in Figures 8 and 9.

Figure 8. The impact of the interactive effect between state ownership and less corruption on renewable energy consumption

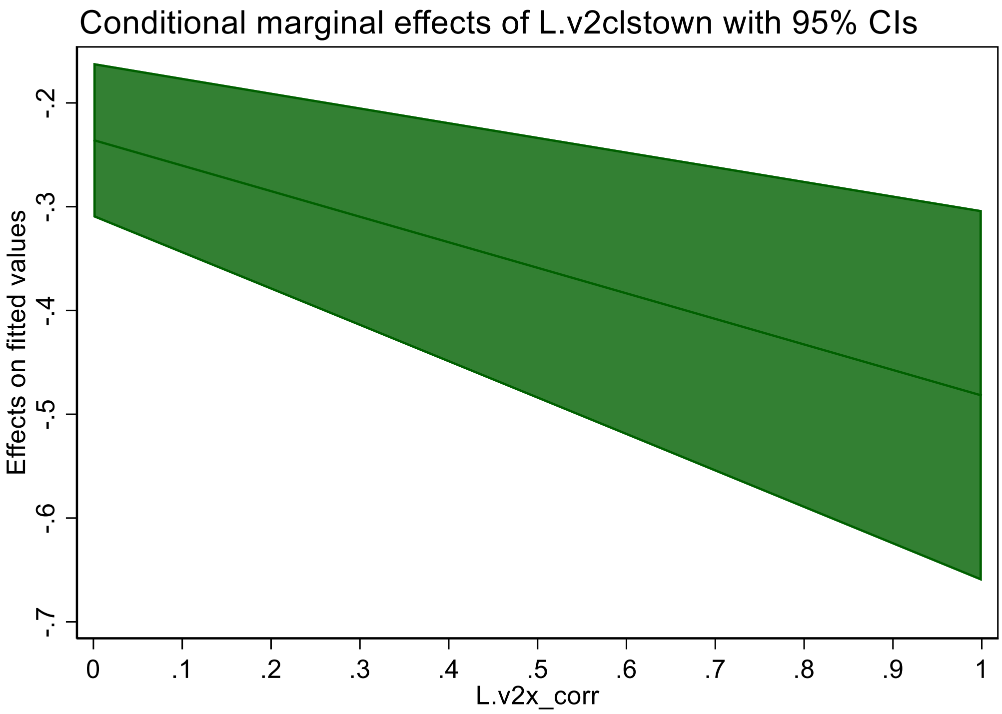
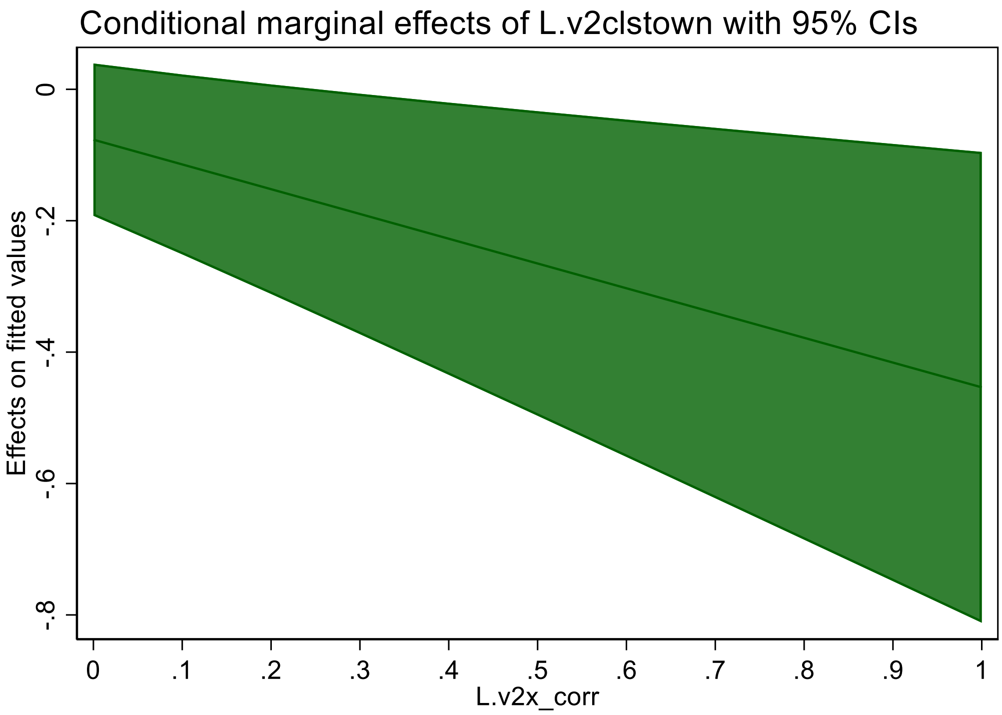


Figure 9. The impact of the interactive effect between state ownership and less corruption on eco-innovation



The interactive effect results go against the theory that informs hypothesis 2. Here again, these results might be different for industrialized countries. Running the regression with only western industrial economies makes the interactive effect in column 2 insignificant as well; it also makes the democracy variable insignificant (see appendix 5). Doing the regression with the other countries that are not western industrial democracies also makes both variables insignificant. So, making the divide between these two categories regarding eco-innovation removes the significance of the findings and leads to no interesting results.

Moving on to hypothesis 3 that State ownership alone is not the solution; it must also be conditioned by functioning democracy, Table 6 includes an interactive effect between state ownership and electoral democracy in the model.

Table 6. The impact of the interactive effect between state ownership and electoral democracy on renewable energy consumption and eco-innovation

VARIABLES	(1) Renewable energy % (log)	(2) Eco-innovation (log)
State ownership	0.03	0.11
	(0.03)	(0.08)
Electoral democracy	-0.46***	0.52**
	(0.08)	(0.21)
State ownership * electoral democracy	-0.32***	-0.05
	(0.06)	(0.11)
Less corruption	-0.17**	0.06
	(0.07)	(0.25)
GDP per capita (log)	-0.28***	1.27***
	(0.04)	(0.08)
Trade % of GDP (log)	0.12***	0.50***
	(0.03)	(0.08)
Resource rents % of GDP (log)	-0.01	-0.07***
	(0.01)	(0.02)
Urban population (log)	-0.70***	-0.05
	(0.09)	(0.22)
Population (log)		0.90***
		(0.11)
Constant	7.51***	-27.00***
	(0.30)	(2.22)
Observations	4,228	3,140
Number of groups	164	154

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Beginning with column 1 in Table 6, state ownership alone is not significant. Electoral democracy alone with state ownership set to zero is significant and has a negative effect on renewable energy as a % of total energy consumption. The interactive effect between state ownership and electoral democracy is also significant and has a negative impact on the dependent variable. Less corruption and GDP per capita are also significant and negatively impact the dependent variable. Trade as a % of GDP is significant and positively affects renewable energy. The resource rent variable is not significant, and the urban population variable is significant and negatively impacts renewable energy as a % of total energy consumption.

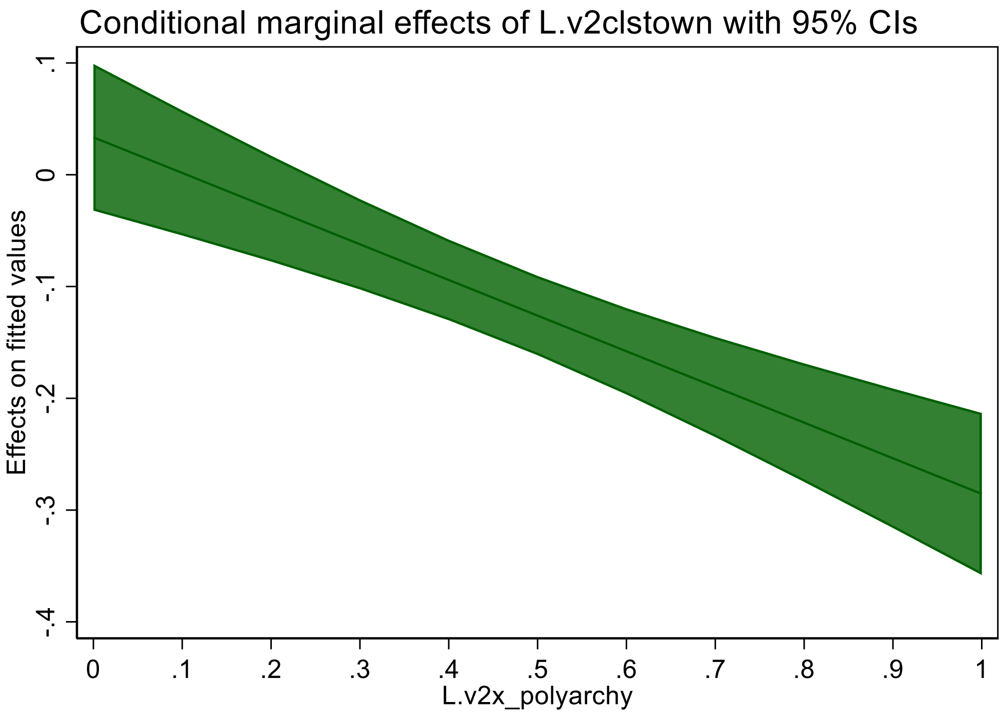
So, in the model with an interactive effect between state ownership and electoral democracy, the interactive effect also reduces renewable energy consumption, as shown in Figure 10. Again, whether these effects are different for western industrialized democracies is tested. Doing this makes the interactive effect insignificant, and less corruption now significantly increases the % of renewable energy consumption. The regression with the developing countries leads to similar results when all countries are included.

Chen et al. (2021) can shed some light on these findings. They found that economic growth increases renewable energy use in democratic countries while economic growth decreases renewable energy in less democratic countries. Another model can control this with an interactive effect between GDP per capita and electoral democracy. The result from this model (see appendix 7) is that state ownership with no interactive effect is significant and negatively impacts the % of renewable energy. Both GDP per capita and electoral democracy alone, with the value of the other variable at zero, are significant and negatively impact renewable energy. However, the interactive effect is significant and positively impacts the percentage of renewable energy. Therefore, it seems Chen et al. (2021) findings hold for this model and that economic growth and democracy increase renewable energy, while both of the variables alone actually decrease the % of renewable energy consumption.

In column 2 of Table 6, state ownership of the economy alone is insignificant. Electoral democracy alone is significant and positively impacts eco-innovation. The interactive effect between state ownership and electoral democracy is not significant. Neither is the corruption variable. GDP per capita and trade as a % of GDP are both significant and positively affect eco-innovation. The natural resource rents variable is significant and negatively affects the dependent variable. The urbanization variable is not significant. The population variable is significant and positively affects eco-innovation.

The results in column 2 of Table 6 are not very revealing, as none of the main variables of interest are significant. However, testing the regression for only western industrial democracies does lead to some interesting results. Now the interactive effect is significant and leads to an increase in eco-innovation. The variable measuring less corruption also becomes significant and leads to an increase in eco-innovation. In other words, an increase in state ownership and democracy leads to more eco-innovation in western industrial democracies. The significant and positive effect is interesting and supports some aspects of hypothesis 3.

Figure 10. The impact of the interactive effect between state ownership and electoral democracy on renewable energy consumption



Testing this only for developing countries leads to no significant results for any of the variables of interest. This means that this regression supports the hypothesis that more state ownership, conditioned by democracy, is a driver of eco-innovation, which is again an important mechanism in the transition toward lowering GHG emissions but only in western industrial democracies.

After having tested all three hypotheses for all the dependent variables, some alternative models will be run to check for other explanations based on theory, like the EKC and alternative variables, to test robustness.

5.2. Alternative models

Povitkina (2018) argues that democracy is only good in low corruption contexts. Controlling for this with an interactive effect between more democracy and less corruption supports the findings of Povitkina (see appendix 8). The interactive effect between less corruption and electoral democracy decreases CO_2 per GDP and CO_2 per capita. Meanwhile, it increases GHG per capita. The interactive effect also increases both the % of renewable energy consumption and eco-innovation. State ownership, however, harms all climate outcomes in the model, the only exception being that it increases eco-innovation. Therefore, the results for state ownership are similar to the results in the basic model in Table 2.

Including only western industrial countries in the corruption and democracy model makes all the interactive effects between less corruption and electoral democracy insignificant. At the same time, state ownership now significantly reduces all three measures of GHG emissions. Meanwhile, it significantly increases renewable energy consumption and is insignificant for eco-innovation. Testing the model for only developing countries led again to new results. The interactive effect is now significant for all the dependent variables. It has a negative effect on both measures of CO_2 emissions and a positive effect on GHG emissions per capita, renewable energy consumption, and innovation. State ownership alone is also significant in this model and has a positive effect on all the dependent variables except for renewable energy consumption, where it has a negative effect.

Going into detail on these results is beyond the focus of this thesis, as it focuses specifically on state ownership. Previous research has, however, investigated this relationship. Sommer (2020) argues that the varied and mixed results of democracy and CO_2 emissions in the literature are that controlling for clientelism as a specific form of corruption has been neglected. The results of Sommer's research were that the interactive effects between democracy and reducing clientelism show that a reduction in clientelism generally reduces the amount of CO_2 emissions for high- and low-income countries but not for middle-income countries. Running a similar interactive effect between corruption and democracy in my model led to changed results for the impact of state ownership. Therefore, future research might investigate the impact of the interaction between democracy and corruption (or clientelism) and state ownership on GHG emissions. It might also be relevant to look at the difference between low-, middle-, and high-income countries as Sommer found different results for these groups.

There is also comprehensive literature on economic growth and climate performance, and testing some of the findings from this literature might also be relevant. The EKC control is relevant to control for as it is often discussed in the literature, and there are, as discussed earlier, a plethora of different findings (Shahbaz & Sinha, 2019). As Joshi and Beck (2018) investigated whether political freedom and economic freedom impact the EKC, it will be interesting to do this here as well. However, the focus here is more on how the EKC influences political and economic freedom. As less state ownership correlates with measurements of economic freedom (de Soysa, 2022), state ownership can arguably be an alternative measurement of economic freedom. As the variables are inverted in my thesis, a higher value would mean less political freedom. Only test EKC for the emission variables as this is the focus of previous research

Including this EKC based on Joshi and Beck (2018) leads to some interesting results. Adding the EKC does not change much for the model in Table 2. However, it indicates that there is a curvilinear relationship, if not, and EKC for at least some of the dependent variables. The quadratic effect of GDP per capita is significant for all the dependent variables in the model from Table 2 when the model has no interactive effects (see appendix 9). The effect is most drastic for CO_2 per GDP (see appendix 10 for Figures of the quadratic effects of GDP per capita without any interactive effects). There is also a curvilinear effect for CO_2 per capita and GHG per capita, but the effect is not as drastic. It does not get better at the higher values than the lower ones, and there is no EKC in these two models. The curvilinear effect for GHG per capita is even weaker. The curvilinear effect is also quite drastic for renewable energy as a % of total energy consumption and eco-innovation. However, there is a curvilinear relationship the other way for these two variables. This makes sense as more of these values mean better climate performance. Introducing the quadratic effect of GDP per capita does not change the model much. The only major change in the state ownership variable is that eco-innovation is now significant at 10% instead of 5%

Running the models with the interactive effect between state ownership and less corruption in Table 3 again leads to all the quadratic effects being significant. Here, the effect is strongest for CO_2 per GDP while weaker for the two other emission measurements. The interactive effect between ownership and less corruption is not impacted significantly by introducing the quadratic effect to the model.

For the model in Table 4, introducing the quadratic effect does change the results quite significantly (see appendix 11). The interactive effect between state ownership and democracy also reduces both CO_2 per GDP and CO_2 per GDP, while the interactive effect increased CO_2 emissions in the model without the quadratic effect. The interactive effect also reduces GHG per capita as it did before. This indicates that something with economic growth and the curvilinear effect of GDP per capita that makes the interactive effect between state ownership and electoral democracy change in relation to CO_2 emissions. Which exact mechanisms explain this change is hard to say and might be something for future research to pick up on. The quadratic curvilinear effects in the model from Table 4 are very similar to those in Tables 1 and 2.

In summary, there is a curvilinear quadratic effect for GDP per capita. Still, it is not U-shaped anywhere as the curves are either too straight or are too short on one of the sides of the peak.

Further, an interactive effect was tried with three variables, state ownership, corruption, and electoral democracy. This was done to check if state ownership reducing emissions is conditioned on good institutions and more democracy at the same time. However, this did not lead to any interesting results as the three variable interactive effects were insignificant for all the dependent variables measuring emissions.

The ecological footprint is another indicator that has garnished more attention lately as a measurement of environmental performance. Ecological footprint (ECF) has become more widely used lately as a more comprehensive measurement of the amount of pressure humanity puts on the environment (Uddin et al., 2017; York et al., 2009). Importantly, footprint measurements do not give comprehensive coverage to all areas. Instead, they measure how much humans use the world's biologically productive capacity (Wackernagel & Beyers, 2019). Nevertheless, ECF is one of the most comprehensive indicators of environmental quality (Baloch et al., 2019). ECF has also been used with greenhouse gas emissions as an alternative indicator of the pressure of humanity on the environment, for example, when testing the EKC, which yields different results than CO_2 (Altıntaş & Kassouri, 2020). Therefore ECF will be used as an alternative measurement, and to ensure the robustness of the other dependent variables.

The Ecological Footprint Network has defined ECF as: "measuring how much area of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste (carbon dioxide) it generates, using prevailing technology and resource management practices" (Rudolph & Figge, 2017, pp. 350-351).

The data on ecological footprints is retrieved from York University. They:

> [P]roduced [the dataset] using data from global statistics that detail consumption, production, population, and economic parameters by year, and by country or the world. Key sources include the International Energy Agency (IEA), the Food and

Agriculture Organization (FAO) of the United Nations and its ProdStat, TradeStat, ResourceStat, and FishStat databases, UN COMTRADE, CORINE Land Cover, Global Agro-Ecological Zones (GAEZ), Global Land Cover (GLC), Global Carbon Budget, World Bank, International Monetary Fund, and Penn World Tables. (Miller et al., 2022)

The total consumption will be the ecological footprint variable(s) that will be used. Total consumption includes products, imports, and exports. There are also six indicators that measure how much biological capacity is needed to regenerate this total consumption. The biological capacity includes crops, livestock, forest harvest, marine and inland use for human consumption, the area occupied by infrastructure, and forests needed to sequester anthropogenic carbon emissions (Miller et al., 2022). The variable choice builds on previous research that has operationalized ECF in the same way (Danish & wang, 2019; Ulucak & Bilgili, 2018). As ECF as an indicator has seen more use recently, some variables have been found to affect footprints. Driving variables that affect ecological footprints include income, urbanization, natural resource rents, renewable energy (Danish et al., 2020; Danish & wang, 2019), economic growth, foreign direct investments, and natural resources (Baloch et al., 2019). But no one has investigated how state ownership affects it. So, it will be especially interesting to see how state ownership of the economy impacts ecological footprint.

The ECF variable was log-transformed as it was skewed. The EFC model is significant in the Hausman test and can therefore use both fixed and random effects. Still, random effects are used to stay consistent with the other models.

State ownership of the economy significantly increases the ecological footprint in the model with no interactive effects from Table 2 (appendix 12). The same goes for electoral democracy. Less corruption is, however, insignificant. In the model with the interactive effect between state ownership and less corruption based on hypothesis 2 (appendix 13), state ownership alone significantly increases ECF, while the other part of the interactive effect, less corruption, is insignificant. The interactive effect between state ownership and less corruption is significant and increases the ecological footprint. In the last model with the interactive effect based on the interactive effect between state ownership and electoral democracy in hypothesis 3 (appendix 14), both parts of the interactive effect, state ownership and electoral democracy alone, significantly increase the ecological footprint. The interactive effect between the two variables is also significant and has a positive effect. So, state ownership increases ECF alone and in both interactive effects, just like CO_2 emissions do. Testing these models for Western industrial countries as well shows that state ownership with no interactive effect now decreases ECF, while state ownership in both interactive effects still increases the ECF. For the other countries that are not western industrial economies, state ownership increases the ECF in all three instances.

The results from running ecological footprint in the models from Table 2 with no interactive effects, Table 3 with the interactive effect between state ownership and less corruption, and Table 4 with the interactive effects between state ownership and electoral democracy yield similar results to CO_2 per capita. However, one difference from CO_2 per capita is that the curvilinear effect of state ownership is insignificant for ECF in the basic model. Even if the ECF and GDP per capita results are similar, correlating these two variables (logged) shows that the correlation is only 0.296.

The different models have led to both general conclusions and some nuanced findings. The discussion part will discuss this in relation to the hypotheses, theory, and previous research.

5.3. Discussion

The general conclusion from the results section shows that all hypotheses: hypothesis 1 - *State ownership of the economy reduces greenhouse gas emissions and improves emission prevention*. Hypothesis 2 - *State ownership´s effect on greenhouse gas emissions and emission prevention is conditioned by good institutions*. Hypothesis 3 - *State ownership´s effect on greenhouse gas emissions and emission prevention is conditioned by democracy*, is that all but hypothesis 1 can be rejected for CO_2 emissions per GDP produced and CO_2 emissions per capita. While all but hypothesis 1 seem to be supported for general GHG per capita, though only in developing countries.

In the model with no interactive effects in Table 2, the results showed that there was a curvilinear relationship between state ownership and CO_2 emissions per GDP and CO_2 emissions per capita. The optimal point was at -1; this shows that states with some state ownership perform best. The curvilinear effect supports hypothesis 1 to some extent, as it shows that some state ownership is needed. Still, it is hard to say if this is exactly the amount the different new economics discourses might advocate. It is, however, beyond what Prometheans and neo-classical economists argue as they find that there should be as little state involvement in the market as possible (Carter, 2018; Dryzek, 2021). Yet, the quadratic effect of state ownership of the economy is insignificant in the models with interactive effects in Tables 3 and 4.

There is, however, more nuance to the results. In the cases of the models with interactive effects, more state ownership conditioned by good institutions and democracy increases CO_2 emissions in general. In contrast, the interactive effects reduce GHG per capita emissions. However, this positive effect does disappear when only western industrial economies are included. So overall, there seems to be a difference in GHG emissions and CO_2 emissions, as state ownership always increases CO_2 emissions when conditioned by good institutions and democracy. State ownership also generally increases GHG emissions, with the exception of when good institutions and democracy condition it in developing countries.

The different results for general GHG emissions and specific CO_2 emissions can be as the other GHG gasses are most commonly associated with agriculture according to the WDI. GHG emissions are therefore especially prominent in agricultural economies. In contrast, CO_2 comes from sources such as the burning of fossil fuels and industries like cement production (The World Bank, 2022). As developing countries' economies have had more agricultural economies (Mendelsohn & Dinar, 1999), it could be that the difference lies in that these interactive effects from hypotheses 2 and 3 reduce emissions from agriculture but not industry. This could then be a similar mechanism to what Akhbari and Nejati (2019) found for corruption, as they found that a decrease in corruption only reduces CO_2 emissions in developing countries. Akhbari and Nejati say the reason might be that the institutions in developing countries have more room for improvement than those in developing that already have a quite high level of institutional quality. In my model, the mechanism would instead be that state ownership condition by good institutions and electoral democracy only decreases general GHGs and only in developing countries. This is, nevertheless, quite speculative, and future research is needed to establish the mechanisms.

As discussed earlier, previous research has shown that the interactive effect between corruption (or clientelism) and democracy might explain the effect of democracy on emissions (Povitkina, 2018; Sommer, 2020). Running the interactive effect between less corruption and electoral democracy in my model also shows that this interactive effect reduces CO_2 per GDP and CO_2 per capita, yet it increases GHG per capita. State ownership harms all the climate outcomes in this model. Controlling for developed and developing countries also changes the results drastically. Future research should investigate the effect of corruption and democracy on emissions together with state ownership, as this might shed further light on the mechanisms that cause the different results.

Some of the mechanisms that cause emissions were also investigated, using renewable energy as a % of total energy consumption and eco-innovation as dependent variables. First, for renewable energy as a % of total energy consumption, all the hypotheses can be rejected. State ownership seems to reduce renewable energy as a % of total energy consumption alone and when conditioned by good institutions or democracy. This mostly holds for both developed and developing countries, with two exceptions. The interactive effect of state ownership and good institutions is not significant in developing countries, and the interactive effect between state ownership and electoral democracy is insignificant for western industrial economies. Nevertheless, in no instance is state ownership of the economy good for renewable energy as a % of total energy consumption. The negative effect of state ownership on renewable energy goes against the argument that more state ownership is needed to overcome vested interest and market failure that leads to the continuation of non-renewable energy sources such as fossil fuel. Therefore, it might be that free markets and market-based instruments such as a carbon tax or cap-and-trade are better at transferring to renewable energy than a top-down state approach.

The results for eco-innovation are, however, more nuanced. In the model in Table 2 with no interactive effects, state ownership does increase eco-innovation. These results indicate that state ownership of the economy might increase eco-innovation. However, it is interesting that the interactive effects of less corruption or electoral democracy seem to reduce innovation in the case of less corruption and make it insignificant in the case of democracy. One exception is the interactive effect of electoral democracy in western industrialized democracies, where the interactive effect is significant and increases eco-innovation. In general, hypothesis 1 seems to hold, while hypothesis 2 is rejected as the conditional effect of less corruption on statism reduces eco-innovation. In contrast, hypothesis 3 is rejected for developing countries while being supported in western industrial democracies (developed countries).

Those adhering to the new economics discourses, such as Mariana Mazzucato (2014, 2021), might therefore be right in saying that states can take an active and leading role in fostering eco-innovation. However, that good institutions and democracy seem to remove this positive association is puzzling. Especially as previous research finds that good institutions in general and less corruption increase innovation (Anokhin & Schulze, 2009), and corruption also impedes eco-innovation specifically (Hrabynskyi et al., 2017). Therefore, it might be that less corruption only increases eco-innovation when state ownership is low. In other words, less corruption only increases eco-innovation in free markets. Further research should investigate this relationship. The mixed results for the conditional effect of democracy on state ownership are less puzzling as empirical research has found that democracy in itself does not increase innovation, even if democratic countries have higher levels of innovation (Gao et al., 2017).

Some alternative models found some additional effects that can impact the models. First, the EKC was tested for as this is a major issue in the literature. Most of the models have curvilinear effects; still, none of these exactly represent the EKC. Additionally, including the curvilinear effect of GDP per capita used to capture the EKC makes the interactive effect between state ownership and electoral democracy reduce both measurements of CO_2 emissions. Therefore, it seems that including a curvilinear effect of GDP per capita supports the argument of hypothesis 3, that *state ownership alone is not the solution; it must also be conditioned by functioning democracy,* and this effect might be connected to the economic growth. However, it is beyond the scope of this thesis, and the hypotheses investigate why this is the case.

Lastly, using ECF as an alternative measurement of climate performance leads to comparable results to CO_2 per capita. One major difference is that the quadratic effect of state ownership is not significant for ECF; this means that it is not the case that some state ownership of important sectors improves ECF as it does with CO_2 emissions. Therefore, it seems that more state ownership, in every instance, increases ECF. In other words, free markets are better at reducing state ECF.

Finally, when it comes to answering the research question of "*How does state ownership of the economy affect greenhouse gas emissions?"*. Overall, it seems Hepburn (2010) is correct in saying that neither state nor market is the ultimate solution. They both have their advantages and disadvantages that are context-specific. Both market failures and state failures are serious issues; therefore, an approach that looks at the specifics of each situation is needed. In some instances, more state ownership can reduce emissions. For example, some state ownership reduces CO_2 emissions. In other cases, state ownership may only decrease emissions when conditioned by good institutions and democracy, as in developing countries. In other instances, free markets overall perform better than state ownership, for instance, on renewable energy consumption and ECF.

It might also be that this can change in the future, as some have argued that states have just started to use their potential as environmental actors (Mayer & Rajavuori, 2017; Reiche, 2010). Therefore, the environmental state and new economics should not be dismissed even if the free market performs better in some instances. Instead, the best approach might be to look at the potential of both state and market and allow both approaches to work together. This can, for example, take the form of the state playing a leading role in setting the mission and correcting market failures while letting the market do what it is best at, as Mazzucato (2014, 2021) has argued.

Finally, even if democracy sometimes increases emissions, it might be better to work within the democratic system because of the other goods it provides rather than abandoning democracy. Wilkinson and Pickett (2009) have argued that there might be more support for dealing with climate change in a more egalitarian society. However, previous research has found mixed results regarding egalitarian democracy and climate (Bergquist et al., 2020; Roeland & de Soysa, 2021). Still, future research could investigate the specific relationship between state ownership and egalitarian democracy as I only controlled for electoral democracy in this thesis.

Lastly, even if democracy might not directly reduce GHG emissions, it still has its own merits. This is related to the argument of Bjørn Lomborg (2020) that even in climate change is a crucial issue, it should not necessarily always be prioritized over other important issues in society. Other important issues might include reducing levels of poverty or issues like democracy, as these may be goods in themselves.

6. Conclusion

The answer to the research question "*How does state ownership of the economy affect greenhouse gas emissions?"* is that it depends. The conclusion is that all three hypotheses are supported in some instances and rejected in others. So, no general claim can be made that either the free market or state ownership of the economy is a general solution to reducing climate change. Hypothesis 1, that "*State ownership of the economy reduces greenhouse gas emissions and improves emission prevention,"* is supported to some extent. Some state ownership of important capital reduces CO_2 per GDP and CO_2 per capita, so both weak and strong sustainability when measured in CO_2. Meanwhile, state ownership with no conditional effects only increases general GHG per capita. State ownership of the economy does, however, reduce GHG emissions in developing countries when it is conditioned by electoral democracy or good institutions. The reduction from the conditional effects supports hypothesis 2 that *State ownership´s effect on greenhouse gas emissions and emission prevention is conditioned by good institutions*" and hypothesis 3 that "*State ownership´s effect on greenhouse gas emissions and emission prevention is conditioned by democracy,"* but only for general GHG emissions per capita, and only in developing countries. While hypothesis 1 is supported in general but only for specific CO_2 emissions and not for general GHG emissions. The difference in results might be because non-CO_2 GHGs are related to agriculture and is therefore relatively more prominent in developing countries as they have more agricultural and less industrial economies.

Renewable energy consumption as a percentage of total energy consumption and eco-innovation were also used as indicators of the mechanisms for the prevention of GHG emissions. The results here were that more state ownership never increases renewable energy consumption and decreases it in most instances. Therefore, free markets seem to have performed best in the transition to renewable energy. For eco-innovation, state ownership alone leads to an increase, while the conditional effect of less corruption on state ownership reduces eco-innovation. The conditional effect of democracy makes state ownership insignificant but becomes significant and positively affects eco-innovation when only developed countries are included in the model.

Overall the results show that state ownership and free markets perform differently depending on the type of GHG reduction. The results bolster the argument that the state and the market must work together to deal most effectively with climate change, as they both have strengths and weaknesses.

Future research should use qualitative studies to investigate further the difference in the different mechanisms for state ownership of GHG and specific CO_2 emissions. It should also investigate the mechanisms that might explain the different impacts of state ownership in developed and developing countries. For example, one might see how clientelism and rent-seeking occur across these regimes. Or how business, industry, and organized interests' political objectives may derail democratic expectations around state ownership and green policies. Another issue that needs further investigation is how the EKC is related to state ownership of the economy. Lastly, further research using other measurements of state involvement, such as government spending, could shed a different light on the role of governments in reducing GHG emissions or dealing with other environmental issues.

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8. Appendix

Appendix 1: The effect of state ownership, less corruption, and electoral democracy on GHG emissions and GHG emission prevention (fixed effects)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	CO2 per GDP (log)	CO2 per capita (log)	GHG per capita (log)	Renewble energy % (log)	Eco-patents (log)
State ownership	0.06***	0.04***	0.09***	-0.09***	0.13***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)
Less corruption	0.11*	0.12**	-0.35***	-0.11	-0.22
	(0.06)	(0.06)	(0.07)	(0.07)	(0.29)
Electoral democracy	0.36***	0.34***	0.18***	-0.36***	0.45**
	(0.04)	(0.04)	(0.04)	(0.07)	(0.21)
GDP per capita (log)	-0.37***	0.59***	0.55***	-0.26***	1.32***
	(0.03)	(0.02)	(0.02)	(0.03)	(0.13)
Trade % of GDP (log)	0.06***	0.09***	0.07***	0.12***	0.52***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.08)
Resource rents % of GDP (log)	0.00	0.01	-0.04***	-0.02	-0.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Urban population (log)	0.88***	0.88***	-0.17***	-0.71***	0.60**
	(0.09)	(0.09)	(0.04)	(0.11)	(0.25)
Population (log					0.61***
					(0.22)
Constant	0.00	0.00	-9.54***	7.43***	0.00
	(0.00)	(0.00)	(0.17)	(0.29)	(0.00)
Observations	5,996	6,054	6,061	4,236	3,140
Number of groups	162	164	164	164	154

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 2: List of Western industrial countries

United States of America, Canada, Great Britain, France, Germany, Belgium, Netherlands, Austria, Ireland, Switzerland, Italy, Greece, Spain, Portugal, Luxembourg, Iceland, Liechtenstein, Monaco, Norway, Denmark, Sweden, Finland, Japan, Australia, and New Zealand.

Appendix 3: Matrix of correlation

Variables	-1	-2	-3	-4	-5	-6	-7	-8	-9
(1) State ownership	1								
(2) Less corruption	-0.230	1							
(3) Electoral democracy	-0.618	0.621	1						
(4) GDP per capita (log)	-0.302	0.678	0.586	1					
(5) Trade % of GDP (log)	-0.062	0.187	0.106	0.298	1				
(6) Resource rents % of GDP (log)	0.353	-0.473	-0.448	-0.468	-0.203	1			
(7) Urban population (log)	-0.257	0.384	0.438	0.767	0.245	-0.329	1		
(8) Year	-0.248	-0.045	0.252	0.157	0.264	-0.028	0.262	1	
(9) Population (log)	-0.081	-0.103	0.027	-0.024	-0.524	0.077	0.082	0.068	1

Appendix 4: The impact of the interactive effect between state ownership and less corruption on measures of GHG emissions (Western industrial democracies)

VARIABLES	(1) CO2 per GDP (log)	(2) CO2 per capita (log)	(3) GHG per capita (log)
State ownership	-0.06***	-0.06***	-0.06***
	(0.02)	(0.02)	(0.02)
Less corruption	0.10	0.05	0.14
	(0.21)	(0.22)	(0.21)
State ownership * less corruption	0.59***	0.55***	0.59***
	(0.09)	(0.08)	(0.12)
Electoral democracy	0.65***	0.64***	0.53***
	(0.12)	(0.12)	(0.10)
GDP per capita (log)	-0.65***	0.33***	0.05
	(0.06)	(0.06)	(0.04)
Trade % of GDP (log)	-0.08**	-0.05	0.01
	(0.04)	(0.04)	(0.04)
Resource rents % of GDP (log)	-0.00	-0.00	-0.01**
	(0.01)	(0.01)	(0.00)
Urban population (log)	1.04***	1.02***	0.99***
	(0.11)	(0.12)	(0.11)
Constant	0.93	0.00	-10.05***
	(0.73)	(0.00)	(0.57)
Observations	1,000	1,000	1,019
Number of groups	23	23	23

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 5: The impact of the interactive effect between state ownership and less corruption on renewable energy consumption and eco-innovation (Western industrial democracies)

VARIABLES	(1) Renewable energy % (log)	(2) Eco-patents (log)
State ownership	0.16**	-0.10
	(0.08)	(0.09)
Less corruption	0.79*	2.71***
	(0.40)	(0.64)
State ownership * less corruption	-0.21	0.48
	(0.32)	(0.31)
Electoral democracy	5.72***	0.18
	(1.31)	(0.32)
GDP per capita (log)	-0.25	0.79***
	(0.19)	(0.22)
Trade % of GDP (log)	0.77***	-0.02
	(0.16)	(0.11)
Resource rents % of GDP (log)	0.06	0.05*
	(0.04)	(0.02)
Urban population (log)	-0.50***	2.09***
	(0.15)	(0.51)
Population (log)		1.09***
		(0.08)
Constant	0.00	-29.92***
	(0.00)	(4.38)
Observations	637	1,022
Number of groups	23	23

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 6: The impact of the interactive effect between state ownership and less corruption on renewable energy consumption and eco-innovation (Developing countries)

VARIABLES	(1) Renewable energy % (log)	(2) Eco-patents (log)
State ownership	-0.23***	0.03
	(0.04)	(0.09)
Less corruption	-0.26***	-0.24
	(0.05)	(0.30)
State ownership * less corruption	-0.20***	-0.20
	(0.05)	(0.17)
Electoral democracy	-0.22***	0.44
	(0.07)	(0.27)
GDP per capita (log)	-0.22***	1.06***
	(0.04)	(0.11)
Trade % of GDP (log)	0.05**	0.63***
	(0.02)	(0.09)
Resource rents % of GDP (log)	-0.01	-0.12***
	(0.01)	(0.02)
Urban population (log)	-0.52***	-0.22
	(0.11)	(0.19)
Population (log)		0.81***
		(0.11)
Constant	6.48***	-23.59***
	(0.26)	(2.21)
Observations	3,599	2,118
Number of groups	141	131

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 7: GDP per capita and democracy

VARIABLES	(1) Renewable energy % (log)	(2) Eco-patents (log)
State ownership	-0.09***	0.08**
	(0.02)	(0.04)
Less corruption	-0.15**	-0.14
	(0.07)	(0.25)
GDP per capita (log)	-0.38***	0.85***
	(0.03)	(0.12)
Electoral democracy	-2.24***	-6.28***
	(0.58)	(1.02)
GDP per capita (log) * electoral democracy	0.25***	0.80***
	(0.08)	(0.12)
Trade % of GDP (log)	0.10***	0.49***
	(0.03)	(0.08)
Resource rents % of GDP (log)	-0.01	-0.04**
	(0.01)	(0.02)
Urban population (log)	-0.66***	0.29
	(0.10)	(0.18)
Population (log		0.89***
		(0.11)
Constant	8.12***	0.00
	(0.23)	(0.00)
Observations	4,236	3,140
Number of groups	164	154

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 8: Interactive effect between corruption and democracy

VARIABLES	(1) CO2 per GDP (log)	(2) CO2 per capita (log)	(3) GHG per capita (log)	(4) Renewable energy % (log)	(5) Eco-patents (log)
State ownership	0.06***	0.05***	0.08***	-0.09***	0.11**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)
Less corruption	0.41***	0.41***	-0.80***	-0.49***	-1.56***
	(0.06)	(0.06)	(0.10)	(0.09)	(0.37)
Electoral democracy	-0.06	-0.08	0.82***	0.18*	1.79***
	(0.06)	(0.06)	(0.06)	(0.10)	(0.35)
Less corruption * Electoral democracy	-0.89***	-0.87***	1.36***	0.89***	3.10***
	(0.11)	(0.10)	(0.15)	(0.16)	(0.75)
GDP per capita (log)	-0.34***	0.63***	0.50***	-0.27***	1.26***
	(0.03)	(0.02)	(0.02)	(0.03)	(0.12)
Trade % of GDP (log)	0.06***	0.08***	0.09***	0.12***	0.51***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.08)
Resource rents % of GDP (log)	0.00	0.01	-0.03***	-0.01	-0.03
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Urban population (log)	0.85***	0.84***	-0.12***	-0.71***	0.86***
	(0.10)	(0.09)	(0.03)	(0.11)	(0.25)
Population (log					0.73***
					(0.21)
Constant	0.00	0.00	-9.63***	7.19***	0.00
	(0.00)	(0.00)	(0.19)	(0.28)	(0.00)
Observations	5,996	6,054	6,061	4,236	3,140
Number of groups	162	164	164	164	154

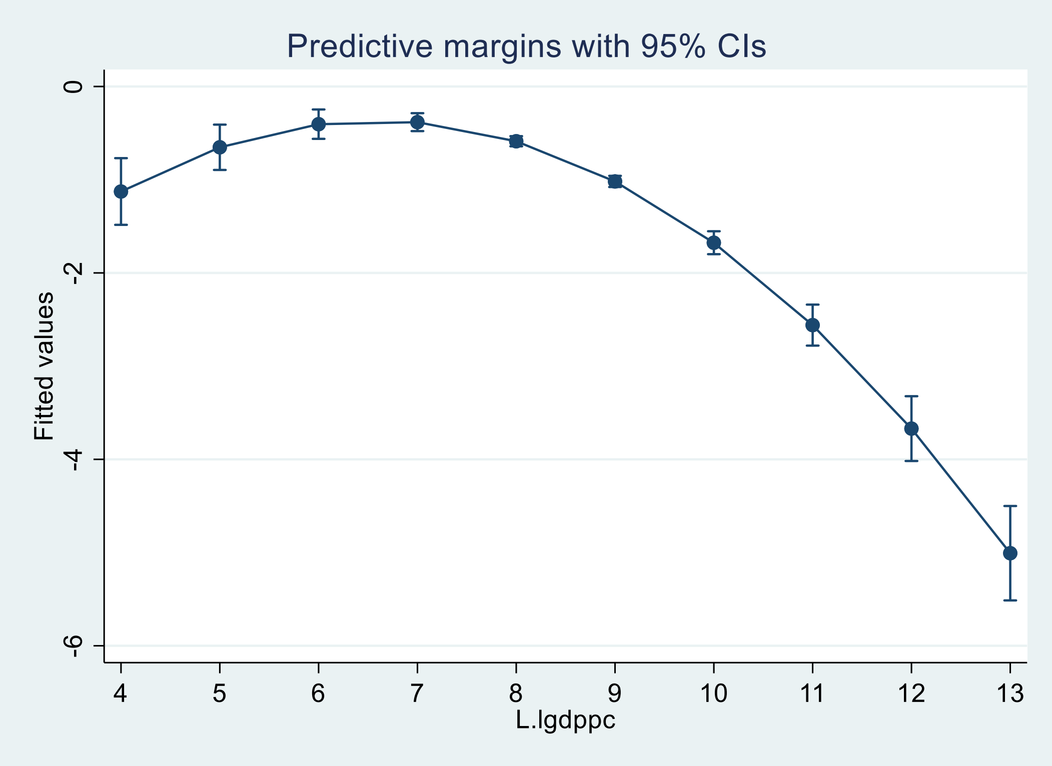
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 9: Testing for EKC

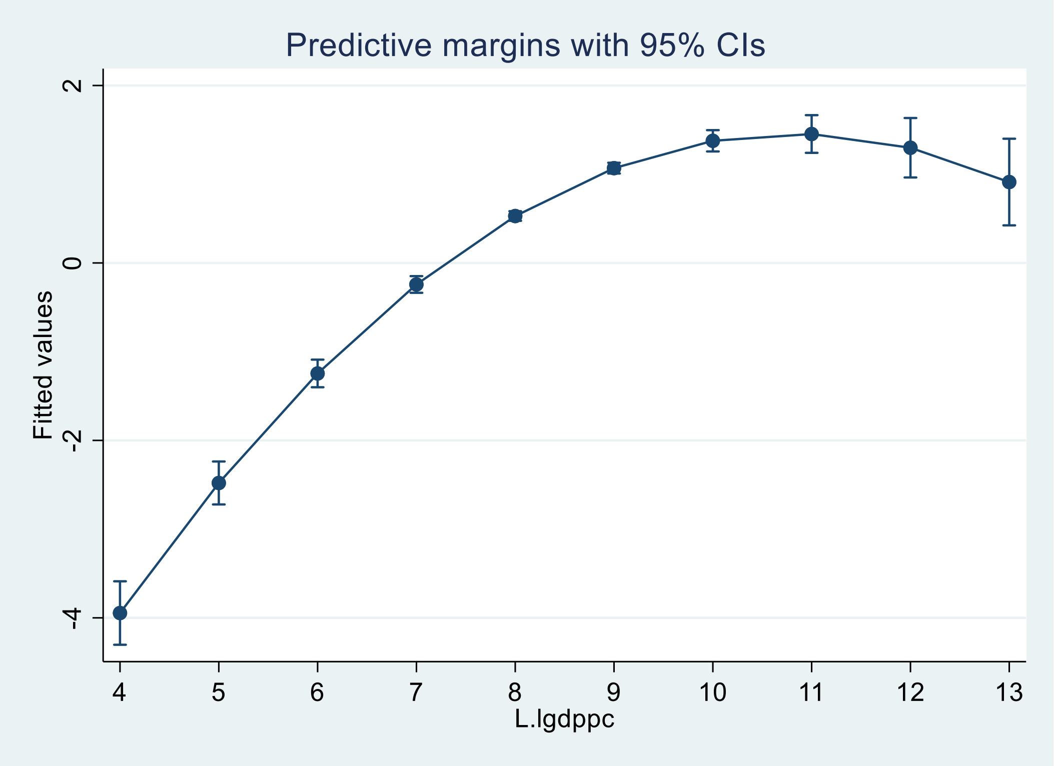
VARIABLES	(1) CO2 per GDP (log)	(2) CO2 per capita (log)	(3) GHG per capita (log)	(4) Renewble energy % (log)	(5) Eco-patents (log)
State ownership	0.08***	0.07***	0.10***	-0.11***	0.07*
	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)
Less corruption	0.27***	0.29***	-0.29***	-0.15**	-0.02
	(0.06)	(0.05)	(0.07)	(0.06)	(0.26)
Electoral democracy	0.29***	0.27***	0.14***	-0.28***	0.59***
	(0.04)	(0.03)	(0.04)	(0.08)	(0.21)
GDP per capita (log)	1.49***	2.51***	1.06***	-1.89***	0.18
	(0.14)	(0.14)	(0.14)	(0.26)	(0.48)
GDP per capita (log) * GDP per capita (log)	-0.11***	-0.12***	-0.03***	0.10***	0.06**
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
Trade % of GDP (log)	0.04**	0.07***	0.07***	0.11***	0.52***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.08)
Resource rents % of GDP (log)	-0.01	0.00	-0.03***	-0.01	-0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Urban population (log)	0.63***	0.63***	-0.21***	-0.48***	0.13
	(0.09)	(0.09)	(0.05)	(0.11)	(0.23)
Population (log					0.90***
					(0.11)
Constant	-7.76***	-14.68***	0.00	13.10***	0.00
	(0.43)	(0.42)	(0.00)	(0.64)	(0.00)
Observations	5,996	6,054	6,061	4,236	3,140
Number of groups	162	164	164	164	154

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

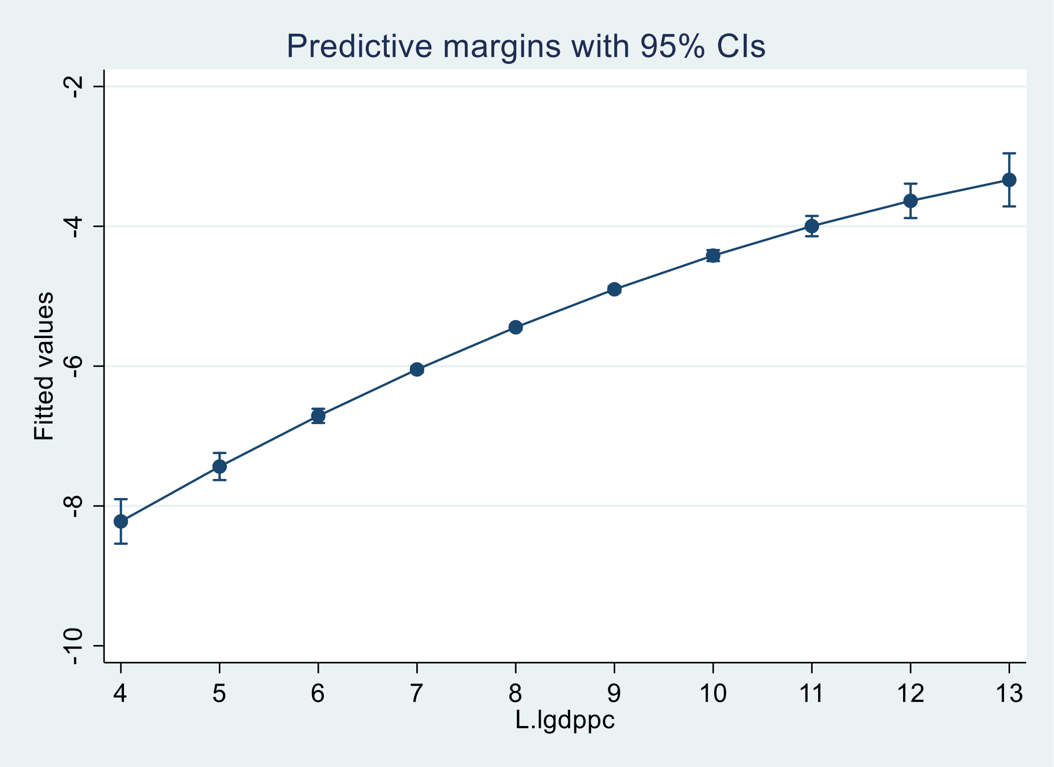
Appendix 10.1: Curvilinear effect of the quadratic effect of GDP per capita with CO2 per GDP as the dependent variable



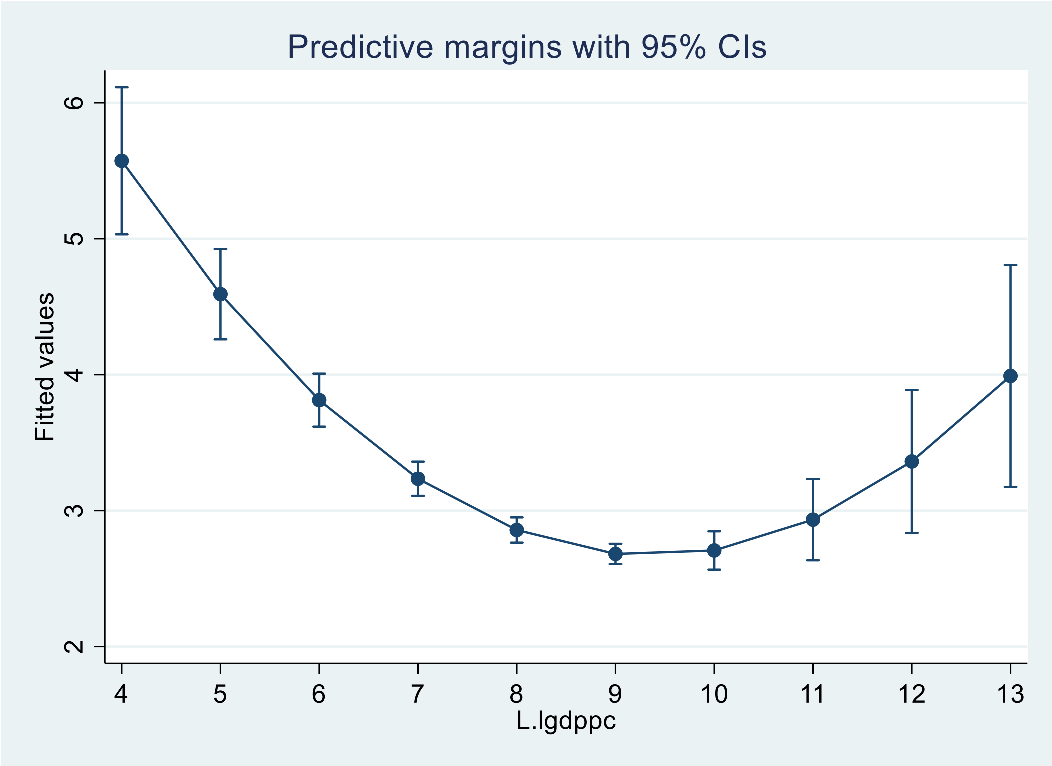
Appendix 10.2: Curvilinear effect of the quadratic effect of GDP per capita with CO_2 per capita as the dependent variable



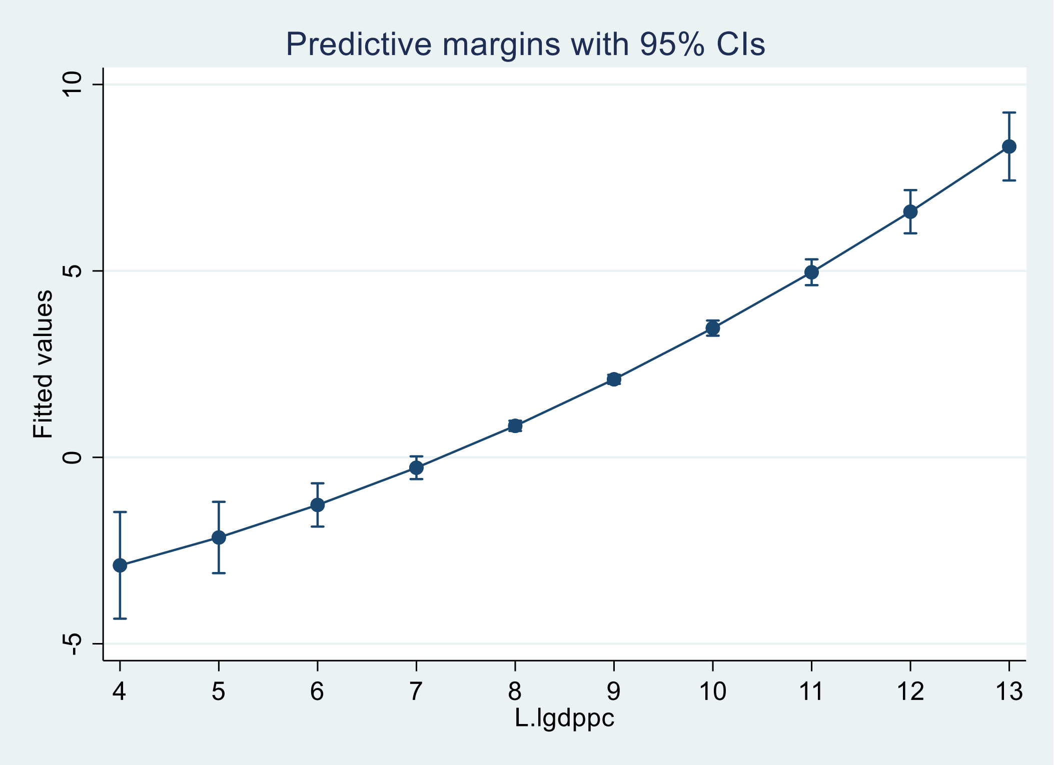
Appendix 10.3: Curvilinear effect of the quadratic effect of GDP per capita with GHG per capita as the dependent variable



Appendix 10.4: Curvilinear effect of the quadratic effect of GDP per capita with renewable energy consumption as the dependent variable



Appendix 10.5: Curvilinear effect of the quadratic effect of GDP per capita with Eco-innovation as the dependent variable



Appendix 11: Testing for EKC and interactive effect between state ownership and electoral democracy

VARIABLES	(1) CO2 per GDP (log)	(2) CO2 per capita (log)	(3) GHG per capita (log)
State ownership	0.11***	0.09***	0.17***
	(0.01)	(0.01)	(0.01)
Electoral democracy	0.25***	0.24***	0.06
	(0.04)	(0.04)	(0.05)
State ownership * electoral democracy	-0.08**	-0.07**	-0.19***
	(0.03)	(0.03)	(0.03)
Less corruption	0.24***	0.27***	-0.36***
	(0.06)	(0.05)	(0.07)
GDP per capita (log)	1.53***	2.55***	1.17***
	(0.13)	(0.13)	(0.14)
GDP per capita * GDP per capita (log)	-0.12***	-0.12***	-0.04***
	(0.01)	(0.01)	(0.01)
Trade % of GDP (log)	0.04**	0.07***	0.06***
	(0.02)	(0.02)	(0.02)
Resource rents % of GDP (log)	-0.00	0.00	-0.03***
	(0.01)	(0.01)	(0.01)
Urban population (log)	0.64***	0.64***	-0.17***
	(0.09)	(0.09)	(0.04)
Constant	0.00	0.00	-11.95***
	(0.00)	(0.00)	(0.50)
Observations	5,996	6,054	6,061
Number of groups	162	164	164

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 12: Robustness test with ECF

VARIABLES	(1) Ecological footprint
State ownership	0.08***
	(0.01)
Less corruption	-0.09*
	(0.05)
Electoral democracy	0.22***
	(0.03)
GDP per capita (log)	0.11***
	(0.02)
Trade % of GDP (log)	-0.02
	(0.02)
Resource rents % of GDP (log)	0.00
	(0.01)
Urban population (log)	0.44***
	(0.03)
Constant	13.80***
	(0.15)
Observations	5,981
Number of groups	160

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 13: Robustness test with ECF and interactive effect between state ownership and less corruption

VARIABLES	(1) ecological footprint
State ownership	0.18***
	(0.01)
Less corruption	-0.10*
	(0.06)
State ownership * less corruption	0.21***
	(0.01)
Electoral democracy	0.21***
	(0.03)
GDP per capita (log)	0.14***
	(0.02)
Trade % of GDP (log)	-0.02
	(0.02)
Resource rents % of GDP (log)	-0.00
	(0.01)
Urban population (log)	0.37***
	(0.03)
Constant	0.00
	(0.00)
Observations	5,981
Number of groups	160

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

Appendix 14: Robustness test with ECF and interactive effect between state ownership and electoral democracy

VARIABLES	(1) Ecological footprint
State ownership	0.04***
	(0.01)
Electoral democracy	0.28***
	(0.03)
State ownership * electoral democracy	0.14***
	(0.04)
Less corruption	-0.03
	(0.04)
GDP per capita (log)	0.11***
	(0.02)
Trade % of GDP (log)	-0.02
	(0.02)
Resource rents % of GDP (log)	-0.00
	(0.01)
Urban population (log)	0.39***
	(0.03)
Constant	0.00
	(0.00)
Observations	5,981
Number of groups	160

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
(Year fixed effects estimated)
(All x variables lagged one year)

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