Is Climate Action Dependent on Economic Prosperity?
Empirical Evidence from Global Data Analysis

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Abstract

Climate action, a fairly vague term, can range from recycling waste to international trade policies. Various factors can affect the level of climate action. Undoubtedly, with more financial resources there are wider possibilities to act, but is that the case? In this research, I look at the influence of economic development on climate action variables by considering a maximum of 159 nations. By establishing a simple cross-sectoral climate action model, considering the level of environmental trade, innovations, taxation, and fossil fuel subsidies, I develop a dataset for bivariate and multivariate analyses. I find the level of economic development (GDP per capita) has a significant positive impact on climate action variables, while also having a significantly positive relationship with the level of fossil fuel subsidies. Additionally, higher levels of democracy, climate vulnerability, and lower income inequality can be beneficial factors for increased climate action. Unfortunately, when such confounding variables are included in multivariate analysis, economic development occasionally shows reduced significance. In general, there is considerable evidence that GDP plays a significant role in determining the level of climate action. This link should not be abandoned in theoretical and empirical research when considering the importance and influence of economic development on the environment.

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Introduction

Nowadays, the interaction between climate change, climate actions, and economic growth is a widely discussed topic. For instance, Stern and Stiglitz (2023) recently discussed how addressing climate change can enhance economic growth. At the same time, alternative economic ideas such as degrowth have gained traction arguing that abandoning GDP as a goal will allow for a more efficient allocation of resources towards wellbeing and the environment (Hickel et al., 2022). Moreover, green growth has been introduced to argue that an increase in GDP is valuable if it constitutes an even larger decrease in greenhouse gas (GHG) emissions, achieving rapid decoupling to meet Paris Agreement commitments (Vogel & Hickel, 2023). Undoubtedly, climate action is important to address the consequences of high-intensity usage of fossil fuels, which are the main sources of carbon emissions (van Asselt & Green, 2023). However, the level of climate action might also depend on economic prosperity through higher financial resources, technological capabilities, and tax revenues (Recchia, 2002). Additional influential factors in determining the level of climate action can be environmental awareness, existing institutional frameworks for climate action implementation, or values connected to financial resource allocation[1] (Seelarbokus, 2014).

This research aims to understand if economic growth only degrades the environment or whether economic growth can also play a role in tackling climate change impacts. The consequences of GDP growth on climate change can be seen already as increases in global temperatures and the rise of extreme weather events. However, the result of efforts to reduce harmful GHG emissions might only be seen in decades (Denning, 2018; Fiorino, 2011). Undoubtedly, current climate action plans remain insufficient (UNFCCC, 2022). Yet, the link between economic growth and climate action is overlooked by mainstream academia while

[1] Assuming that these factors are associated with economic prosperity from theoretical frameworks (see Jänicke, 2005; Recchia, 2002; Seelarbokus, 2014; Shaffik, 1994).

considering the current climate change research environment. I see this link as the essence of modern debates on action for climate change mitigation. Especially since climate action is a concept difficult to clearly define, estimate, and measure. Therefore, perceptions of both the motivators and outcomes of climate action differ. Analyses can generate unclear and controversial results for which most approaches consider unclear indicators and a small range of economically similar countries. Thus, in my research, I will answer the research question: "What is the effect of economic development on climate action variables on a global scale?". To answer this question, I will conduct an extensive literature review and generate a bivariate and regression analysis dataset.

In Section 1 I will be analyzing the existing literature for theoretical and empirical background. Section 2 will focus on building and justifying the climate action model considered in this research through existing models. Section 3 will expand on the model considered in this research while Section 4 will examine the properties of the data and the bivariate analysis. Section 5 will state the results of regression analyses. Section 6 will discuss the results linking them to the existing literature and conclude the research.

1. Theoretical and Empirical Background

In the following section, I will define climate action, which is crucial for theoretical understanding and building a framework. Then, I will introduce how economic development and climate are often linked through environmental quality. Furthermore, I will show the theoretical and empirical link between economic growth and environmental (climate) actions, essential for answering my research question. Lastly, I will look at other independent factors that tend to have a strong influence on climate action in the literature.

To examine the effects of economic development on climate action, first, a thorough understanding of the definition of climate action is needed. There are countless climate action definitions, and I will consider several perspectives to determine a more inclusive one. Under European Union (EU) law, climate action refers to “efforts taken to combat climate change and its impacts” (EUR-Lex, n.d.). It defines climate action from reducing GHG emissions (mitigation) to acting such as preparing and adjusting for climate change impacts in the future (adaptation). According to the Latin American climate action platform (ActionLAC), climate action is “any policy, measure, or program that reduces greenhouse gases, builds resilience to climate change, or supports and finances those goals” (ActionLAC, 2016). The definition by ActionLAC adds an important element to the EU law definition: financing, a crucial part of developing functional policies. A more elaborative definition is used in the “Close the Gap Foundation” platform, in which climate action “refers to a series of strategies, policies, and initiatives aimed at reducing greenhouse gas emissions, transitioning to low-carbon and renewable energy sources, enhancing climate resilience, and promoting sustainable practices to combat climate change” (Close the Gap Foundation, n.d.). I will use the Close the Gap definition as the most elaborative for this paper. It includes an essential element of climate change: the transfer to low-carbon technology and renewable energy sources (van Asselt & Green, 2023).

While understanding the definition of climate action is necessary for interpretation and modeling, the primary view on the link between the economy and the environment should be discussed. Since the Industrial Revolution, economic expansion has been coupled with GHG emissions (Haberl et al., 2020). Furthermore, economic development and exploitation of natural resources cause several environmental issues such as large increases in pollution, levels of deforestation, and harmful waste (Shafik, 1994). At the same time, it is also responsible for the rise of private corporate organizations and interests, which leads to destructive consumption and capital accumulation (Koch & Fritz, 2014; Recchia, 2002). Research on the relationship between environmental quality indicators and income has revealed a basis for the econometric calculation of an inverted U-shaped relationship known as the environmental Kuznets curve (EKC) (Ekins, 1997). The EKC proposed that the relationship between income and the level of environmental degradation shifts from negative to positive as countries rise over middle-income levels. It indicates that economic growth would eventually reduce the level of environmental degradation. Yet, EKC results should be interpreted cautiously because the econometrical results are weak and relative to the indicators used. Shafik (1994), for instance, finds that higher incomes can be associated with less degradation only if environmental quality directly affects human welfare. When the costs of environmental damage can be externalized, income growth results in steady degradation. Yet, EKC also does not consider the effects of increased income and consumption on future generations (Ekins, 1997). Only some indicators for air pollution support the EKC hypothesis, with the "most plausible, or least unconvincing" being the level of NO_{2x}, CO, SO_2 (Ekins, 1997; Stern, 2004). As a result, EKC is viewed with skepticism and it is doubtful that countries follow a common, U-shaped trajectory as their income increases (Fiorino, 2011; Stern, 2004). Although there might not be a concrete U-shaped link between income and environmental quality, there are clear patterns between environmental indicators and economic growth (Shafik, 1994).

Theories such as the EKC focus on environmental degradation, yet this study focuses on the extent or efforts to which economic prosperity exhibits increased climate action. Fortunately, some theories linking economic development to climate action have been established by academics. I will consider three main theoretical links: economic development produces monetary and non-monetary advances, changes in attitude toward climate action, and the conflict between socioeconomic and environmental needs in developing nations.

Recchia (2002) proposes structural constraint theory for international environmental agreements. It contends that economic development can produce financial resources, technological capabilities, and tax revenues that can then be used to protect the environment. Wealthier countries are also predicted to have a financially comfortable population willing to devote resources to environmental protection (Fuest et al., 2023; Jänicke, 2005; Lenschow et al., 2005; Recchia, 2002). Since further economic gains and accumulation have declining value due to falling marginal utility, non-economic benefits such as environmental protection and climate action tend to be appreciated and increasingly demanded (Recchia, 2002). Therefore, economically prosperous countries would have more economic resources value for investing in non-economic benefits.

Not only economically more developed countries have more means for climate action, but also developed nations should appreciate environmental quality more. Seelarbokus (2014) proposes that since developing countries can tolerate more environmental hazards, they would be less willing to pay for additional environmental quality. At the same time, the developed nations would consider it a necessity. Therefore, developed countries should have a population that is increasingly environmentally conscious, aware, and active (Jänicke, 2005). Assuming, that political players use the tactic of pleasing domestic public opinion to maintain power and stability, developed countries should be more involved in climate action (Seelarbokus, 2014). Of course, many low-income societies such as tribal peoples also highly value environmental conservation (Davis, 1992). So, it might not be a question of contrasting preferences, but rather one of the different budget constraints and levels of industrialization (Shaffik, 1994). Empirical research also suggests that income correlates positively with a country's readiness to sign international environmental agreements, with wealthier countries ratifying more agreements (Neumayer, 2002; Roberts et al., 2004). Thus, the theoretical models stand unclear on the value of environmental quality between different income levels. Between industrialized countries, the higher-income countries tend to have a higher environmental awareness in the population, and political powers are expected to act on it to maintain power.

While lower-income societies might also value environmental conservation, a conflict in developing nations on the use of financial means is crucial in determining this relationship. In higher-income countries sustainable development, which includes climate action, is perceived as “meeting the needs of the present generation without compromising future generations' ability to meet their own needs" (United Nations Brundtland Commission, 1987). At the same time, in the lower-income nations, it elevates to a level of conflict between meeting basic socioeconomic needs of sustenance, such as food, clothing, and housing, and sustainable development (Seelarbokus, 2014). Naturally, developing economies are more likely to avoid measures that inhibit economic growth (Recchia, 2002). This is also noticeable in the lack of existing institutional and legal frameworks for climate policy implementation and the lack of expertise, and governmental capacity, to act on environmental issues (Seelarbokus, 2014). Hence, an effective resource allocation based on socioeconomic sustenance needs can prevent developing countries from exercising climate action.

Empirical research has also provided support for the theoretical frameworks. Over the last decade, certain high-income countries have demonstrated the feasibility of decoupling CO2 emissions from GDP (Ritchie, 2021). However, this trend is not observed in less-developed nations (Vanegas Cantarero, 2020). According to Liefferink et al. (2009), there is evidence that economic development has a considerable impact on environmental policy. Specifically, higher economic development is associated with a smaller difference between a country's existing climate policy and the strictest policy possible. However, membership in the EU appears to have a stronger influence. Unfortunately, Liefferink et al. (2009) also find that when confounding variables are included in multivariate analysis, economic development shows reduced significance by exhibiting weaker explanatory power, consistent with Shaffik’s (1994) results. Furthermore, Puertas and Marti (2021) attempt to identify homogenous groupings of countries using the pillars of the Climate Change Performance Index (CCPI) and GDP per capita. Unfortunately, by trying to identify similar commitments to climate action within groups of countries with similar economic development, the cluster analysis produces controversial results, such as placing India in a high-ranked climate performance cluster alongside Switzerland. While India shows some positive progress and is placed high by the CCPI index, it is still the world's third-largest producer of GHG emissions, questioning the validity of these results (Pueartas & Marti, 2021). On the other hand, Jakučionytė-Skodienė & Liobikienė (2021) found a positive and significant relationship between climate change mitigation activities and economic development. This study focuses on EU-scale and qualitative research based on individual behavior, concluding that richer countries have greater economic capacity to execute climate-friendly, but costly measures. Similarly, Schmidt and Fleig (2018) find that countries with higher GDP per capita and membership in the EU have more comprehensive climate policies based on purely enumerative indicators such as the number of topics covered. However, Grant and Kelley (2008) point out that such an enumerative technique is prone to errors. Overall, there is some empirical evidence through various methods that a link between economic development and climate action exists. Yet, a clear statistical analysis is often missing due to the hardship of measuring climate action, which is why this link is explored in this study.

Lastly, it is necessary to discuss what other factors influence the level of climate action apart from economic development. For instance, Ylä-Anttila et al. (2018) argue that the smaller economic weight of the fossil fuel industry is crucial in determining the level of climate action. At the same time, Mahdavi et al. (2022) find that fossil fuel taxes and subsidies are driven by the country's fiscal needs instead of environmental commitments. Furthermore, income equality is associated with less pollution in perfect democracies (Eriksson & Persson, 2002). Scruggs (1998) argues that more income inequality will result in lower degradation of the environment because the poor will have less access to consumption opportunities. De Soysa (2021) supports this view with empirical research while also finding that greater democracy seems to hurt environmental sustainability. Neumayer (2002) finds that democracies place a greater land area under preservation and show higher participation and commitment rates with environmental agreements. A perspective of social inequality is brought by Cushing et al. (2015), who argue social inequality negatively impacts the environment through asymmetries in political power. Lower rates of climate action are caused by increasing the environmental intensity of society’s consumption or decreasing social cohesion and willingness to cooperate. Similar research has identified highly varied influences on climate policy in terms of other independent factors. Overall, increased climate action/better environmental performance has been observed under the effect of:

- Political characters:
  - Left-wing government (Tobin, 2017), or lower strength of green parties (Koubi & Bernauer, 2008);
  - Presidential systems (Koubi & Bernauer, 2008);
  - Close links/membership of the EU (Liefferink et al., 2009; Schmidt & Fleig, 2018; Tobin, 2017);
  - Fewer political strains (Tobin, 2017);
  - Increased level of democracy (Bättig & Bernauer, 2009; Koubi & Bernauer, 2008; Hammond & Smith, 2017; Neumayer, 2002; Ylä-Anttila et al., 2018), or reduced level of democracy (de Soysa, 2021);
- Non-political characters:
  - Small economic weight of the fossil fuel industry (Ylä-Anttila et al., 2018);
  - Existence of a national science community and national culture of science (Ylä-Anttila et al., 2018);

- Higher income inequality (Gini coefficient) (de Soysa, 2021; Scruggs, 1998), but also increased strength of labor unions (Koubi & Bernauer, 2008), or higher income equality under perfect democracy (Eriksson & Persson, 2002);
- Higher social equality (Cushing et al., 2015), or higher social inequality (Grafton & Knowles, 2004);
- Higher climate vulnerability and extreme weather events (Peterson, 2021), but vulnerability might also be irrelevant (Christoff & Eckersley; 2011).

Altogether, the outcomes of empirical research on the dependency of the level of climate action on either economic development or other factors vary depending on the sample, data method, and model used. Increased economic development may result in a higher level of climate action, influenced by other supporting factors. As demonstrated by theoretical models and empirical studies, the progress of economic growth and increased climate action can allow for the decoupling of economic growth and GHG emissions depending on the policies adopted. Of course, there are numerous counterarguments to this viewpoint. For example, if economic expansion is desirable, it contradicts the motivation to minimize material footprint or carbon intensity, both of which have a positive effect on GDP (Nature Editorials, 2023). Despite such counterarguments, economic growth and tackling climate change could not be completely incompatible and, therefore, this link will be further explored in this study.

2. Measuring Climate Action

While the literature adds valuable understanding of links on how economic development and other factors influence environmental quality and (climate) actions, measuring climate actions is complicated. The measurements of climate action are countless and increasingly more complicated. For instance, the seemingly most popular climate action measurement is the Climate Change Performance Index (CCPI), also used in the study by Pueartas & Marti (2021).

The CCPI index is available for 59 economies and has valuable indicators in such areas as GHG emission trends, energy use, renewable energy, and climate policy. Yet, it also omits a large portion of countries for lack of data, having a trade-off for more comprehensive data but losing data availability (Uhlic, 2023). Frequently, such indicators include climate action targets or progress towards those, which is relevant, but not an objective measurement because it is not based on existing action but on vision. In this way, most climate action indicators and trackers mix the measurement steps, which Hale et al. (2019) separate into goals, inputs, and outcomes. For this, some theoretical models have also been criticized (see Scruggs, 2003 critique on Jänicke, 2005). By clearly separating climate actions it is possible to dissect this complicated task of measuring climate action for clear interpretation purposes. Therefore, such indicators can be useful in overall country ranking, yet can add little to understanding the relationship between clear independent variables such as economic development and climate action.

Nevertheless, the common areas that the indicators focus on (excluding targets and projections) are GHG emissions (trends or absolute), climate finance, and energy production policies. A similar approach can be seen through the classification of the Climate Actions and Policies Measurement Framework (CAPMF), which offers a clear framework for climate action measurement (OECD, 2024). The framework considers measuring sectoral, cross-sectoral, and international policies, which compile a cumulative CAPMF index. The common areas discussed by the climate action/environmental performance indicators respond to the cross-sectoral policy part of the CAPMF index, which includes GHG emission targets, public research and development (R&D) expenditure, fossil fuel production policies, climate governance, and climate finance (not yet covered in CAPMF) (Nachtigall et al., 2024). This also reflects the targets of this study, as cross-sectoral policies can be more representative of the climate action environment in a particular country without having to contextualize the policies for each sector[2]. Such an approach also allows including a larger variety and sample of countries as there is a possibility to have a model that is simpler for data availability, yet has a larger scope, covering larger climate action pillars.

Based on the common indicators by the existing climate change indexes and the CAPMF cross-sectoral index sections, an indicator per each of the common themes was assigned. Because this research aims to consider a larger variety of nations covered, the data availability has a large impact on the climate action indicators chosen for each cross-sectoral field covered. The data availability was examined through the available datasets in established sources such as the OECD, the World Bank, Our World in Data, IMF, and SDG databases. The choice of an indicator not only was based on the data availability but also the representative power of the respective sector. Altogether, a total of 4 indicators were chosen to represent this cross-sectoral climate action model. The allocated indicator for the theme of public R&D expenditure is the "Development of environment-related technologies (innovations), per capita". Although it does not represent the direct public expenditure, the scientific community's input is representative of the field and public R&D expenditure (Satrovic et al., 2021). Furthermore, the allocated indicator of fossil fuel production policies is the "Fossil fuel subsidies", which, although representing both subsidies on consumption and production, has a wider range on the fossil fuel policy in the nation. Of course, such a variable is not directly associated with higher climate action, therefore, an inverse climate action variable is expected to have a negative relationship with economic growth in this research. Climate governance is illustrated by "Total trade of low-carbon technology" which allows the consideration of international interconnection between the countries (as well as policies) for increased trade and use of low-carbon trade items

[2] The GHG emissions targets will be omitted from this study since it is not representative of absolute climate *actions*, but has more of a visionary power relative to each country, as it tells very little about policy commitment and output (Christoff & Eckersley, 2011).

(Neumayer, 2002; Roberts et al., 2004). Lastly, the climate finance indicator is "Environmentally related tax revenue" which incentivizes society for environmentally friendlier choices and collects the financial means for beneficial financialization projects.

These indicators nicely tie together with the climate action definition used in this research[3]. The "series of strategies, policies, and initiatives aimed at reducing GHG emissions" respond to all indicators. At the same time the "transition to low-carbon technology" refers to the trade of low-carbon technology and environmentally-related innovations. Furthermore "transfer to renewable energy sources" is tied with fossil fuel subsidies (or therefore lack of them). "Enhanced climate resilience" is tied with low carbon technology trade and environmentally-related innovations. Lastly, all indicators respond to "promoting sustainable practices to combat climate change".

3. Models and Variables

Based on the indicator framework for climate action, some confounding variables must be noted. Because of the empirical literature review, which has very mixed results with a wide variety of confounding variables, I will consider a concise theoretical study of Christoff & Eckersley (2011) in Oxford's Handbook of Climate Change and Society. It is hard to devise a single metric to provide the basis for comparing state performance for all states and with more parameters it is hard to make judgments about the performance. Yet, Christoff & Eckersley argue that analysis of state responses can depend on multiple factors apart from economic growth: general regime type, the character of political institutions, national interests, national discourses, strategies of accumulation, and domestic actors. Out of these, the last three are very

[3] "Series of strategies, policies, and initiatives aimed at reducing greenhouse gas emissions, transitioning to low-carbon and renewable energy sources, enhancing climate resilience, and promoting sustainable practices to combat climate change" (Close the Gap Foundation, n.d.).

hard to measure in a numeric value. Therefore, the confounding variables in this study will consist of:

- The Gini index, as a part of the general regime type is expected to have a negative coefficient with climate action variables. The bigger the income inequality, the less climate action is expected (Koubi & Bernauer, 2008; Eriksson & Persson, 2002).;
- The democracy index, as a part of the character of political institutions is expected to have a positive effect on climate action variables. With higher democracy index more climate action is expected (Bättig & Bernauer, 2009; Hammond & Smith, 2017; Ylä Anttila et al., 2018).;
- Deaths and missing from national disasters, as part of national interests are expected to have a positive effect with climate action variables. With more deaths and missing from national disasters, more climate action is expected (Peterson, 2021).

Table 1 below presents all variables included in my analysis (dependent, independent, controls), their names, abbreviations for the regression models, descriptions, and sources. To estimate the effect of economic development on climate action, I will use the following regression model:

$$\mathrm{CA_i} = \beta_0 + \beta_1 \log(\mathrm{GDP_i}) + \gamma' \mathrm{X_i} + \varepsilon_i$$

In the model my dependent variable is the climate action (CA_i), and my main independent variable the logarithmic value of GDP per capita *($log(GDP_i)$).* X denotes a set of control variables added sequentially to my model (see Section 5 and Table 4 for the results of my empirical analysis). i denotes the country, β_0 is the intercept, $\beta_1$the regression coefficient of my main independent variable, and γ the set of regression coefficients for the control variables of the model. ε is the error term. All data refer to the year 2018. This is to capture the probably

Table 1

Variables used in this research

Type of variable	Acronym	Full name	Description[a]	Source
Dependent	TRA	Total trade of low carbon technology (% of GDP), log	Measuring the sum of low carbon technology product exports and imports. Low-carbon technologies include mechanics like wind turbines, solar panels, biomass systems, and carbon capture equipment.	International Monetary Fund Climate Change Dashboard (IMF, 2024)
	INN	Development of environment-related innovations (per capita), log	Measuring inventive activity using patent data across a wide range of environment-related technological domains, including environmental management, water-related adaptation, and climate change mitigation technologies. The counts used here include only higher-value inventions (patent family size=2).	Technology development dataset of the OECD Environment Database (OECD 2024a)
	TAX	Environmentally related tax revenue, (% of GDP)	Measuring the sum of four mutually exclusive tax base categories: energy products (e.g. fossil fuels and electricity); transport (e.g. registration or use of motor vehicles); pollution (e.g. SOx and NOx emission taxes); resources (e.g. hunting and fishing taxes).	OECD database "Policy Instruments for the Environment (PINE)" (OECD, 2024b)
	SUB	Fossil fuel subsidies (% of GDP), log	Measuring pre-tax subsidies (consumption and production) on fossil fuels as an index of USD per capita.	Country Climate and Development Report (World Bank, 2024)
Main independent	GDP	GDP per capita (current USD), log	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.	World Bank national accounts data and OECD National Accounts data files (World Bank, 2023)
Control	GINI	Gini index	The Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality.	World Bank, Poverty and Inequality Platform (World Bank, 2021)
	DEM	Democracy index	The Democracy Index is based on 60 indicators, grouped into five categories: electoral process and pluralism, civil liberties, functioning of government, political participation, and political culture. Countries are given a rating on a zero (least democratic) to ten (most democratic) scale, and the overall index is the average of the five total category scores.	Economist Intelligence Unit; Our World in Data (Economist Intelligence Unit, 2023)
	DAM	Number of deaths and missing persons attributed to disasters, log [b] (per 100,000 population)	This indicator measures the number of people who died, went missing, or were directly affected by disasters per 100,000 population. Directly affected: people who have suffered injury, illness, or other health effects; who were evacuated, displaced, relocated, or have suffered direct damage to their livelihoods, economic, physical, social, cultural, and environmental assets.	United Nations SDG database (United Nations, 2023)

Note: The table displays the variables used in this research. The columns represent the type of variable, the acronym used in analysis, the full name, the description, and the source of data.

[a] Descriptions taken from metadata of the respective database.

[b] Since the data includes many null-values, logarithmic transformation is done through the

use of $log(Y + c)$ with Y as the observation and $c = 0.1$ (This approach has commonly been used in research encountering similar issue (Chen & Roth, 2023) . Robustness has been assessed with original values for DEM variable with no logarithmic transformation, yielding the same results.

more representative pre-COVID period. Also, most of the variables used in the analysis have a sufficient/large number of observations for that year.

4. Data

The following section will focus on the descriptive statistics of the dataset. Firstly, I will discuss the summary statistics of the gathered data. As many intricate relationships exist between the variables used, I will also look at the correlation matrix considering bivariate analysis for all variables. Lastly, I will discuss the scatterplots with linear trends between economic development and all climate action variables.

Table 2 represents summary statistics for variables considered in this research. The main independent variable GDP per capita ranges from 5.4 (Burundi, equal to 232.06 US$) to 12.2 Monaco, equal to 193968.09 US$) with 203 observations. With the logarithmic transformation, the GDP per capita

Table 2

Summary statistics

Type of variable	Variable	Unique (#)[a]	Mean	SD	Min	Median	Max
Main independent	GDP	203	8.9	1.5	5.4	8.8	12.2
Dependent	TRA	160	0.4	0.8	-2.3	0.3	2.8
	INN	100	-0.1	2.4	-4.6	-0.2	4.6
	TAX	91	1.6	1.1	0.0	1.4	6.2
	SUB	126	3.9	1.5	-0.2	4.0	7.4
Control	DEM	144	5.5	2.2	1.4	5.7	9.9
	GINI	74	35.8	6.8	24.6	35.2	53.9
	DAM	82	-1.0	1.4	-2.3	-1.5	4.4

Note: The table shows summary statistics for variables used in this research.

[a] Unique number of observations respond to the original number of observations for each variable as found in the dataset. It does not respond to the number that enters the regressions.

variable employs normal distribution.

The dependent variables have considerably fewer observations, with the TAX variable having the lowest number of observations (n=91). There are negative values for variables TRA, INN, and SUB observed because of the logarithmic transformation, which normally distributes the data. The level of environmental trade (TRA) ranges between -2.3 (Afghanistan, equal to 0.10 % of GDP) and 2.8 (Hong Kong, equal to 15.93% of GDP). There is a wide distribution in the level of environmental innovations, with the smallest values observed in countries such as Tanzania, Mali, and Jordan (<0.2 innovations per capita). The highest value for environmental innovations is for the Republic of Korea (96.57 innovations per capita). Furthermore, the average environmental tax revenue is 1.4% of GDP. Mozambique and Thailand have reported no environmental tax revenues, while the highest value is in the Solomon Islands (6.17% of GDP). The lowest level of fossil fuel subsidies is reported in Afghanistan (0.83% of GDP) while the highest is reported in Kuwait (1714.25% of GDP). These data points show the wide range of climate action levels and countries covered in the data set.

Moreover, there are considerably fewer observations for GINI and DAM variables which can impact the regression analysis results. By having fewer mutual observations, the regression can result in poorly estimated models with large standard errors. All of the control variables are normally distributed as the DAM variable has a logarithmic transformation. The democracy index ranges from 1 to 10, with the lowest value of 1.4 estimated in the Syrian Arab Republic, while the most democratic country is estimated to be Norway, with a score of 9.87. Similarly, the Gini index ranges from 1 to 100, with the highest income equality in Slovenia (24.6), while the highest income inequality is observed in Brazil (53.9). The level of deaths and missing persons attributable to natural disasters has mostly small values, while the highest one is observed in Kiribati (77.7 per 100000 inhabitants).

Overall, there is a wide coverage of data used in this analysis. To display the coverage, Figure A1 in the Appendix shows the maximum amount (159) of countries included in any multivariate analysis (see Section 5), covering extensive samples from all continents. Some countries are not covered due to data availability. Figure A2 in the Appendix shows the minimum number of countries covered in any regression, still including representative samples from all continents.

Further analysis includes a correlation matrix between all variables considered in this study (Table 3)[4]. As argued in this paper, GDP is associated with being beneficial to the level of climate action. However, GDP exhibits a positive correlation with all the dependent climate action variables, including the level of fossil fuel subsidies (.42). A strong positive correlation is shown between environmental innovations and GDP (.87). Moreover, economic development also has a positive relationship with the level of democracy (.63). At the same time GDP has a

Table 3

Correlation matrix

	GDP	DEM	GINI	DAM	TRA	INN	TAX	SUB
GDP	1	.	.	.	.	.	.	.
DEM	.63	1	.	.	.	.	.	.
GINI	-.32	-.17	1	.	.	.	.	.
DAM	-.33	-.10	.16	1	.	.	.	.
TRA	.41	.33	-.49	-.12	1	.	.	.
INN	.87	.64	-.39	-.25	.45	1	.	.
TAX	.40	.52	-.44	-.16	.29	.45	1	.
SUB	.42	-.04	-.21	-.18	.17	.02	.19	1

Note: Table displays data of correlation analysis between two variables. The abbreviation explanations can be found in Table 1.

[4] Additional confounding variables such as level of corruption and political stability were considered for the statistical analysis. However, they were removed from the model due to high correlation with the main independent variable (≥0.7).

negative relationship with income inequality (-.32) and deaths and missing from natural disasters (-.33).

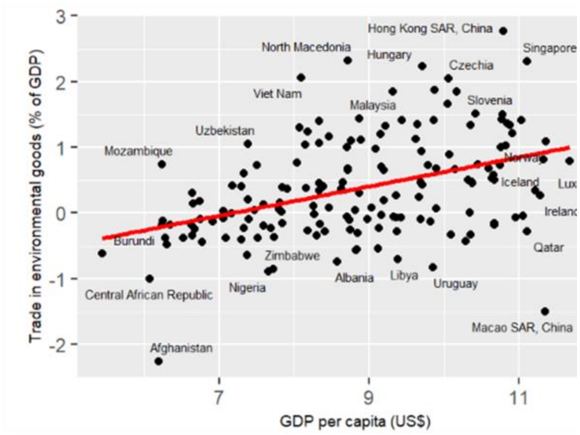
The variables with a negative link to economic growth, GINI, and DAM, show a weakly complementary correlation (.16). At the same time, they show a negative connection with every other variable. Such correlations were expected for GINI, but the DAM variable, as part of climate vulnerability, was expected to have a positive relationship with climate action which it does only with fossil fuel subsidies (-.18). The fossil fuel subsidies (SUB) variable has no relationship with the level of democracy and environmental innovations (-.04 and .02, respectively). However, in addition to GDP, fossil fuel subsidies also seem to have a positive relationship with environmental trade (.17), and tax (.19).

A deeper analysis of the main variables for this research is done using scatterplots between all four climate action variables (TRA, INN TAX, and SUB) and GDP (Figure 1-4)[5]. In all cases positive linear trends emerge between the climate action variables and GDP. Figure 1, describing the relationship between environmental trade and GDP shows that larger values of environmental trade come from some Asian countries (China, Singapore, Vietnam, and Malaysia) and Eastern European countries (North Macedonia, Slovakia, Slovenia, Czechia, Estonia). Figure 2, shows the relationship between environmental innovations and GDP. There is a tight relationship which is expected with a correlation coefficient of .87 (Table 3). There are very few environmental innovations per capita in African countries (Niger, Uganda, Mali, Tanzania). Yet, many environmental innovations are observed in industrialized "Western" countries (Japan, Korea, Germany, Austria, and Denmark).

[5] For some observations, the scatterplots include the name of the country. However, this is not shown for all observations, yet country names that are not displayed in the scatterplots are also used in the analysis and interpretation.

Figure 1

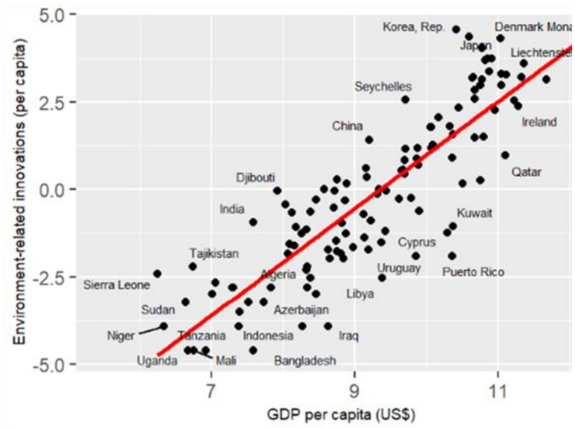
GDP and trade



Note: The figure displays a scatterplot and a linear trend (in red) between the GDP per capita (US$) and trade of environmental goods (% of GDP). Both variables are expressed as logarithmic

Figure 2

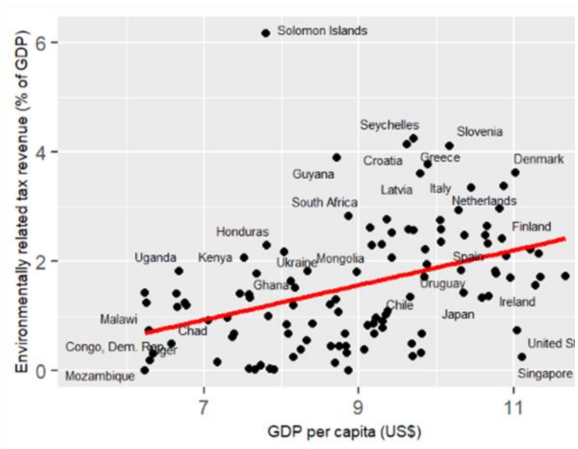
GDP and innovations



Note: The figure displays a scatterplot and a linear trend (in red) between the GDP per capita (US$) and environment-related innovations (per capita). Both variables are expressed as logarithmic values.

Figure 3

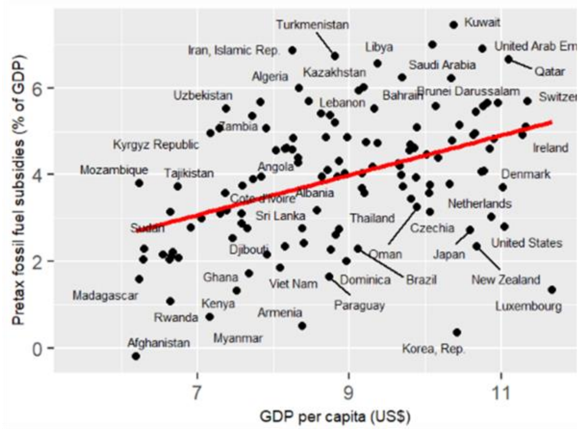
GDP and tax



Note: The figure displays a scatterplot and a linear trend (in red) between the GDP per capita (US$) and environmentally related tax revenue (% of GDP). GDP per capita is expressed as a logarithmic value.

Figure 4

GDP and subsidies



Note: The figure displays a scatterplot and a linear trend (in red) between the GDP per capita (US$) and pretax fossil fuel subsidies (% of GDP). Both values are expressed as logarithmic values.

Figure 3 displays the relationship between GDP and environmental tax revenue level. Generally, there is a linearly positive trend noticeable, while in some of the wealthiest countries, the level of environmental taxes is much lower (United States, Singapore). At the same time, European countries with similar levels of economic development (Finland, Netherlands, Denmark) have much higher levels of environmental taxes. The Solomon Islands seem to be an outlier of this scatterplot, which can be explained by the Solomon Islands having unexpectedly high tax revenues in 2018 (OECD, 2023). The low-tax-low-GDP part of the scatterplot seems largely represented by African states.

Figure 4 shows the relationship between per capita GDP and the level of fossil fuel subsidies. Although data is rather scattered, there is a positive linear trend shown. It is noticeable that the upper part of the scatterplot (high fossil fuel subsidies) is occupied largely by fossil fuel-dependent countries such as Kuwait, Saudi Arabia, UAE, and Iran. On the other hand, the bottom part of the scatterplot (low subsidies) is represented by African countries on the lower GDP value side (Afghanistan, Rwanda, Kenya) and highly industrialized countries on the higher GDP value side (Korea, United States, Netherlands).

According to the correlation matrix and scatterplots, there seems to be a positive linear relationship between all climate action variables and economic development. Of course, no conclusions about causation can be drawn yet. However, a higher level of fossil fuel subsidies is an inverse indicator of climate action, so the positive correlation for this dependent variable is surprising.

5. Results

In multivariate analysis for every dependent climate action variable, model 1 will consider a regression with only the main independent variable GDP; models 2-4 will consider the main independent variable and one confounding variable DEM; GINI, and DAM, respectively; model 5 will include all confounding variables. Table 4 displays the regression analysis results using 2018 data. The table divides regressions based on dependent variables (A-D) environmental trade, tax, innovations, and fossil fuel subsidies, respectively, and on models (1-5). The analysis includes the number of observations; r^2 and adjusted r^2 as well as the F statistic.

In Models A1-D1, the GDP per capita regression coefficient is positive and highly significant (at the 1% level). The model shows that for a 1% increase in GDP per capita, environmental trade (% of GDP) increases by 0.22% (A1) while there is a 1.5% (B1) increase in environmental innovations (per capita). At the same time, it also shows 0.0033 percentage points (C1) increase in environmental tax (% of GDP), and a 0.46% (D1) increase in fossil fuel subsidies (% of GDP).

In Models A2-D2 including GDP per capita as well as the democracy index, the sample size reduces in a range of 6-12 %. This is due to lower mutual observations that are usable in this regression. In Models A2; B2 and D2 GDP per capita remains positive and highly significant yet insignificant when environmental tax is used as a dependent variable (C2). While the democracy index has a significant positive effect on environmental innovations (B2) and tax (C2), it shows a significantly negative effect on fossil fuel subsidies (D2) and an insignificant effect on environmental trade (A2). In all models adjusted r^2 is higher than in model 1 (increases range between 0.02-0.13).

Model 3 introduces the Gini coefficient as a confounding variable, with all of the coefficients for GDP remaining positive and significant (at the 5% level). The Gini coefficient shows a small negative, yet significant coefficient in models A3, B3, and C3 (at the 5% level). However, there is also a large reduction in the observations due to data availability for the Gini coefficient. There are also considerably higher adjusted r^2 values in models 3A (Adj.r^2=0.280),

Table 4

Regression analysis

	Dependent variable A: Environmental trade				
	(1)	(2)	(3)	(4)	(5)
GDP per capita	0.222***	0.249***	0.150**	0.232***	0.158*
	(0.040)	(0.054)	(0.059)	(0.050)	(0.090)
Democracy index		0.011			-0.008
		(0.037)			(0.062)
Gini index			-0.045***		-0.039***
			(0.011)		(0.013)
Deaths and missing				0.016	0.003
				(0.051)	(0.068)
Constant	-1.598***	-1.856***	0.794	-1.660***	0.540
	(0.354)	(0.375)	(0.788)	(0.429)	(0.913)
Observations	159	140	82	97	55
R2	0.168	0.228	0.297	0.199	0.295
Adjusted R2	0.163	0.217	0.280	0.182	0.239
F Statistic	31.715*** (df = 1; 157)	20.251*** (df = 2; 137)	16.726*** (df = 2; 79)	11.663*** (df = 2; 94)	5.236*** (df = 4; 50)

	Dependent variable B: Environmental innovations				
	(1)	(2)	(3)	(4)	(5)
GDP per capita	1.531***	1.376***	1.482***	1.598***	1.432***
	(0.082)	(0.106)	(0.107)	(0.105)	(0.178)
Democracy index		0.182***			0.135
		(0.065)			(0.116)
Gini index			-0.049**		-0.062**
			(0.020)		(0.026)
Deaths and missing				0.032	0.039
				(0.070)	(0.070)
Constant	-14.321***	-13.981***	-11.955***	-14.872***	-12.043***
	(0.770)	(0.800)	(1.390)	(0.990)	(1.859)
Observations	119	109	70	72	46
R2	0.749	0.773	0.782	0.771	0.785
Adjusted R2	0.747	0.768	0.776	0.764	0.765
F Statistic	349.804*** (df = 1; 117)	179.986*** (df = 2; 106)	120.205*** (df = 2; 67)	116.162*** (df = 2; 69)	37.521*** (df = 4; 41)

	Dependent variable C: Environmental tax revenue				
	(1)	(2)	(3)	(4)	(5)
GDP per capita	0.326***	0.154	0.343***	0.285***	0.082
	(0.070)	(0.096)	(0.082)	(0.090)	(0.143)
Democracy index		0.196***			0.220*
		(0.073)			(0.111)
Gini index			-0.044***		-0.045**
			(0.017)		(0.018)
Deaths and missing				-0.019	-0.016
				(0.075)	(0.076)
Constant	-1.372**	-1.111*	0.192	-1.015	1.124
	(0.633)	(0.577)	(1.128)	(0.823)	(1.257)
Observations	113	103	67	71	44
R2	0.164	0.299	0.364	0.135	0.415
Adjusted R2	0.156	0.285	0.344	0.109	0.354
F Statistic	21.750*** (df = 1; 111)	21.281*** (df = 2; 100)	18.297*** (df = 2; 64)	5.293*** (df = 2; 68)	6.903*** (df = 4; 39)

	Dependent variable D: Fossil fuel subsidies				
	(1)	(2)	(3)	(4)	(5)
GDP per capita	0.458***	0.738***	0.314**	0.438***	0.429**
	(0.089)	(0.109)	(0.132)	(0.114)	(0.195)
Democracy index		-0.318***			-0.162
		(0.071)			(0.130)
Gini index			-0.017		-0.021
			(0.024)		(0.028)
Deaths and missing				-0.125	-0.150*
				(0.080)	(0.083)
Constant	-0.132	-0.803	1.668	-0.023	1.865
	(0.801)	(0.797)	(1.740)	(1.038)	(2.024)
Observations	125	115	60	75	41
R2	0.177	0.292	0.130	0.211	0.239
Adjusted R2	0.171	0.279	0.100	0.189	0.155
F Statistic	26.494*** (df = 1; 123)	23.108*** (df = 2; 112)	4.265** (df = 2; 57)	9.623*** (df = 2; 72)	2.834** (df = 4; 36)

Note: The table displays regression analysis for the data of the year 2018. The dependent variable is the climate action, separated in 4 indicators, representing tables A – D. Each dependent variable has 5 regression models, indicated by numeric column values 1 – 5.

Statistical significance at the 10%, 5%, and 1% levels are indicated by one, two, and three asterisks, respectively.

3B (Adj.r^2=0.776), and 3C (Adj.r^2=0.344). Model D3 shows much lower r^2 values than with previous models.

Model 4 considers deaths and missing from natural disasters as a confounding variable. While GDP remains significant and positive for all the dependent models, the confounding variable has a small and insignificant effect for all dependent variables. Nonetheless, the adjusted r^2 is higher in comparison to model 1 for dependent variables A, B, and D.

Model 5 includes all independent variables: the main independent variable GDP, the democracy index, the Gini index, and deaths and missing persons attributable to natural disasters. In model A5 there is a significant effect of GDP and Gini variable on the dependent variable. For each 1% increase in GDP, environmental trade (% of GDP) increases by 0.16%. Moreover, a 1 unit increase in Gini will render a 3.9% reduction in environmental trade level (% of GDP). Model B5 denotes a highly significant effect of GDP and the Gini coefficient on environmental innovations (per capita). A 1% increase in GDP level will result in a 1.4% increase in the level of environmental innovations. Moreover, a 1 unit increase in the Gini coefficient will result in a 6.2% decrease in the level of environmental innovations. Model C5 shows an insignificant effect of GDP on environmental taxes (% of GDP), yet a significant effect of the democracy index and Gini coefficient. A 1 unit increase in the democracy index will have a 0.22 unit increase for environmental tax (% of GDP). Moreover, 1 unit increase in the Gini coefficient will reduce environmental tax (% of GDP) by 0.045 units. Lastly, model D5 shows a significant effect of GDP and deaths and a missing index on fossil fuel subsidies (% of GDP). A 1% increase in GDP will result in a 0.43% increase in fossil fuel subsidies (% of GDP), while a 1% increase in deaths and missing will result in a 0.15% reduction in fossil fuel subsidies (% of GDP). All models (A5-D5) show a significantly lower amount of mutual observations. Only model C5 shows higher adjusted r^2 (Adj.r^2 = 0.354) compared to previous models.

In total, the regression models show a positive effect of economic growth on climate action variables. The coefficient varies according to the model used. With the introduction of confounding independent variables, the significance of economic development on climate action is mostly strong. However, occasionally it turns less significant (at the 5% or 10% level) or insignificant (in models C2 and C5). The democracy index has a significantly positive effect on climate action with environmental innovations and taxes used as the dependent variables. At the same time, it has a significantly negative impact on fossil fuel subsidies. The Gini index has a negative effect on all dependent variables, yet is insignificant when fossil fuel subsidies are used as a dependent variable. The level of deaths and missing persons have a negative effect on all climate action variables, while it is significant only if fossil fuel subsidies are used as a dependent variable. More variables do not constitute a higher representative power of the model by exhibiting volatile adjusted r^2. By introducing more variables in the model, the sample size significantly drops. In models with environmental innovations as the dependent variable (B) adjusted r^2 is significantly higher than in other dependent variable models (Adj.r^2 ≈ 0.75). The F statistic is highly significant in all models at the 1% level apart from D5 noticing a slight reduction to the 5% level, showing a high joint significance level in all regressions.

6. Discussion

The outcomes of this research provided an interesting insight into how economic development and other factors influence the climate action variables. The analysis has been done through bivariate correlation analysis with visual representation in scatterplots. The data has been used in multiple regression models for each dependent variable, with differing independent variables. The following section will focus on reiterating the main results from the study, linking them to the research question and the existing body of literature. Furthermore, the limitations of this study will be discussed as this study focused mainly on the variables that have available data. Therefore, the findings have to be interpreted with caution. Additionally, some suggestions for further studies will be given.

6.1.Economic Development and Climate Action

According to the analysis, while economic growth always positively impacts all climate action variables, the interpretation of this influence varies per dependent variable. This is mainly because the dependent variables- level of environmental trade, innovations, and tax are associated with higher levels of climate action. At the same time, the fossil fuel subsidies can be considered an inverse climate action variable, as with an increase in fossil fuel subsidies, there are larger incentives to use more fossil fuels, damaging and harming the environment even more. Therefore, concerning the research question: “What is the effect of economic development on climate action variables on a global scale?” the findings show that economic development has a positive relationship with all climate action variables. This, however, requires further elaboration as the positive relationship does not imply a positive influence on climate action.

The results showed a positive link between the level of economic growth and environmental trade. Accordingly, environmental trade increases with economic growth, by 1% of GDP per capita growth resulting in a range of 0.16 to 0.25% increase in the level of environmental trade. Wealthier countries are expected to have more financial resources and technological capabilities (Recchia, 2002). More financial means allow for greater buying power for environmental goods, increasing the amount imported. At the same time, higher technological capabilities allow for high-desired environmental goods that could increase the amount exported. Since commercial activities are mostly conducted online, an individual can purchase and ship products from any country. As wealthier countries have more environmentally conscious and active citizens, it is likely to result in a greater demand for low-carbon goods (Jänicke, 2005; Recchia, 2002). These results confirm the theory that developing countries are less likely to spend means on low-carbon goods, as they tend to be costlier. Instead, they might invest these means in supporting their lacking primary needs. Such links can be plausible as wealthier countries are expected to sign more international environmental agreements (Neumayer, 2002; Roberts et al., 2004). Overall, higher economic development results in a higher level of low-carbon trade, supported by theoretical models based on financial, technological, e-commerce, value prioritization frameworks, and other empirical research.

Not only does economic growth positively affect the level of environmental trade, but also the level of environmental innovations. The results show that for a 1% increase in GDP per capita, the level of environmental innovations is expected to increase by 1.4-1.6%. These variables have a very tight relationship as shown in Figure 2. A higher level of economic development responds to more financial and technological capabilities to develop and improve the level of environmental innovations (Recchia, 2002). The theoretical link between the level of financial resources and environmental innovations is also supported by researchers arguing that the level of innovations is a representative indicator of public (and private) expenditure in R&D (Satrovic et al., 2021). Additionally, by having a more environmentally conscious population, citizens of wealthier countries might be more interested in working and investing in the research and development of environmental goods (Jänicke, 2005). As a result, wealthier countries may have more human resources available for environmental research and development. Of course, given a positive relationship between environmental trade and innovation (correlation coefficient = .45), higher economic growth would imply more environmental innovations, which supports a higher level of environmental trade, primarily exports, and vice versa. An additional factor influencing the level of environmental innovations could be a national science community, also implying a higher level of R&D (Ylä-Anttila et al., 2018). Overall, a higher level of economic development results in a higher level of environmental innovations, which can be explained through higher financial and technological capabilities, human capital, the interaction between environmental trade and innovations, and the existence of a national science community.

According to the regression results, economic development also positively affects the level of environmental taxes. The results show that a 1% increase in GDP per capita will render a 0.0029 to 0.0034 percentage point increase in the level of environmental tax (as % of GDP), considering only statistically significant values. The two regressions in which the effect of GDP turns insignificant include the democracy index which seems to have a larger influence on the variable. While the results note a generally positive link in some regressions, it could be explained by wealthier countries having larger tax revenues (Recchia, 2002) because of more financial resources. Of course, the theoretical models can also contradict this statement, as if the population is environmentally active, they will make more environmentally conscious decisions. Further, fewer environmentally harmful choices will constitute a lower need for increased levels of environmental taxes, thus lower tax revenues. Indeed, Mahdavi et al. (2009) also argue that, for instance, fossil fuel taxes are largely dependent on a country's fiscal needs instead of environmental commitments. As fossil fuel taxes are a large part of environmental taxes, such an argumentation would explain why a higher level of economic development would not always result in a higher level of environmental taxation. Overall, there seems to be no unanimous influence of economic development on the level of environmental taxes through both the theoretical frameworks and the results of this study, as the positive impact of economic growth seems to be possibly undermined by the inclusion of the democracy index in the regressions.

Results also indicate that the level of economic growth induces higher levels of fossil fuel subsidies. As increased levels of fossil fuel subsidies incentivize the harmful use of fossil fuels, it contributes to more environmental damage. It can be noted there is a connection between the level of fossil fuel subsidies and the economic weight of the fossil fuel industry, with heavily fossil fuel-based countries such as Kuwait, Qatar, Saudi Arabia, UAE, and Iran having also very high levels of subsidies (Figure 4). This link has also been shown in academic research (Ylä-Anttila et al., 2018). Unfortunately, most of these fossil-fuel-reliant countries not only have high fossil fuel subsidies but also have built their high level of economic development on fossil fuels, having an incentive to subsidize the main commodity of the economy. Therefore, it is plausible that the level of fossil fuel subsidies does not depend on environmental commitments, but rather on fiscal needs (Mahdavi et al., 2022). Mahdavi's argument and the impact of the economic weight of the fossil fuel industry is a great source to explain why the fossil fuel subsidies globally keep increasing with economic growth at a time when the world seeks to transfer to renewable energy. Therefore, globally the action of reduced fossil fuel subsidies cannot yet be considered as an indicator of positive climate action, as fossil fuel reliance, especially in Middle Eastern countries, is a dictating factor of the trend. So, based on the findings of this study and existing literature, it appears there is currently a strong positive relationship between economic development and fossil fuel subsidies, which are heavily influenced by fossil-fuel-dependent countries.

This study's main results find no unanimous relationship between economic development and chosen climate variables; this link can also be considered through the earlier EKC hypothesis. The EKC proposed that the relationship between economic growth and environmental degradation could shift from positive to negative over middle-income levels to establish an inverted-U-shaped relationship. Literature suggests that currently there is a linearly positive relationship between economic growth and environmental degradation (Ekins, 1997; Stern, 2004). Yet, there is considerable reason to believe that higher economic development can influence a higher level of climate action through some models and variables. Based on the results, there are plausible reasons to experience the EKC. Both the theoretical and empirical models have a reason to argue that higher economic growth can have higher climate action. At some point, the level of climate action could respond to the climate degradation that higher wealth induces through coupled emissions. With exponentially growing levels of climate action, the relationship between economic development and environmental degradation can eventually transfer from a linear to an inverted U-shape. Yet, this will not be experienced without three important considerations. Firstly, there is not enough climate action yet to offset the harmful actions by anthropogenic activities (UNFCCC, 2022). Secondly, the effects of climate action are likely to be seen no earlier than in decades (Denning, 2018; Fiorino, 2011). Thirdly, the governance of climate-action-stagnant sectors such as the fossil fuel industry has to be reconsidered to tackle the effects of climate change from all perspectives. Once these considerations can be understood and acted upon, EKC could become plausible, as already shown by the decoupling of emissions and wealth in high-income states such as the United Kingdom, France, Germany, United States, Sweden, and Finland with many other upper and middle-income states exhibiting a similar trend (Ritchie, 2021).

6.2.Other Considerations

While the overall impact of economic development on climate action is not unanimous, there are interesting considerations to be included, going above the influence of economic growth on climate action. In this section, I will focus on the interesting findings with the control variables, consider the representative power of the model, and link it to the varying sample size.

According to the findings, higher levels of democracy influence higher levels of environmental innovation and taxation, as well as lower fossil fuel subsidies. This is especially important as a large body of literature focuses on understanding the impact of democracy on climate action and environmental quality. The results of this study confirm the positive effect of the level of democracy on climate action, as argued in the literature (Bättig & Bernauer, 2009; Koubi & Bernauer, 2008; Hammond & Smith, 2017; Neumayer, 2002 Ylä-Anttila et al., 2018). The influence of the level of democracy is crucial as it indicates that democratic institutions and values can induce a higher level of environmental innovations and tax as well as lower fossil fuel subsidies.

Furthermore, there is considerable evidence that income inequality and the level of deaths and missing persons from natural disasters positively affect the climate action variables. The findings of this study show that higher income inequality harms the level of environmental trade, innovations, and taxes, contrary to the claims in literature argued by de Soysa (2021) and Scruggs (1998). Although it has little effect on the level of fossil fuel subsidies, reducing income inequality helps to increase the level of climate action. Interestingly, the level of deaths and missing persons from natural disasters only significantly affects the level of fossil fuel subsidies. This shows that while fossil fuel subsidies might not be largely affected by environmental commitments, as argued before, the drastic impact of climate change levels on citizens is a crucial factor that can lower the level of fossil fuel subsidies. This finding approves Peterson's (2021) view of the importance of climate vulnerability. While it does not have a significant impact on positive climate action indicators, such as the level of environmental trade, innovations, and tax, it does impact total climate action by reducing fossil fuel subsidies. This result is opposing the view of Christoff & Eckersley (2011), who argued that climate vulnerability is an irrelevant factor. Overall, the influence of the level of deaths and missing persons, and lower income inequality measured as the Gini coefficient expectedly improved climate action.

Further on, there are some interesting considerations about the representative power of the models used. Interestingly, the variation in economic growth and other independent variables in this study explain no more than 40% of the change in dependent variables for environmental trade, tax, and fossil fuel subsidies. However, the models were much better at explaining the change in the level of environmental innovations, with the change in independent variables explaining around 75% of the change in the level of environmental innovations. As the level of economic development determines the financial resources available for climate action (Recchia, 2002), the indicator of environmentally related innovations is also a great representative of the public R&D expenditure sector as indicated by Satrovic et al. (2021). Overall, the models used in this study were successful in explaining a large change in the level of environmental innovations, with the regressions having lower representative power in other dependent variable models.

The link between sample size and explanatory power (adjusted r^2) indicated possible further connections. When confounding variables were introduced in the models, the effect of economic development became less significant, identical to the research done by Lieffernick et al. (2009). This would imply that the influence of economic development on climate action is very important, yet other factors can have a significant influence, too. Interestingly, more confounding variables do not necessarily imply higher accuracy (adjusted r^2). For environmental trade and innovations, the more accurate model (highest adjusted r^2) consisted of GDP and Gini, for environmental tax it was all of the independent variables, while for fossil fuel subsidies it was with GDP and democracy index. Of course, a higher explanatory power could also be associated with fewer variables, as, for instance, models including the Gini coefficient had considerably fewer observations. While such a reduced number of observations could have influenced the result, the number of observations never dropped under 40. In all of the regressions, the joint effect of the independent variables on climate action was significant (at the 1% level in all but one model, in which significance lowered to the 5% level). So, the models successfully explained some of the complex relationships between the variables used in this study.

6.3. Limitations and Recommendations

Previous discussion and analysis have introduced some of the issues and limitations that can influence the findings of this study. The limitations discussed in this section consider data coverage, the climate action model, and the scope of independent factors. The next section of the discussion will address these limitations and make recommendations for future research.

Firstly, there are considerable limitations in covering the global data. The climate action model framework was based on the selected literature with data availability affecting the particular choice of indicators. Such data is not available for countries and, as such, the sample size for a regression with an increased number of variables can considerably decrease (in the models with the largest number of indicators, the sample size was only around one-quarter of all countries considered). Not only were there datasets with a reduced number of observations but also the data availability varied per year, unfortunately. As this research introduces ideas of climate action's long-term influence, considering data from other years would strengthen the ideas expressed in this paper. Therefore, the avenue for improving this research is to consider a practical data-collection procedure, in which there is a possibility to cover a greater number of countries and periods while increasing the number of variables.

Secondly, climate action remains a complex concept to measure, which can be covered through numerous perspectives. This research largely focused on simplifying the climate action measurement as the commonly considered indicators include unreliable indicators (such as goals and targets). Moreover, the cross-sectoral model can also be improved by considering "Renewable energy subsidies" instead of "Fossil fuel subsidies". The current indicator "Fossil fuel subsidies" is necessary, yet, contrary to others, induces larger climate damage, not climate action. As a result, it is vital to acknowledge that the model used in this study has the potential to be enhanced by considering additional cross-sectoral variables, as well as sectoral and international climate action indicators.

Lastly, as demonstrated by the results, the independent variables significantly impacted the outcomes. The results yielded successful results considering both the influence of the main independent variable and the joint significance of all independent variables of climate action. Yet, the coverage of independent factors could have improved the representative power of some models. Certainly, having a larger number of indicators is not always better, but it can reveal some of the more influential factors via separate regressions. Consequently, additional research on the factors influencing the specific climate action variables would be required, allowing for more accurate models. However, alongside this suggestion, there could be a possible trade-off with the level of common observations per regression.

Conclusion

Can we consider economic development as only being detrimental to the environment, or can it help it, too? This research has provided insight into this question by building a cross-sectoral climate action model and assessing if a larger GDP positively influences climate action variables. The theoretical and empirical models used in this research argue that higher economic development leads to more environmental trade and innovations. Unfortunately, there were inconclusive results when environmental tax is considered the dependent variable. Theoretically, higher wealth can be associated with higher taxes. On the other hand, higher wealth responds to higher environmental awareness, thus less environmentally harmful decisions and a lower need for taxes. Interestingly, the models show that higher economic development will result in higher fossil fuel subsidies as they respond better to fiscal needs rather than environmental commitments. In addition, higher levels of democracy, climate vulnerability, and lower income inequality can be beneficial factors for increased climate action.

The detrimental consequences of climate change can be seen already, therefore, links between economic development and the environment seem largely focused on this influence. Surely, there is a positive correlation between economic growth and environmental degradation. Yet, the effect of climate action could be seen only in decades. There is currently not enough climate action to offset the consequences of climate change. However, increasing action and awareness brings the question of whether there is a possibility of reaching the EKC hypothesis in the long term. For such a result to be realistic, reliance on the fossil fuel industry must be addressed as fossil fuel subsidies incentivize the use of carbon-intensive materials. Overall, higher economic development not only results in more emissions as often argued by scholars, but it also seems to positively affect the environment through climate action, assuming that climate action translates into successful outcomes.

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Appendix

Country range in different regressions

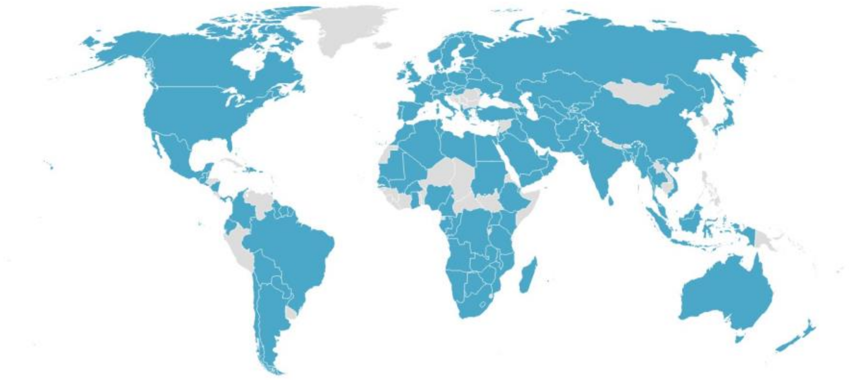

Figure A1: The map represents countries covered in the regression with the highest number of observations (A1).

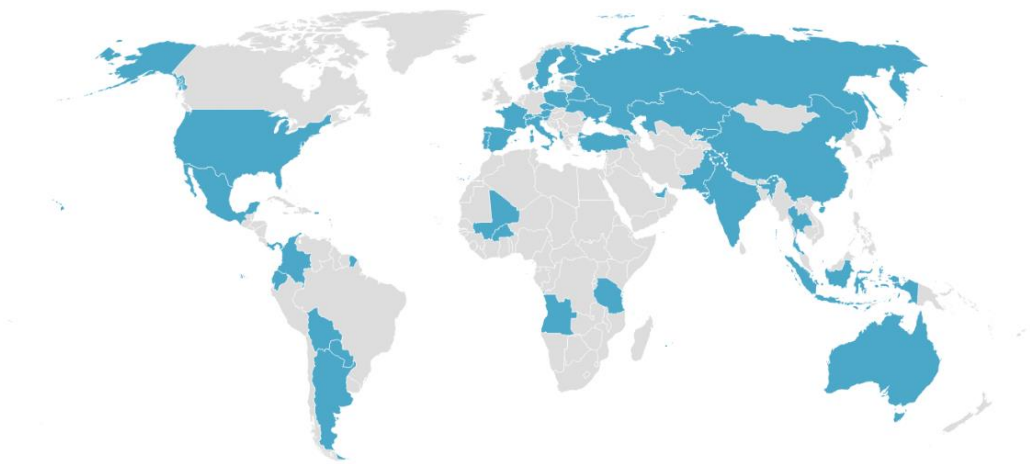

Figure A2: The map represents countries covered in the regression with the lowest number of observations (D5).

Legend:

- Covered in this analysis
- Not covered in this analysis