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ANALYSIS OF CARBON EMISSIONS BEFORE AND AFTER INTERVENTION: DIFFERENCE IN DIFFERENCE BASED EVIDENCE FROM EMERGING ECONOMIES

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Abstract

The pre and post treatment of CO_2 in E-7 countries is investigated in this study. Data from WDI and UNDP were collected from 1991 to 2022. Utilizing the Difference in Difference methodology, the study found that intervention helps in reduction of CO_2 emissions in the selected treatment group of emerging seven economies compared with the control group. Economic Growth, Population, manufacturing exports, HDI and GFCF all contributed to carbon emissions while renewable energy use mitigated carbon emissions. It is recommended that the government of the selected economies may focus on the adoption of advanced technologies to combat carbon emissions. Furthermore, it is also suggested that economic expansion may also be channelized as per environmental regulations and the masses must be aware of the promotion of sustainable practices.

INTRODUCTION

Economic and policy research has long focused on the link between economic production and the environment, especially regarding the objectives of sustainable development. This is due to the direct link between the environment and economic output. Many people believe that the early levels of development are marked by eco-friendly deterioration brought on by economic expansion. This is a commonly accepted notion. In a similar spirit, those who oppose environmentally sensitive laws have often claimed that such measures impede economic advancement. The Donald J. Trump (president of United States) recently announced that the country will no longer be taking part in the historic Paris climate agreement. This illustrates what I'm trying to say. Even though in the climate change agreement the United States of America was regarded as one of the main nations, this choice was made. On November 7, 2017, the widely syndicated American newspaper USA Today reported that the United States of America was the sole country not participating in the Paris Agreement. According to

the narrative, there was the only nation (United State) still out of the Paris Agreement following Syria's announcement a week earlier that it intended to join.

As a result, the effective implementation of climate agreements to reduce greenhouse gas emissions at the expense of economic growth has been rekindled, at least in the United States (Rice et al., 2017). This is the situation in the United States of America. In recent years, greenhouse gas (GHG) emissions and their impact on the environment have become major global issues. While this is happening, many governments around the world are focusing on economic expansion. On Climate Change the United Nations Framework Convention is playing an increasingly crucial role in developing international guidelines for reducing greenhouse gas emissions. Emissions of greenhouse gases are molecules that build in the atmosphere, causing the greenhouse effect and, ultimately, global warming. On the other hand, economic growth refers to the gradual expansion output of goods and services in countries, which is commonly measured in GDP. This expansion is known as the gradual expansion of economic growth. The acronym UNFCCC stands for the United Nations Framework Convention on Climate Change (UNFCCC). It is an universal pact that was signed in 1992 with the purpose of stabilizing greenhouse gas focuses to avoid dangerous human influence on the climate system. When comparing the average change in outcomes over time of two groups, one of whom received therapy or intervention, the Difference-in-Differences technique is a statistical instrument that can be used to analyze the differences.

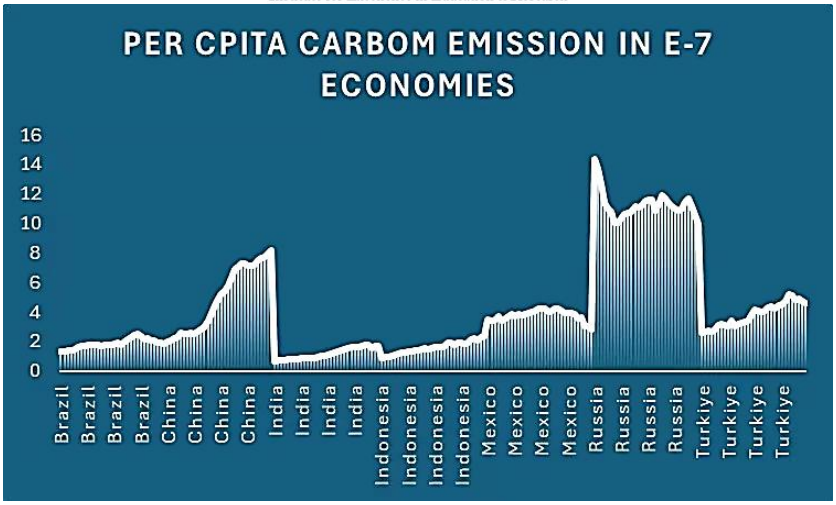
The connection between rising economic activity and emissions of greenhouse gases is complex and multi-faceted. Historically, more greenhouse gas emissions have been linked to more rapid economic growth. This is because both consumption and industrial activity have surged. But there are a lot of competing theories on how GDP growth would affect greenhouse gas emissions in the long run. Some argue that a decline in emissions per unit of GDP is inevitable as economies grow and adopt cleaner technologies, making them more energy efficient. The current discussion has revived this topic, and this study adds to it by re-examining the empirical relationships between economic progress, greenhouse gas emissions, and international climate agreements. Using a tried-and-true empirical method, we can quantify the impacts of Kyoto Protocol participation on national GDP per capita growth (GDPPCG) rates and emissions of greenhouse gases. In 1997, the United Nations Framework Convention on Climate Change made significant progress with the Kyoto Protocol (KP), the first global agreement to restrict emissions of greenhouse gases. But the KP wasn't officially in effect until 2005. An official pledge to decrease greenhouse gases emissions was made by the parties referred to as "industrialized countries" or "economies in transition" under the UN Framework Convention on Climate Change (Ringius et al., 2002). This pledge was made for the first time. To assess the impact of this pledge, we apply a difference-in-differences (DiD) technique to find out if the KP countries listed in Annex I have cut their emissions of greenhouse gases and/or had slower GDP per capita growth (GDPPCG) rates after 2005 compared to the countries not listed in Annex I.

To make well-informed policy decisions about sustainable development, a thorough comprehension of the connections between greenhouse gas emissions and economic growth is important. Governments and international organizations must figure out how to combine climate change mitigation and economic growth to maintain long-term environmental and economic stability. The United Nations Framework Convention on Climate Change (UNFCCC) is a vital piece in the global battle against greenhouse gas emissions. The agreement imposes binding obligations on industrialized nations to limit their emissions and establishes a framework for cooperation on adaptation and mitigation of climate change. The Kyoto Protocol and the Paris Agreement are two of the agreements that the United Nations Framework Convention on Climate Change (UNFCCC) has successfully negotiated to strengthen international efforts to address climate change.

While many studies have examined the link between environmental protection and economic development, there is a clear need for additional investigation on the export effects of global environmental treaties such as the Kyoto Protocol. Furthermore, studies often fail to include the impact

of these agreements; researching growth and the environment without considering these effects would likely yield biased results (Finus et al., 2005). This study uses the DiD method to investigate the connections between the KP Annex I designation, greenhouse gas emissions, and economic growth; however, we do review a few relevant publications below. The UNFCCC faces many issues in achieving its objectives, despite its importance. Issues with enforcement of certain provisions, finances, and general compliance are among these. For the UNFCCC to achieve its goal of driving actual climate action, it is essential to resolve these challenges.

The Difference-in-Differences technique offers a thorough way to assess the impact of climate policies and agreements. The method delves into the connections among economic expansion, carbon dioxide emissions, and UNFCCC. Examining data collected both before and after the policy shift will allow researchers to draw conclusions about the intervention's causal effect on GDP growth and greenhouse gas emissions. An often-reported empirical result in the literature is that, in the absence of regulation, carbon dioxide emissions tend to rise in tandem with economic expansion, especially in emerging nations. Conversely, studies have demonstrated that developed countries have crossed a tipping point where their emissions of greenhouse gases are falling regardless of how much their economies grow at the same rate. An abbreviation for the Environmental Kuznets Curve, this phenomenon is commonly known as EKC. Environmental degradation will persist up to a certain income per capita, after which it will begin to decline as economies grow, if the EKC theory is to be believed. Several reasons, including growing environmental awareness, new technologies, and the stronger environmental restrictions that come with concentrated economic development, explain this trend (Weikard et al., 2006). The Kyoto Protocol (KP) was an innovative global initiative that aimed to lower greenhouse gas emissions by the signatory nations listed in Annex I. None the less, its efficacy has been a point of contention. Opponents contend that it might hinder the economic progress of wealthy nations by unfairly taxing them. But proponents say that we can't solve the world's climate problem alone and that we should put the long-term advantages of lessened climate dangers ahead of the short-term financial expenses.



Literature Review

The financial implications of global environmental accords have been the subject of much study during the last two decades. The primary focus of this study is on the theoretical difficulties of several linked topics, such as creating institutions, facilitating member participation, coordinating activities, enforcing agreements, and preserving stability. an examination of the correlation between GDPs per capita and GHG emissions for the specific group of nations under the KP, to test the 'Environmental

Kuznets Curve' hypothesis (Huang et al., 2008). An oversight in the analysis is that it doesn't look at the question of whether these nations were really motivated to lower their emissions by the obligations of the Annex I designation. Second, using a DiD method, we can measure the change in carbon dioxide emissions, carbon "footprints," and carbon embodied in imported goods for a group of forty nations both before and after the KP was ratified (some of these countries signed before 2005).

Using a more direct empirical specification that includes a wider definition of emissions and a bigger sample of nations, we set our research apart from others. We instead compared Annex I countries to non-Annex I countries after the KP went into force in 2005 to see whether the former reduced greenhouse gas emissions (GHG) (our metric includes all GHGs, not just CO2), rather than looking at whether countries reduced CO2 emissions after ratifying the KP (Achiele et al., 2012). Finally, another important difference of our research is that studies do not assess the effect of KP on GDP per capita growth. Prior to delving into our empirical analysis, we commence by doing a comprehensive literature assessment of the two branches that are most relevant to this paper. The evolution of the UNFCCC is the subject of the first. The second one deals with how progress in the economy affects the natural world.

Global Climate Agreements Established Under the Framework of the (UNFCCC)

In response to the increasingly urgent issue of climate change, international climate agreements, as set out by the UNFCCC, play a crucial role. If states are serious about working together to combat climate change, they must ratify these accords. This guiding principle acknowledges that industrialized nations bear an inconsistent share of the blameworthiness for climate change due to their longer history of substantial contributions. Developing nations are urged to address climate change in accordance with their resources and the assistance they get. The framework also sets up a way for countries to track and report on how far they've come in achieving their climate targets (Protocol et al., 2010).

For the KP to be implemented, it was necessary for at least 55 countries, or 55% of the total in 1990, to ratify it, as per the agreement's design. The Russian Federation did not submit the ratification until 2005. The Protocol established deadlines for the Annex I countries to accomplish their GHG emission caps in relation to 1990 levels. The per ton of emissions estimates of the global marginal damage were essentially consistent with the estimates of the marginal cost per ton of CO_2 that were reduced under the KP at that time. However, Nordhaus and Boyer estimated that the United States would be responsible for approximately two-thirds of the over $700 billion in total expenditures. They also estimated that the benefit-cost ratio of the Protocol would be 1/7.

In the December 2009 Copenhagen Accord, 141 nations reaffirmed their commitment to and support for the KP accord, citing climate change as "one of the greatest challenges of our time" (Barrett et al., 2003). The countries listed in Annex I have established a target of reducing emissions by 2020. These commitments were not legally enforceable, and the Accord encountered additional challenges, including the determination of which countries should establish emission reduction objectives, the negotiation of the number of international agreements, the amount of carbon that should be reduced, the determination of country targets, and the role that agricultural and forest policies should play.

Even if high-income nations follow through on their carbon reduction obligations in the Copenhagen Accord, the objective of limiting global warming to 2 degrees Celsius may not be met. Falkner et al. discovered that important parties refused to sign a legally binding climate deal. The conference indicated that the 'global accord' may have reached its limits of efficacy (Barrett et al., 1998). The Paris Agreement was signed by 195 governments in December 2015. The Paris Agreement's article 2.1 demands a more comprehensive worldwide response to poverty allivation climate change, sustainable development. It also emphasizes enhanced commitment to these goals. The main target is to keep global mean temperatures "well below" 2 degrees Celsius over pre-industrial levels, with further attempts to limit the increase to 1.5 degrees Celsius. Article 2.2 of the Agreement aspires to establish justice and the notion of common but

differentiated duties and capabilities, considering national conditions (Barrett et al., 1998).

The Paris Agreement requires wealthier nations to contribute financially and lowers environmental policy requirements for low-income nations to alleviate some of the financial strain that is being placed on economically disadvantaged populations (also known as "economically disadvantaged populations"). This is done in recognition of the fact that these nations have made a negligible contribution to the levels of greenhouse gas emissions that are now in existence. Developed nations have committed to assisting less developed nations in lowering their emissions of greenhouse gases by the year 2020 by channeling a total of one hundred billion dollars in yearly funding from both public and private sources. Considering that the gross domestic product in 2015 was somewhat more than $18 trillion, this figure is about equivalent to 0.5 percent of that total.

As a result of the administration of Republican President George W. Bush, the United States of America formally withdrew from the agreement in 2001, although it was never ratified. Except for the United States, no country that was a part of Annex I ratified the KP.

During the administration of Barack Obama, the United States of America joined the Copenhagen Accord in 2009. Two years later, in 2015, it joined the Paris Agreement about climate change. However, foreign leaders have accused the United States of being inattentive to the fight against climate change. This accusation comes after President Donald J. Trump (R) said in 2017 that the United States will withdraw from the Paris Agreement, which caused concern all over the world and prompted censure. Some people believe that the United States' decision to withdraw from the Paris Agreement, even though it is in a leadership position within the United Nations Framework Convention on Climate Change (UNFCCC), could have a negative impact on the long-term viability of the agreement by encouraging other smaller nations to follow suit (Dimitrov et al., 2010).

Claiming its design would disproportionately burden American firms and consumers while doing little to reduce the emissions of other large emitters of greenhouse gases, the United States has opposed both the Kyoto Protocol and the Paris Agreement. This opposition is since the United States is a major emitter of greenhouse gases. In 2001, for example, former President George W. Bush declined the KP because, according to him, it "set no standards for India and China" and the United States "could prove economically crippling" due to the conditions. This was the reason why he rejected the KP. Although an article published in 2001 by The Heritage Foundation, a well-known think tank in the United States that has a conservative leaning, praised Mr. Bush's decision. This opinion was reaffirmed in a report on the Paris Agreement that was published in 2016 by the Heritage Foundation. The research expressed concern over " lower incomes, less economic growth, fewer opportunities for American workers, and higher unemployment," which was a sentiment that had lasted for fifteen years. Trump, who is currently serving as the President of the United States, has also expressed his dislike of the Paris Agreement, but for reasons that are very similar to those of this candidate. It is Mr. Trump's assertion that the United States economy "would be close to $3 trillion in lost GDP" over the next two decades, and that the agreement "punishes" the United States while placing forgiving restrictions on China and India. An article published on the website of The Economist in June 2017 highlights the fact that most American voters were opposed to the decision of Mr. Trump to withdraw from the Paris Agreement. This may be a source of encouragement.

More intellectual opposition to UNFCCC contracts has been measured. Bodansky claims that the KP and Paris Agreement classifications were political rather than legal, and that the country classification is not dynamic enough. Despite tremendous economic development and high GDP per capita Singapore and Qatar remain categorized as "developing" under the KP. Detractors believe that there are more effective ways to tackle climate change than implementing international agreements like the Kyoto Protocol. Nordhaus explores various approaches to the KP that could better mitigate global warming threats. He pushes for tradable permit models for GHG emissions under carbon taxes.

Growth and Environment

This work adds to the research on the link between economic development and environmental sustainability. Economic growth is not always destructive to the environment. Economic development has a significant role in ensuring environmental sustainability. Evaluating the influence of economic development on the environment sometimes involves testing for the Environmental Kuznets Curve (EKC). The EKC hypothesis predicts an inverse-U-shaped link between a country's GDP per capita and localized environmental quality, such as pollution levels. In the early stages of development, pollution is aggravated by growing economic activity. According to Falkner et al. (2010), when incomes rise, the demand for environmental quality increases, leading to a decrease in pollution.

Copeland and Taylor found inadequate data to support the "simple and predictable" association between per-capita income and pollution. Our work does not directly test the EKC theory, but considers a comparable effect on GHG emissions. Our empirical estimates are inconsistent, which supports Copeland and Taylor's conclusion.

China's recent experience highlights how economic growth can have a negative influence on the environment, as widely reported. China's rapid expansion has led to substantial pollution in major cities. Despite promising to reduce emissions by 2020, China has lately become the world's leading CO2 emitter. Several studies have investigated the impact of economic expansion and financial development on CO2 emissions in China. Compare China and India's experiences on trade openness, growth, energy consumption, and CO2 emissions. The study found that structural changes, income per capita, and energy use all are significant impact on CO2 emissions in China. However, these relationships cannot be shown decisively in India.

3. Data and Methodology:

3.1. Data

The data for this study was obtained from World Development Indicators (WDI) and UNDP. The data spans from 2000 to 2023, providing a comprehensive view of the trends and changes over two decades. The dependent variable in this study is per capita carbon emissions, measured in metric tons per person. The independent variables include per capita GDP, energy use, renewable energy consumption, population, manufacturing output, HDI, and GFCF. The list of countries selected for this study are in fig 1 while each variable along with its definition and source are given in table 1 below.

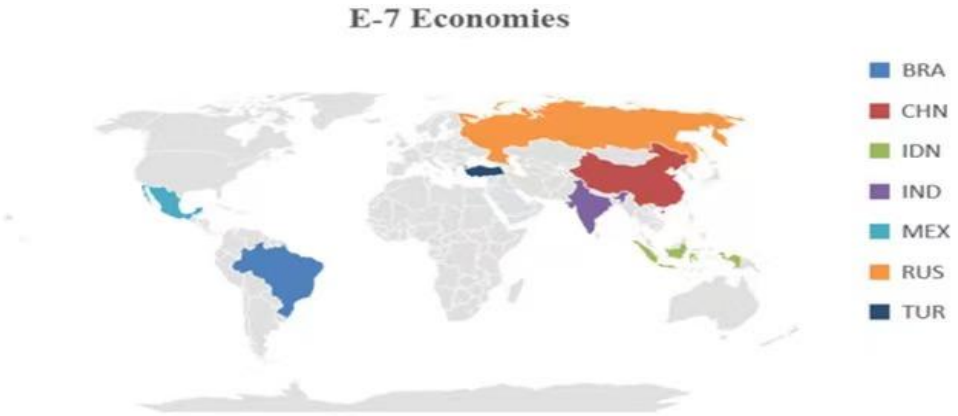


Fig.1: Map and List of E-7 Economies

Table 1: Definition and Source of Data

Variables	Definition	Source
Carbon Dioxide emission (CPC)	$C2_2$ emitted from the consumption and combustion of solid, liquid, and gas fuels and gas flaring.	WDI

Per Capita GDP (GDPPC)	It is based on local currency (constant) and separated by the mid-year population of a country. It includes production and consumption within the economy in a particular year.	WDI
Energy Use (Ener use)	The use of energy refers to consumption of key energy before it is converted into different end-use fuels, which is equal to domestic production plus imports and stock adjustment, minus exports and fuels used by ships and airplanes for foreign travel.	WDI
Renewable Energy (Renco)	WDI defines it as its share in overall energy consumed in a country.	WDI
Total Population (TOTPOP)	All residents regardless of citizenship or legal status make up the total population.	WDI, IMF
Manufacturing Export (ManuExpo)	Manufactures comprise commodities, chemicals, basic manufactures, and miscellaneous manufactured goods machinery and transport equipment excluding division non-ferrous metals	WGI
Gross Fixed Capital Formation (GFCF)	It consists of domestic investment on plant, land enhancement, railways & road construction.	WDI
Human Development Index (HDI)	It is an index of education, life expectancy and GDP per capita.	UNDP

3.2. Methodology

Difference in Difference (DiD) is amongst the most popular approaches that simulate the experiment where the effect of certain events (also known as treatment) on dependent variable is resolute by comparison of the avg. change in the dependent variable over time for a treatment group with a control group that does not receive the treatment. To rephrase, the DiD estimator accounts for all pertinent factors by first calculating the average change in the outcome variable between the pre- and post-treatment periods for each group, and then by subtracting the treatment itself from these two averages in the post-treatment period. If the difference between the treatment and control groups are statistically significant, then the event in issue had a different effect on the treatment group. This is regarding an overview of the DiD method and its many uses. It is easy to estimate the effects of CO2 emissions on GDP per capita growth using the DiD approach. In case of the seven emerging economies, the study took the panel data over 1991–2023. We selected 2000 as a bench year and believe that taking it as a baseline is ideal as it was the year of new century which provides relatively a clean tab for research. Additionally, for E-7 economies, it was the year of a recovery from the most devastating financial crisis named as "Asian Financial Crisis of 1997". This analysis will help us to understand the recovery and development of the sample nations from this crisis. Furthermore, from 2000, the world dynamics changed to a considerable extent with globalization of the world economies and therefore, our sample economies, taking advantage of this globalization, expanded by reforming the economic structure. These restructurings open the doors for investment. Moreover, to see the performance of the sample economies, we need to analyze the MDG's set by United Nations in 2000. These goals help in understanding the social, political and economic transformation of the world economies in general and our sample economies in particular. Thus, using 2000 as a benchmark allows for a comprehensive analysis of the significant economic, political and social changes that have influenced the E-7 economies over the past decades.

Our regression equation is

$$\begin{aligned} CPC_{it} = {} & \varphi_i + \psi_t + \beta_1 D_{it} + \beta_2 gdppc_{it} \\ & + \beta_3 ener\,use_{it} + \beta_4 renco_{it} \\ & + \beta_5 manu\,export_{it} + \beta_6 hdi \\ & + \beta_7 gfcf + \varepsilon_{it} \end{aligned}$$

In this equation φ_i and ψ_t are the country and year specific effects. D_{it} is the Difference in Difference treatment for our sample economies with β_1 is a measure of these treatment effects on per capita carbon emissions. Rest of the explanatory variables are given along with their β_{2-7} coefficients. Epsilons represent error term.

4. Results and Discussions

4.1. Descriptive Statistics:

There are 224 observations for each sample and the statistics presented in table 2, showed that the mean and median of all the selected variables are positive whereas the mean of CO2_PC, Ener use Renco, TOTPOP, HDI and GFCF is higher than its respective median which shows a positive skewness in the series. Further, the mean and median are closer to each other's showing that there is very slight symmetry in the series but still not normally distributed. The kurtosis values are less than 3 for Renco, TOTPOP and Manu Export showing that these series followed platykurtic pattern while it is greater than 3 for all the others suggesting that these series followed leptokurtic pattern. The Jarque Bera (JB) test and its corresponding "p" values rejected the null hypothesis of normal distribution.

Table 2. Descriptive Statistics

	CPC	GDPPC	Ener use	Renco	TOTPOP	Manu Expo	HDI	GFCF
Mean	4.0595	3.1540	1704.74	25.2663	4.6008	57.7014	3.4504	25.7659
Median	2.8180	3.8336	1314.26	21.2500	1.8808	70.1572	0.6905	23.7086
Maximum	14.3970	13.6358	5870.23	58.4000	141217500	94.3003	23.9347	44.5187
Minimum	0.6830	-14.6139	358.3040	3.2000	55321172	0.6980	0.4340	14.3861
Std. Dev.	3.368532	4.598148	1363.956	16.53047	5.0208	28.83008	6.899663	7.168649
Skewness	1.3361	-0.9774	1.5856	0.2377	0.9866	-0.8415	2.0942	0.8405
Kurtosis	3.5898	4.9402	4.3306	1.5866	2.1093	2.5921	5.4764	3.0433
Jarque-Bera	69.89598	70.80249	110.3951	20.75376	43.74362	27.99374	220.9697	26.39227
Probability	0.000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000
Observation	224	224	224	224	224	224	224	224

4.2. Correlation Matrix:

In table 3 we presented the outcomes of the correlation matrix which shows that GDPPC, Renco, TOTPOP, Manu Export and GFCF are negatively correlation with CPC while Ener use and HDI are positively correlation with CPC. Higher GDP per capita may reflect a more developed economy with better technology and more efficient production processes. This can result in lower emissions per unit of GDP. Increasing the share of renewable energy reduces dependence on fossil fuels, which are the primary source of CO_2 emissions. A higher proportion of renewables in the energy mix means that overall CO_2 emissions decrease. Higher population can lead to more efficient public transportation and infrastructure, reducing per capita emissions. Urban areas with higher populations might have more shared resources and services, which can lower individual carbon footprints. If a country's exports are increasingly composed of high-tech, low-emission goods, overall emissions per capita can decline. Stringent environmental regulations on manufacturing can lead to reduced emissions. Investment in modern, efficient infrastructure and technology can lower emissions by improving energy efficiency and reducing waste. Capital formation often includes investments in renewable energy and sustainable practices, reducing overall emissions. Ener uses are positively correlated with co2 emission and moves same direction. More energy use, particularly from fossil fuels, directly leads to higher CO_2 emissions. Higher energy consumption often indicates a higher level of industrial activity and transportation, which contribute to CO_2 emissions. Higher HDI is associated with better living standards, leading to increased consumption of goods and services that require energy. Higher HDI often correlates with

greater access to energy-consuming amenities, such as air conditioning, private vehicles, and electronic devices, which increase CO_2 emissions.

Table 2. Correlation Matrix:

	CPC	GDPPC	Ener use	Renco	TOTPOP	Manu Export	HDI	GFCF
CPC	1.000							
GDPPC	-0.1299	1.000						
Ener use	0.9727	-0.2059	1.000					
Renco	-0.7895	0.0668	-0.7014	1.000				
TOTPOP	-0.1651	0.4510	-0.2659	0.2121	1.000			
Manu Expo	-0.5350	0.3036	-0.6691	0.1168	0.4519	1.000		
HDI	0.8809	-0.2260	0.9286	-0.5407	-0.2601	-0.8026	1.000	
GFCF	-0.0649	0.4848	-0.2199	-0.0449	0.7463	0.5113	-0.3041	1.000

4.3. Result Interpretation and Discussion:

Table 4 represents pre and post treatment period unconditional mean, which indicates that CO_2 per capita is lower before 20000. The mean CO2 emissions per capita have increased from 1.508117 before 2000 to 1.992337 after 2000. Both periods have relatively small standard errors, indicating that the mean estimates are precise. The t-statistic of 27.467 and 40.78 are quite larges indicating that the means are statistically significant.

Table 4. Mean Comparison

CPC (Dep Var)	Before 2000	After 2000
Total observations	9	23
Mean	1.508117	1.992337
St. Error	0.054905	0.048847
t-Statistics	27.467	40.78

Linear Regression (Difference in Difference Analysis) Outcomes:

For Carbon emissions, we find a negative, statistically significant DiD treatment effect. This suggested that treatment group experienced a greater reduction in per capita carbon emissions after the treatment, compared to the control group in case of our sample economies. Per capita GDP is found to have a significant contribution in co2 emission. These results support the finding of Chi, et al., (2024) and Yunzhao, (2022) summarizing that economic growth threatens environmental quality. It indicated that higher growth cause carbon emissions because of higher industrial activity, energy consumption, and transportation needs, resulting in greater fossil fuel use and deforestation and hence, degrading the environment.

Energy use as an explanatory variable also enter with positive sign suggesting that it cause carbon emission which is quite understandable as in emerging economies energy need is primarily met from conventional sources i.e. natural gas, oil and coal which cause environmental degradation by emitting carbon dioxide. Our results support the findings of Khan et al., (2021).

Renewable energy (RE) enters in our model with significantly reduction impacts on carbon emission in E-7 economies. These outcomes are in support of previous literature (i.e. Chi, et al., 2024). It reduces carbon emissions by replacing fossil fuels with cleaner alternatives. The RE sources does not emissions and therefore are environmentally friendly. Population too comes with a cause of carbon emissions which is justifiable as shown by Khan et al., (2021) by discussing that more people require energy for housing, transportation, and consumption. This heightened demand leads to greater use of conventional energy use, resulting in higher carbon emissions.

Manufacturing processes, especially in heavy

industries, are energy-intensive and contribute significantly to carbon emissions. As E-7 economies focus on manufacturing exports, the energy consumption in these sectors increase. Exporting goods also involves transportation, which adds to carbon emissions through fuel consumption in shipping and logistics.

Improvements in HDI often correlate with better living standards, higher energy consumption, and consequently, higher carbon emissions. As people gain better access to electricity, transportation, and other amenities, energy use rises. While higher HDI can lead to greater environmental awareness and potential adoption of greener technologies, the transition period often involves increased energy use and emissions.

Higher GFCF indicates more investment in infrastructure, machinery, and buildings. Construction and development activities are energy-intensive and lead to higher carbon emissions. Investment in industrial capacity can lead to an expansion of energy-intensive industries, further increasing emissions.

Table 4: Linear regression (Dependent Variable: CPC)

	Coef.	St. Err.	t-value	p-value
Did interaction	-.087	0.0345	-2.52	.006
GDPPC	.443	0.1372	3.2288	0.000
Ener use	0.712	0.2784	2.5574	0.008
Renco	-.023	.0041	-5.6097	0.000
TOTPOP	0.9162	0.4187	2.1882	0.017
Manu Exports	.0140	.0030	4.6666	0.000
HDI	.0790	.0210	3.7619	0.000
GFCF	.0510	.0080	6.375	0.000
Constant	-1.2620	.3600	-3.51	.001
R-Sq.: 0.078				
F-Stat: 1764.399 (0.000)				

5. Conclusion and Policy Implications:

5.1. Conclusion

This study analyzed the pre-and post-treatment carbon emission in seven emerging economies. Data from WDI and UNDP covered the period from 1991 to 2022. By using the Difference in Difference approach, the analysis reveals that interventions have effectively reduced per capita carbon emissions in the treatment group of E-7 economies compared to the control group. Economic growth, measured by per capita GDP, significantly contributes to carbon emissions, driven by increased industrial activity, energy consumption, and transportation needs. Energy use, predominantly from conventional sources, further increases emissions, while renewable energy demonstrates a substantial reduction impact, underscoring the importance of transitioning to cleaner alternatives. Population growth also causes emissions of carbon dioxide because of the increased energy demands and use. Additionally, the manufacturing sector, although is the backbone of the economy but cause carbon emission to a considerable extent and therefore urges for the adoption of clean and green technologies. HDI and GFCF both were found to be a cause of carbon emission. These outcomes suggested that there is a need for promotion to adopt clean technologies to mitigate carbon emission.

5.2. Policy Implications

Following policy suggestions can be put forward to the concerned authorities to combat environmental degradation caused by carbon emissions.

- Adopting renewable energy is helpful in mitigation of carbon emission and therefore, it is suggested that the authorities may improve it by investing more in R&D which will help in advancement of technologies that will further facilitate the storage and use of renewable energy.
- The prime objective of every economy is to achieve the desirable economic growth, but it

comes with energy use and thus emissions. Therefore, the growth has to be channelized by enforcing strict environmental regulations. Industrial and urban development should be aligned with these environmental regulations to minimize the environmental threats.

- Controlled population with public awareness programs will help in carbon mitigation. Government agencies should promote sustainable lifestyles where collective actions will be needed to drive the environmentally friendly practices.

REFERENCES

Aichele, R., & Felbermayr, G. (2012). Kyoto and the carbon footprint of nations. Journal of Environmental Economics and Management, 63(3), 336-354.

Barrett, S. (1998). Political economy of the Kyoto Protocol. *Oxford review of economic policy*, *14*(4), 20-39.

Barrett, S., & Stavins, R. (2003). Increasing participation and compliance in international climate change agreements. International Environmental Agreements, 3, 349-376.

Bosetti, V., Carraro, C., De Cian, E., Massetti, E., & Tavoni, M. (2013). Incentives and stability of international climate coalitions: An integrated assessment. Energy Policy, 55, 44-56.

Chi Keung Lau, Gupteswar Patel, Mantu Kumar Mahalik, Bimal Kishore Sahoo & Giray Gozgor (2024) Effectiveness of Fiscal and Monetary Policies in Promoting Environmental Quality: Evidence from Five Large Emerging Economies, Emerging Markets Finance and Trade, 60:1, 203-215, DOI: 10.1080/1540496X.2023.2210716

Dimitrov, R. S. (2010). Inside Copenhagen: the state of climate governance. Global environmental politics, 10(2), 18-24.

Falkner, R., Stephan, H., & Vogler, J. (2010). International climate policy after Copenhagen: Towards a 'building blocks' approach. Global Policy, 1(3), 252-262.

Finus, M., Altamirano-Cabrera, J. C., & Van Ierland, E. C. (2005). The effect of membership rules and voting schemes on the success of international climate agreements. *Public Choice*, *125*(1), 95-127.

Huang, W. M., Lee, G. W., & Wu, C. C. (2008). GHG emissions, GDP growth and the Kyoto Protocol: A revisit of Environmental Kuznets Curve hypothesis. *Energy Policy*, *36*(1), 239-247.

Khan, N. H., Ju, Y., Danish, Latif, Z., & Khan, K. (2021). Nexus between carbon emission, financial development, and access to electricity: Incorporating the role of natural resources and population growth. *Journal of Public Affairs*, *21*(1), e2131. https://doi.org/10.1002/pa.2131

Protocol, K. (2010). Framework convention on climate change. *Kyoto Protocol*.

Rice, D. The U.S. Is Now the Only Country Not Part of Paris Climate Agreement after Syria Signs On. USA Today. 7 November 2017.

Ringius, L., Torvanger, A., & Underdal, A. (2002). Burden sharing and fairness principles in international climate policy. International Environmental Agreements, 2, 1-22.

Watson, R. T., Noble, I. R., Bolin, B., Ravindranath, N. H., Verardo, D. J., & Dokken, D. J. (2000). Land use, land use change, and forestry (pp. ix+-373).

Weikard, H. P., Finus, M., & Altamirano-Cabrera, J. C. (2006). The impact of surplus sharing on the stability of international climate agreements. Oxford Economic Papers, 58(2), 209-232.

Yunzhao, L. (2022). Modelling the role of eco innovation, renewable energy, and environmental taxes in carbon emissions reduction in E− 7 economies: evidence from advance panel estimations. Renewable Energy, 190, 309-318.