

Antecedents To Climate Change: Study Of Top Economies

Bunny Singh Bhatia¹, Amanjot Kaur², Parveen Kaur Lamba³

¹Assistant Professor, Department of Commerce, SGTB Khalsa College, Delhi University, Delhi, India, bunny@sgtbkhalsa.du.ac.in

²Guest Faculty, Department of Commerce, SGTB Khalsa College, Delhi University, Delhi, India, amanjotkaur9396@gmail.com

³Associate Professor, Department of Commerce, SGTB Khalsa College, Delhi University, Delhi, India, parveenklamba@sgtbkhalsa.du.ac.in

Abstract

This paper intends to explain the significance and implications of climate change across developed and developing nations. We intend to explore the association between carbon emission and economic growth for three top economies the USA, China and India using VECM. Further, various mitigation strategies have also been suggested to curb the effects of climate change. Carbon emission is granger causing economic growth in the Indian context only. The coefficient of DDCO is -0.37 and it is significant at 5 percent level. It suggests that a rise in carbon emission by one percent leads to decline in GDP by 0.37 percent keeping other things constant. The effect of carbon emission is significant for India only, but not for the USA and China.

Key words: Climate Change, GDP, Implications, Mitigations, Granger Causality

Climate change refers to disturbances in the climate such as global warming, extreme weather, frequent weather changes, sea level rise and ocean acidifications. It has been seen that in order to achieve higher economic growth, many countries opt for industrialization overlooking its harmful effects on climate. In December 2015, Paris Agreement on the issue of climate change was signed by more than 180 countries, wherein these countries pledged to take mitigation initiatives to curb carbon emissions. In the long run, the impact of climate change has economic implications on the growth and sustainable development of a nation. The problem arises from the fact that economic development through industrialization leads to emission of gases from harmful fossil fuels and other sources. The rise in carbon emission leads to more deaths due to increase in air pollution and climate disturbances. These disturbances could also lead to loss of GDP through impact on climate penetrating sectors. The number of natural catastrophe events and man-made disasters keeps on increasing year after year. These events result in huge losses because increased urbanization, dense populations, concentration of assets leads to augmented economic losses. Climate change poses rigorous challenges to economic growth, with its impacts varying across different regions and economic contexts. Understanding the relationship between climate change and economic growth is crucial for formulating effective policies that mitigate negative effects while promoting sustainable development.

Sustainable growth is essential to mitigate the harmful effects of climate change. Policies that focus on investment in skills, access to finance, infrastructure, and entrepreneurship can help mitigate climate risks (Bowen et al., 2012). However, excessive near-term mitigation efforts could pose a threat to long-term economic growth (Mendelsohn, 2009). Climate change can lead to an unequal income distribution, affecting the poor section of the society. Climate policies addressing the issues of market failures can contribute towards the growth and reduce carbon emissions, potentially increasing incomes and employment in a more sustainable manner.(Rezai et al., 2018; Stern & Stiglitz, 2023).

Environmental policies, particularly those that are stringent, can effectively reduce environmental damages associated with economic growth. The relationship between economic growth and environmental quality can be depicted through an inverted U-shaped or N-shaped pattern, depending on the stringency of environmental regulations (De Angelis et al., 2019).

The consequences of climate change on economic paradigms vary by region. In Africa, for example, temperature changes have different impacts depending on the climate zone, with some regions showing greater resilience and adaptability (Zhao & Liu, 2023). Similarly, some analyses indicate that climate change has both direct and indirect impacts on economic parameters, particularly in developing countries

(Benhamed et al., 2023). While climate change presents significant challenges to economic growth, the impacts are not uniform across regions or economic contexts. Effective growth policies and stringent environmental regulations can mitigate some of the negative effects, but careful consideration of regional differences and income distribution is essential for developing comprehensive strategies. International collaboration is crucial for designing and implementing effective climate change mitigation and adaptation strategies (Bowen et al., 2012; Benhamed et al., 2023; Zhao & Liu, 2023). While climate change presents significant challenges to economic growth, the impacts are not uniform across regions or economic contexts. Effective growth policies and stringent environmental regulations can mitigate some of the negative effects, but careful consideration of regional differences and income distribution is essential for developing comprehensive strategies. International collaboration is crucial for designing and implementing effective climate change mitigation and adaptation strategies (Bowen et al., 2012; Benhamed et al., 2023; Zhao & Liu, 2023).

Carbon Emission and Economic growth

The relationship between carbon emissions and economic growth is a critical area of study, particularly in the context of sustainable development and environmental policy. Understanding this nexus is essential for formulating strategies that balance economic advancement with environmental conservation. There is a bidirectional causality between economic growth and carbon emissions, meaning that as economic growth increases, carbon emissions tend to rise, and vice versa. This relationship suggests that efforts to reduce emissions could potentially impact economic growth negatively (Mardani et al., 2019; Zhang et al., 2019). Studies have shown varying degrees of decoupling between economic growth and carbon emissions across different regions and sectors. For instance, China's construction industry shows significant spatial differences in decoupling states, indicating regional variations in how economic growth relates to carbon emissions (Du et al., 2019; Wang & Jiang, 2019). Globally, a three-step decoupling process has been observed, where economic growth first decouples from carbon intensity, then from carbon emissions per capita, and finally from total carbon emissions (Shuai et al., 2019). In developing countries, economic growth and energy consumption are significant sources of carbon emissions, whereas in developed countries, this link is less pronounced. This suggests that developing countries may face more challenges in reducing emissions without hindering economic growth (Waheed et al., 2019; Acheampong, 2018). In China's agricultural sector, there is evidence supporting the Environmental Kuznets Curve (EKC) hypothesis, where economic growth initially leads to increased emissions, but eventually results in reduced emissions as the economy matures (Zhang et al., 2019). In contrast, India's economic growth is negatively impacted by CO₂ emissions, highlighting the need for a shift towards renewable energy sources (Udemba et al., 2021). A common recommendation across studies is the transition from non-renewable to renewable energy sources to reduce carbon emissions while supporting economic growth. This transition is crucial for both developing and developed countries to achieve sustainable development goals (Waheed et al., 2019; Udemba et al., 2021). Adjusting the industrial structure to reduce dependence on fossil fuels and enhance energy efficiency is vital. For example, in China, sectors like construction and transportation are positively correlated with carbon emissions, suggesting a need for targeted policy interventions (Dong et al., 2020; Wang & Jiang, 2019).

Financial Impacts of Climate Change

Climate change is expected to have a limited impact on the global economy in the short term, with some initial positive effects. However, in the long run, negative impacts are likely to dominate, particularly in poorer, hotter, and lower-lying countries (Mendelsohn, 2009; Tol, 2018; Tol, 2009). These regions are more vulnerable to climate change, which can exacerbate poverty and hinder economic growth (Tol, 2018; Benhamed et al., 2023).

There are climate sensitive sectors such as agriculture, forestry, tourism), which will be affected by any kind of adversity in the climate. Therefore, in the long run, climate change will affect GDP. It is estimated to lose 2 %, if temperature rises by 3 % over a long period of time. Further there will be eco system disturbances and health issues due to that. The greater impact will be on the region that is having higher initial temperature and low growth rate

Table 1

Country / Regions	Impact of Climate Change	Reason for implications
Sub-Saharan Africa	High	labor productivity and health
South East Asia	High	sea level rise and agriculture
Middle East and North Africa (MENA)	High	Water scarcity
United States,	Average	Negative labor productive offset by tourism and agriculture
Europe	Average	Crop productivity and tourism
China	Average	Increase crop productivity

Source Author own

Developing countries are more vulnerable as compare to developed countries due to the following reasons

- Large agricultural sectors,
- Higher rainfall variability,
- Climate related natural disaster

The findings of Dasgupta (2007) suggested that Small Island and countries like Bangladesh, Mauritius, Egypt, Guyana and other small island could face loss of 10% GDP due to the impact of High Sea level.

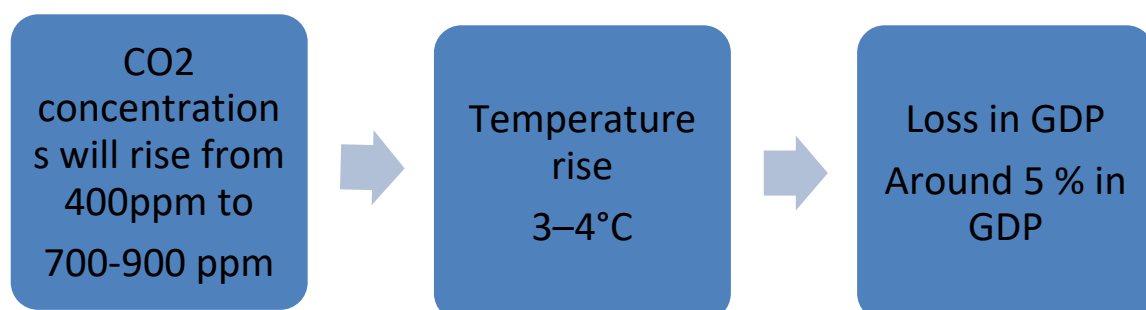
Tourism is also affected due to the negative effect of climate change. This will affect Exposure to climate change and related extreme weather events affecting tourism. Losses are expected for most developing countries while high attitude advanced economies would gain

Table 2.

Description	2014	Current
CO ₂ concentrations	1900	400ppm
CO ₂ Annual flow	280ppm	32 bmt
Temperature rise	2 bmt	0.8 C

Sources: IEA (2014), IPCC (2014).

The carbon dioxide emission rises from 280ppm to 400 ppm and annual flow of carbon emission keeps on rising. This has led to rise in temperature by 0.8 C. it has serious consequences for loss of output.



Projected variables without mitigation initiatives (2100)

Sources: IEA (2014), IPCC (2014).

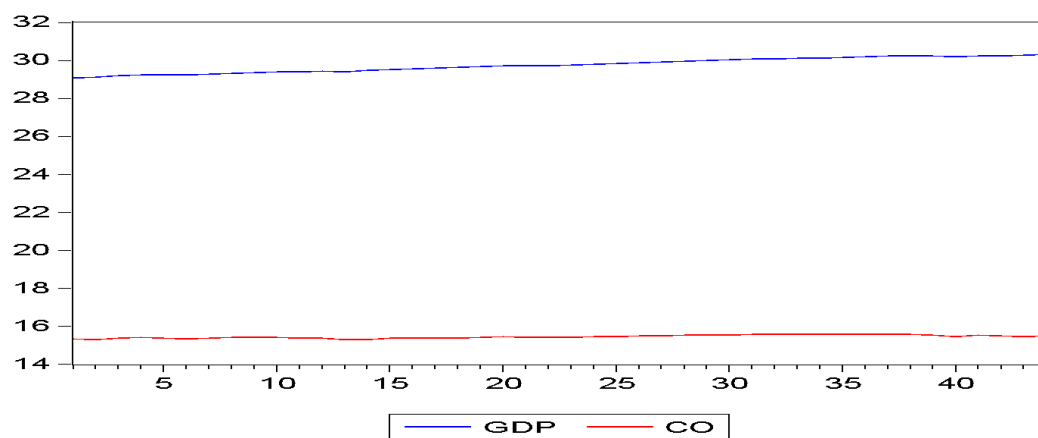
If things continue the same way, then it is the projection that by 2100, CO₂ concentration will rise to 900 ppm, which will bring temperature rise by 3-4 C. It will result in loss of GDP by 5%.

Empirical Investigations

The paper has selected three economies which include the USA, China and India. We have taken two variables that are natural log of GDP and natural log of CO₂ for the period 1970-2017. Then we have conducted an augmented dickey unit root test to check stationarity of the data. Accordingly, variables have been changed to first difference or second difference where they become stationary. Initially graphical representation has been made to give an indication of the relationship between CO₂ and GDP. Then Granger causality test has been conducted to know whether, carbon emission is affecting economic growth or economic growth is causing carbon emission. Further the tool of OLS regression has been conducted to assess the impact of carbon emission on economic growth and vice versa

United States of America

The USA has been selected to represent a developed and advanced economy. The relationship between carbon emission and GDP could be different as compare to developing economies like India and China. It can be easily seen from the graph that GDP is enhancing at a very moderate rate and Carbon emission remains stable during that period.



In the case of the USA, the result of Granger causality is not significant which means neither CO₂ is causing GDP, nor GDP is causing CO₂.

Table 3. Pairwise Granger Causality Tests

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DCO does not Granger Cause DGDP	41	0.06835	0.9341
DGDP does not Granger Cause DCO		1.16665	0.3229

The effect of economic growth on carbon emission

Then Regression analysis has been conducted.

$$DCO_2 = a + b \text{ DGDP} + e$$

Where DCO₂ is the first differential of natural log of carbon dioxide,

DGDP is the first differential of natural log of carbon dioxide

Table 4. Regression analysis

Dependent Variable: DCO

Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DGDP	0.490965	0.118542	4.141690	0.0002
R-squared	0.282356	Mean dependent var		0.003251
Adjusted R-squared	0.282356	S.D. dependent var		0.031736
S.E. of regression	0.026884	Akaike info criterion		-4.371553
Sum squared resid	0.030357	Schwarz criterion		-4.330595
Log likelihood	94.98839	Hannan-Quinn criter.		-4.356449
Durbin-Watson stat	1.762730			

The coefficient of GDP is 0.49 suggesting a positive relationship between GDP and Carbon emission. It suggests that 1% rise in GDP leads to 0.49% rise in carbon emission. The result is significant at 5% level. Adjusted R square is 0.28, which is good; given the fact that control variable is not used in our study

The effect of carbon dioxide emissions on growth

Regression analysis has been conducted to find out the impact of carbon dioxide emission on GDP.

$$DGDP = a + b \text{ DCO} + e$$

Where DCO2 is the first differential of natural log of carbon dioxide

DGDP is the first differential of natural log of carbon dioxide

Dependent Variable: DGDP

Method: Least Squares

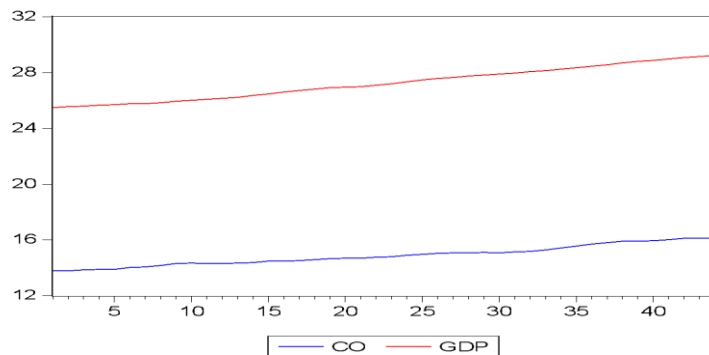
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCO	0.590641	0.142609	4.141690	0.0002
R-squared	-1.062344	Mean dependent var		0.028006
Adjusted R-squared	-1.062344	S.D. dependent var		0.020533
S.E. of regression	0.029488	Akaike info criterion		-4.186716
Sum squared resid	0.036520	Schwarz criterion		-4.145758
Log likelihood	91.01439	Hannan-Quinn criter.		-4.171612
Durbin-Watson stat	0.361140			

The coefficient of carbon emission is 0.59 and it is significant at 5 percent level. It suggests carbon dioxide is positively affecting Economic Growth. But this model is not good as R square is negative.

China

China is the biggest emerging nation. It is achieving economic growth at a very high pace. It is interesting to see the relationship between carbon dioxide and economic growth in case of china.

As visible from the following graphical representation, both the variables are rising at a steady pace over the period of time. It shows that there is some relationship between economic growth and carbon emission.



Granger Causality test has been conducted to find out the direction of causality between economic growth and carbon emission. The result of Granger causality is not significant which means neither CO₂ is causing GDP, nor GDP is causing CO₂.

Pairwise Granger Causality Tests

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DDGDP does not Granger Cause DCO	40	0.19875	0.8207
DCO does not Granger Cause DDGDP		0.14366	0.8667

The results are similar with the results of USA. The results of granger causality are not significant.

The effect of economic growth on carbon emission

Dependent Variable: DCO

Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DDGDP	0.543363	0.322499	1.684854	0.0996
R-squared	-1.440627	Mean dependent var		0.056894
Adjusted R-squared	-1.440627	S.D. dependent var		0.045388

S.E. of regression	0.070907	Akaike info criterion	-2.431367
Sum squared resid	0.206141	Schwarz criterion	-2.389994
Log likelihood	52.05872	Hannan-Quinn criter.	-2.416203
Durbin-Watson stat	0.370170		

$$DCO2 = a + b \text{ DDGDP} + e$$

Where DCO2 is the first differential of natural log of carbon dioxide

DDGDP is the second differential of natural log of carbon dioxide
The coefficient of DDGDP is not significant and suggest that rise in economic growth does not have any effect on carbon emission, which is in line with the result of Granger causality test

The effect of Carbon emission on Economic Growth

The dependent variable is natural log of Gross Domestic Product at constant price and independent variable is natural log of carbon dioxide emissions

Dependent Variable: DDGDP

Method: Least Squares

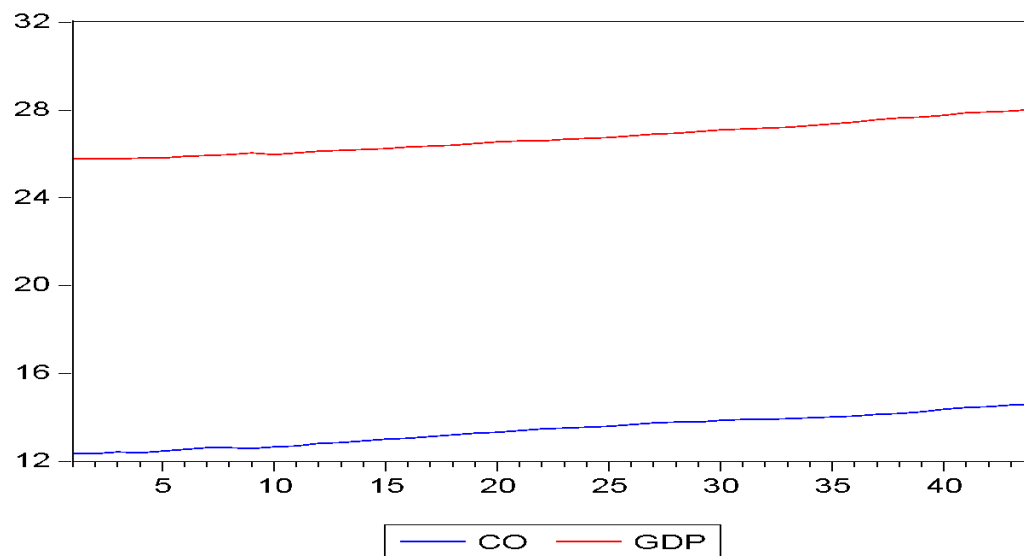
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCO	0.119173	0.070732	1.684854	0.0996
R-squared	0.064736	Mean dependent var		0.000149
Adjusted R-squared	0.064736	S.D. dependent var		0.034337
S.E. of regression	0.033207	Akaike info criterion		-3.948573
Sum squared resid	0.045212	Schwarz criterion		-3.907200
Log likelihood	83.92003	Hannan-Quinn criter.		-3.933408
Durbin-Watson stat	2.607840			

The coefficient of DCO is not significant and suggest that rise in carbon emission does not have any effect on economic Growth, which is in line with the result of Granger causality test

India

India is the third largest country in terms of carbon emission. Use of fossil fuel gases and greenhouse gases plays a major role in the economic growth of India on one hand. On the other hand, it leads to harmful carbon emission.

The graph clearly shows that both GDP and Carbon emission rose over these 44 years. It seems that carbon emission is rising at more pace than Economic growth for India.



The result of granger causality is not similar as compared to the USA and China. The results suggest that carbon emission is causing GDP to grow as P value is less than 0.05.

Pairwise Granger Causality Tests

Sample: 1 44

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DDGDP does not Granger Cause DDCO	40	0.20476	0.8158
DDCO does not Granger Cause DDGDP		8.10690	0.0013

The effect of Economic Growth on Carbon Emission

The following equation has been used to testify the impact of economic growth on carbon emission.

$$DDCO_2 = a + b D DDGDP + e$$

Where DDCO₂ is the first differential of natural log of carbon dioxide

DDGDP is the second differential of natural log of carbon dioxide

The coefficient of DDGDP is -0.32 and it is significant at 5 percent level. It suggests that a rise in economic growth leads to declining carbon emission. Since there is only one explanatory variable, adjusted R square is low at 0.12.

Dependent Variable: DDCO

Method: Least Squares

Sample (adjusted): 3 44

Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DDGDP	-0.325397	0.137335	-2.369364	0.0226
R-squared	0.119885	Mean dependent var		0.000933
Adjusted R-squared	0.119885	S.D. dependent var		0.037826
S.E. of regression	0.035486	Akaike info criterion		-3.815817
Sum squared resid	0.051630	Schwarz criterion		-3.774444
Log likelihood	81.13215	Hannan-Quinn criter.		-3.800652
Durbin-Watson stat	2.752307			

The effect of carbon emission on economic growth

The following equation has been used
 $DDGDP2 = a + b D DDCO + e$

Where DDCO2 is the first differential of natural log of carbon dioxide

DDGDP is the second differential of natural log of carbon dioxide

The coefficient of DDCO is -0.37 and it is significant at 5 percent level. It suggests that rise in carbon emission by one percent leads to a decline in GDP by 0.37 percent keeping other things constant. Since there is only one explanatory variable, adjusted R square is low at 0.12

Dependent Variable: DDGDP

Method: Least Squares

Sample (adjusted): 3 44

Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DDCO	-0.370113	0.156208	-2.369364	0.0226
R-squared	0.119636	Mean dependent var		0.001201
Adjusted R-squared	0.119636	S.D. dependent var		0.040336
S.E. of regression	0.037846	Akaike info criterion		-3.687054
Sum squared resid	0.058726	Schwarz criterion		-3.645681
Log likelihood	78.42814	Hannan-Quinn criter.		-3.671889

INTERPRETATION OF THE RESULT

The relationship between economic growth and carbon emission is not significant in the case of China and the USA. Graph analysis shows that there is some sort of relationship between economic growth and carbon emission in the case of China and USA. Granger Causality and Regression analysis for China shows there is a lack of relationship between Carbon emission and economic growth. China is one of the non-European union countries to reduce carbon emission at a very fast pace. China has started to use non fossil fuels resources and alternative resources to boost its economic growth. The result of India is slightly different than that of China and the USA. Granger causality result is significant for India only. It suggests that carbon emission is affecting economic growth. The possible explanation could be that there is a high degree of correlation between carbon dioxide emissions and economic growth in the case of emerging nations where industry, vehicles and consumption of electricity plays a significant role. The regression result for India suggests that carbon emission is hindering economic growth in India because high carbon emission leads to environmental deprivation in India, which is likely to reduce productivity and therefore affect economic growth. Moreover, several studies suggested that high pollution levels hamper worker productivity and affect growth. The effect of carbon change will be more on the developing countries than developed economies because these comprise more agricultural intensive sectors. India leads in the growth of carbon dioxide at 8 % comes out of generation of electricity as per the report of PWC. There is very high demand for coal in India.

Therefore, it can be concluded that uses of fossil fuel and dirty gases has serious consequences for India, which may not be seen now, but will look visible sooner or later. This consequence will have contagion impact on other advanced and developing nations as discussed earlier. Therefore, the need of the hour is to look into the mitigation strategies to curb dirty gases emissions.

The following are the suggestions which may be helpful in curbing carbon emission:

Carbon pricing

This is one of the effective instruments for curbing carbon emission. In this case, taxes are raised to increase the price of fuel products. Therefore, this will lead to use of alternative technology. In fact, this is beneficial for the interest of the domestic countries. More over this price will be a signal to the industries to use less polluted resources. In addition, this will earn revenue, which can be utilized for green resources.

Financial disclosure

It should be made mandatory for every company to show its carbon footprints and that will make the company more responsible. Stringent regulation will make companies and firms accountable.

Other mitigation strategies

- Promotion of catastrophe bonds and similar hedging instruments will be helpful in promotion of interest to be environmentally friendly and reduce the risk of carbon damage.
- Financial help should be provided by the advanced economies to the developing economies so that they can implement mitigation strategies to curb carbon emission effectively.
- Rise in Clean energy tax: Currently clean energy tax is Rs 50 per ton on the manufacture of coal and fossil fuels in India. It should be increased further so as to divert the resources towards greener alternatives.
- Global emission arbitration: there should be common targets for various countries in the curbing of carbon emission among various nations and international communities.
- Penalty for not achieving the target: It has been seen that targets are not achieved by nations in curbing carbon emission years after years. There should be provision of penalties so as to maintain discipline among nations to stick to the targets

CONCLUSION

In the end we can say that there is a myth that there is a positive relationship between environment degradation and economic growth that should be broken. Developing nations who are triggering economic growth should move towards the use of green resources. Advanced nations should not only give support to developing nations in curbing carbon emission, but also seek to reduce their dumping wastes into developing nations. In this paper only carbon emission is used as a variable. Other variables of environment and growth may be used in future study to give deeper insights into financial implication. Moreover, it may be possible that financial implications could be even more worse than which have been discussed in our paper. The complex relationship between carbon emissions and economic growth requires nuanced policy approaches that consider regional and sectoral differences. While economic growth can drive carbon emissions, strategic energy transitions and industrial optimizations can mitigate environmental impacts without stifling economic progress.

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