Empirical study of Carbon emission and economic development of Indian economy

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Abstract
Economic growth and a sustainable environment are critical for any economy. However, for a government, there are conflicting objectives. An increase in economic growth often leads to environmental degradation. Thus, maintaining a balance between the two objectives is essential. The balance between the variables requires monitoring and the reduction of carbon emissions across various socio-economic sectors. Carbon accounting encompasses a wide range of activities related to the calculation, measurement, verification, and reporting of greenhouse gases. This paper explains the relationship between Carbon Emission Accounting and Gross Value Added for selected Indian sectors. The study uses secondary data sourced from the IEA and RBI websites. Multiple regression is used in the study to explore the relationship between carbon emissions and gross value added across different sectors. The results show that during a low-growth regime, there is an inverse relationship between economic growth and carbon emissions. However, periods of accelerated economic growth depict a positive correlation between the variables. The research findings emphasizes the need for low-carbon technologies, aimed at reducing emissions and promoting sustainable economic growth. This includes energy-efficient technology and replacing non-renewable energy with renewable energy.

Keywords: Carbon emission, Carbon accounting, Gross value added GDP,IEA, RBI
Introduction

Introduction

Economic growth is critical for increasing income, improving employment and a country's welfare. However, it often comes with environmental cost. For developing countries like India, where there is high demand for energy, urbanisation, and industrialisation, the environmental cost of economic growth is an important concern. In developing countries, economic growth is driven by fossil fuels, primarily coal. Consequently, balancing economic growth, urbanisation, and poverty alleviation, while fulfilling international climate requirements, poses a critical challenge for developing countries. The policy question is therefore not whether the country should focus on production at the environmental cost, but how economic growth can be attained using less carbon-intensive methods over time.

To maintain the critical balance between environmental and economic objectives, it is essential to measure and manage carbon emissions across socio-economic spheres. Consequently, carbon accounting plays an important role in measuring and managing carbon emissions. Carbon accounting not only covers the calculation, measurement, and management of carbon but also covers the major tendencies in emissions. It also covers the monetary and strategic aspects of carbon emission. It extends to the complete supply chain of a product, and extends from environmental management accounting to climate accounting. Production-level carbon emissions can be collected using a bottom-up approach to determine further supply chain-level carbon emissions. Carbon accounting plays an important role in carbon management and protects the interests of various stakeholders. There are many frameworks and schemes to report the carbon emissions of businesses to investors or other stakeholders, and one can also find out the relationship between carbon and GHG emissions and the growth of a country (the gross value adde**d).**

Recent statistics reveal that despite India's economic growth, the annualised carbon emission have remained below under 1%. While this points to a structural transition, the primary question remains whether this represents a temporary deviation or a definitive structural shift toward an Environmental Kuznets Curve (EKC) inflexion point. This paper provides an empirical evaluation of the relationship between economic output, energy consumption, and environmental degradation in India.

Literatutre Review

To assess the impact of economic growth on carbon emissions, it is important to measure and manage carbon emissions across socio-economic spheres. In this context, carbon accounting plays an important role. Various researchers have investigated the concept of carbon accounting. According to Ascui and Lowell (2011), carbon accounting includes estimating, calculating, measuring, monitoring, reporting, validating, and verifying carbon dioxide and greenhouse gas emissions. Similar results were documented by Burritt-Tingey-Holyoak (2012).Schaltegger and Csutora (2012) extended the definition and explained that scientific carbon accounting encompasses major trends in emissions, raises awareness and references of carbon emissions aligning with the scope of sustainability. The development of carbon accounting has been extended to environmental management accounting, encompassing supply chain, product issues, climate accounting, etc. According to the GHG Protocol, carbon accounting includes greenhouse gases covered by the Kyoto Protocol: nitrous oxide (N2O), methane (CH4), hydro-fluorocarbons (HFCs), chlorofluorocarbon (PFCs) and sulfur hexa-fluoride (SF6).

Burritt et al. (2011) and Ascui and Lowell (2012) established the explicit link between the physical dimensions of carbon output (absolute mass) and monetary accounting metrics (financial risk, valuation, and carbon pricing). The study was able to effectively internalise the environmental externalities directly onto corporate balance sheets and into macroeconomic models.

There are various research papers examining the empirical relation between carbon emissions and economic growth. Murthy, Panda, and Parikh (2009) explored the direct macroeconomic trade-offs of environmental policy. The empirical simulations demonstrated that imposing rigid carbon limits on the Indian economy led to noticeable contractions in real GDP growth and adversely affected the efforts of poverty alleviation. The study argued that because the elasticity of substitution between fossil fuels and renewable energy was low, carbon mitigation strategies should favour market-oriented carbon pricing rather than blunt emission constraints. Shahbaz et al. (2015) applied the co integration approach and VECM Granger causality from 1970 to 2012 to explore the relationship between economic growth and environmental degradation. The study introduced financial development as a critical variable affecting carbon emissions. The empirical results documented a positive relation between economic growth and carbon emissions; however, financial development is inversely related to emissions. Thus, despite economic growth, financial development reduces carbon emissions. It enables firms to invest in energy-efficient infrastructure and clean technology.

Ahmad et al. (2016) in his study used Auto-regressive Distributed Lag (ARDL) Bounds Testing and Vector Error Correction Model on data from 1971 -2014. The study validated a long-run co-integrating relationship between real GDP per-capita, energy consumption, and carbon intensity at the aggregate level. However when the analysis was done sector wise isolating the structural drivers, revealing that agricultural and industrial energy consumption exerted distinct marginal loads on environmental quality.Akalpler and Hove (2019) challenged the optimistic conclusions of traditional EKC models. The research used ARDL co-integration framework and structural break modeling from 1980–2017. The study revealed when India's severe industrial shifts are modeled endogenously, the relationship between real GDP per capita and carbon emissions appears monotonically increasing rather than inverted U-shaped. The study concluded that India has not reached the threshold of economic development necessary to organically decouple economic expansion from carbon pollution, primarily due to the country's intense reliance on fossil fuels. Khoshnevis Yazdi and Dariani (2019) conducted a comparative analysis of selected BRICS countries to study the relation between economic development and carbon emission . Using Panel Co-integration, and Panel Granger-Causality the study documented a distinct bidirectional Granger causality between economic development and energy utilization. For India specifically, the study highlighted that urbanization creates a structural shift in energy delivery systems—replacing traditional bio-mass with highly centralized, coal-fired grid electricity, which inherently amplifies the emission elasticity of GDP growth.Goswami et al. (2024)mapped the multi-variable macro-drivers of India's post-liberalization expansion. Using time-series ARDL models and Granger Causality testing from 1990 to 2020 the study demonstrated a positive, and statistically significant long-run impact of both real GDP and urban migration on carbon accumulation.

Rajpurohit, S. S., & Sharma, R. (2021) studied the impact of trade openness and financial development on carbon emissions in India. The study is based on the premisis that macroeconomic shocks do not react symmetrically, this study tested how positive and negative shocks to trade and economic growth impacted India's environment.Using Non-linear ARDL (NARDL) framework the study documented asymmetric affect of economic growth on carbon emission. High economic growth increased the carbon footprint, whereas economic contractions did not yield a symmetrical reduction in emissions.

Sharma et al. (2021) studied the impact of financial development, trade openness, and economic growth on Carbon dioxide emissions in BRICS countries. Using Cross-Sectional Augmented Autoregressive Distributed Lag (CS-ARDL) and panel data modelling, (2000–2018) **,** the study documented that trade openness led polluting industries to shift to countries with less strict environmental rules, in the short run. However, the long-run parameters suggested that as GDP increases, the composition affects the shifts towards service-oriented and less carbon-intensive growth dynamics.

Tukhtamurodov et al. (2024) used non-linear panel quantile regression from 2000 to 2023 to study the impact of digitisation on carbon emissions. The research shows that for lower and median quantiles, technological innovation and digitalisation help to reduce carbon emissions. Technological upgradation optimises supply chains, thereby reducing carbon emissions. However, for higher quantiles, the scale of manufacturing and economic growth remained a dominant driver of carbon emissions. Kumar et al. (2025) in their research focused on a specific Indian state - Haryana. The researchers studied the data from 2005 to 2023 and used Dynamic ARDL (DARDL) simulations. Using time-series data, the study demonstrated that regional GDP growth leads to localised carbon emission fueld by agriculture and industrial growth.

Despite the growing body of literature on green economics, a systematic review reveals three critical gaps. There are limited studies on the relationship between economic growth and carbon emissions in India. Additionally, existing research focuses on macroeconomic models using top-down macro variables. There is limited research on state-level data. Furthermore, there is no comprehensive research that breaks down both carbon dioxide and greenhouse gas emissions. Finally, there is no study comparing India's carbon emissions and GDP to those of the USA and China.

To address the identified gaps in the literature, this paper aims to evaluate carbon emissions and broader greenhouse gas (GHG) volumes across specific Indian economic sectors on an annualized basis. Additionally, it seeks to model the dynamic relationships between these sector-specific carbon emissions and their respective Gross Value Added (GVA). Finally, the paper contrasts India's carbon emission and GDP values directly against those of the United States and China.

Objectives

This paper has following objectives:

- To study the carbon emission and GHG sector wise and year wise.
- To compare the carbon emission per capita with respect to USA and China.
- To find out the carbon emission relationship with respect to Gross value added of selected sectors of Indian economy.

Hypothesis

There are following hypothesis of this paper:

- Ho(a) : Carbon emission is directly related to gross value added of selected sectors.
- Ho(b): GHG emission is directly related to gross value added of selected sectors.
- H1(a): Carbon emission is not directly related to gross value added of selected sectors.
- H1(b): GHG is not directly related to gross value added of selected sectors.

Research Methodology

The data collected for this paper is from secondary sources. The CO2 emission and GHG emission data was collected from the GHG portal and IPCC platform whereas gross value added data for selected industry was collected from the RBI website (Handbook of statistics). Data of emission of China and USA has been collected from world o meter.The data is classified according to the need of objectives.

Data analysis

The date presented in the table 1, explain the growth in Fossil Carbon dioxide of India. The data shows that growth of CO2 emissions per capita. There has been a constant increase in CO2 emission and CO2 emission per capita since 2010.There was a little dip in Carbon emission in 2020 during the COVID times. Also India's share in of carbon-dioxide emission is growing over the period of time.

Table 1 : Carbon Dioxide emission in India

Year	India -fossil CO2 emissions (tons)	CO2 emissions change	CO2 emissions per capita	Share of World's CO2 emissions

2010	**1,730,054,152**	**6.72%**	**1.41**	**5.09%**
2011	**1,845,643,741**	**6.68%**	**1.48**	**5.27%**
2012	**2,015,287,562**	**9.19%**	**1.6**	**5.68%**
2013	**2,072,625,613**	**2.85%**	**1.62**	**5.73%**
2014	**2,237,664,734**	**7.96%**	**1.73**	**6.15%**
2015	**2,278,229,605**	**1.81%**	**1.74**	**6.28%**
2016	**2,311,977,119**	**1.48%**	**1.75**	**6.35%**
2017	**2,441,201,462**	**5.59%**	**1.82**	**6.59%**
2018	**2,556,718,912**	**4.73%**	**1.89**	**6.74%**
2019	**2,551,485,098**	**−0.2%**	**1.86**	**6.71%**
2020	**2,356,958,991**	**−7.62%**	**1.7**	**6.51%**
2021	**2,597,934,323**	**10.22%**	**1.86**	**6.80%**
2022	**2,807,080,475**	**8.05%**	**1.99**	**7.28%**
2023	**3,014,522,625**	**7.39%**	**2.12**	**7.71%**
2024	**3,153,829,130**	**4.62%**	**2.19**	**7.96%**

https://www.worldometers.info/co2-emissions/india-co2-emissions/

Table 2: Carbon Dioxide emission in India with respect to GDP

Year	GDP ($Trillion)	fossil CO2 emissions (tons)	% change in CO2 emission	%change in GDP
2010	1.676	**1,730,054,152**		
2011	1.823	**1,845,643,741**	6.7%	8.7%
2012	1.828	**2,015,287,562**	9.2%	0.27%
2013	1.857	**2,072,625,613**	2.8%	1.58%
2014	2.039	**2,237,664,734**	8.0%	9.8%
2015	2.104	**2,278,229,605**	1.8%	3.18%5
2016	2.295	**2,311,977,119**	1.5%	9.07%
2017	2.651	**2,441,201,462**	5.6%	15.5%
2018	2.703	**2,556,718,912**	4.7%	1.96%
2019	2.836	**2,551,485,098**	-0.2%	4.92%
2020	2.675	**2,356,958,991**	-7.6%	-5.67%
2021	3.167	**2,597,934,323**	10.2%	18.39%
2022	3.346	**2,807,080,475**	8.1%	5.65%
2023	3.638	**3,014,522,625**	7.4%	8.72%
2024	3.91	**3,153,829,130**	4.6%	7.47%

https://www.worldometers.info/co2-emissions/india-co2-emissions/

The table 2 confirm that increase in the GDP is not directly proportion to the CO2 emission. As in the year 2011 GDP is grown by 0.27% but CO2 has grown by 9.2% but 2014 the trend is reverse as government has introduced various measures to reduce the CO2 emission. This is evident from the data where GDP growth for the period 2015 to 2021, is higher the growth of carbon emissions. Post COVID 2021 GDP grew by 18.39% however the carbon emission grew by 10.2%. Thus the relation between the two variables is not clearly depicted.

Table 3: Carbon Dioxide emission in India , China and USA

China			USA		India	
Year	**CO2 emissions per capita**	**Share of World's CO2 emissions**	**CO2 emissions per capita**	**Share of World's CO2 emissions**	**CO2 emissions per capita**	**Share of World's CO2 emissions**
2010	**6.7**	**26.81%**	**17.89**	**16.25%**	**1.41**	
2011	**7.28**	**28.42%**	**17.06**	**15.15%**	**1.48**	**5.09%**
2012	**7.47**	**28.94%**	**16.24**	**14.34%**	**1.6**	**5.27%**
2013	**7.78**	**29.74%**	**16.56**	**14.44%**	**1.62**	**5.68%**
2014	**7.83**	**29.90%**	**16.5**	**14.41%**	**1.73**	**5.73%**
2015	**7.69**	**29.62%**	**16.04**	**14.14%**	**1.74**	**6.15%**
2016	**7.68**	**29.61%**	**15.61**	**13.82%**	**1.75**	**6.28%**
2017	**7.8**	**29.71%**	**15.29**	**13.40%**	**1.82**	**6.35%**
2018	**8.15**	**30.41%**	**15.66**	**13.50%**	**1.89**	**6.59%**
2019	**8.32**	**31.08%**	**15.1**	**13.07%**	**1.86**	**6.74%**
2020	**8.4**	**33.04%**	**13.48**	**12.34%**	**1.7**	**6.71%**
2021	**8.79**	**32.84%**	**14.24**	**12.44%**	**1.86**	**6.51%**
2022	**8.74**	**32.48%**	**14.33**	**12.49%**	**1.99**	**6.80%**
2023	**9.08**	**33.29%**	**13.64**	**11.81%**	**2.12**	**7.28%**
2024	**9.13**	**33.12%**	**13.59**	**11.69%**	**2.19**	**7.96%**

https://www.worldometers.info/co2-emissions/india-co2-emissions/

Additionally table 3 depicts the Carbon Dioxide emission in India vs China and USA. The table shows that China contributes maximum to the world's carbon's emission. In 2024 China contributed 33.12% of carbon emission while for USA this percentage was 11.69% and India 7.96%. In terms of carbon emission per capita USA is the highest with 13.59 in 2024 followed by China 9.13 and India 2.19.

Table 4: Sector wise carbon emission in India

Sector	Power Industry	Buildings	Transport	Other industrial combustion	Other sectors
2010	789.77	154.87	192.92	445.87	168.92
2011	833.54	142.44	209.29	482.49	186.06

2012	959.91	154.12	221.52	468.22	215.84
2013	969.22	150.10	226.26	509.20	221.52
2014	1080.98	158.86	235.75	542.66	214.39
2015	1061.57	162.77	257.74	544.611	222.38
2016	1054.36	167.25	269.38	566.68	234.27
2017	1100.31	174.43	291.44	595.32	240.15
2018	1173.92	179.73	296.05	626.33	250.86
2019	1176.12	183.86	305.48	631.90	266.28
2020	1110.32	168.54	276.63	591.79	264.42

https://www.worldometers.info/co2-emissions/india-co2-emissions/

Table 4 depicts that Power Industry is the main source of carbon emission in India followed by industrial combustion, transport and buildings. Coal and oil are the biggest contributors in carbon emissions followed by emission caused by vehicles.

Table 5 : Descriptive Analysis of CO2, GHG and GVA

	C02	GHG	GVA
Mean	16.25879	100.9736	6026.728
Median	0.008171	0.059260	3747.082
Maximum	56.65117	383.7949	18721.15
Minimum	0.000000	0.000000	861.4100
Std. Dev.	23.29661	149.6099	4995.250
Skewness	0.749446	0.884275	1.120811
Kurtosis	1.625652	1.971850	3.298711
Jarque-Bera	5.686326	5.754190	7.031879
Probability	0.058241	0.056298	0.029720
Sum	536.5401	3332.127	198882.0
Sum Sq. Dev.	17367.42	716259.7	7.98E+08
Observations	33	33	33

Source :Authors calulation

The table 5 provide the descriptive analysis of the return series of the three variables CO2, GHG and GVA of selected sectors. Where total observations are 30 and Jarque-Bera statistics provide that CO2 is 91.04984, GHG is 74.60086 and in case of the GVA of selected sectors is 79.2115.

Panel Regression - fixed. Further a panel least squares test was conducted for the period from 2005 to 2015 as audited data was available for this period only. Total periods included for this are 11 and 3 cross sections and total panel (balanced) observations 33.

Table 6 Return series CO2, GHG and GVA

	RETURN CO2	RETURN GHG	RETURN GVA
Mean	0.309039	0.039590	0.129181
Median	-0.063168	0.060932	0.063861
Maximum	9.196186	7.249964	0.858581
Minimum	-2.165120	-6.058353	0.001895
Std. Dev.	2.256491	1.977082	0.206677
Skewness	2.574182	0.779367	2.692817

Kurtosis	10.17893	11.15062	8.862098
Jarque-Bera	91.04984	74.60086	79.21157
Probability	0.000000	0.000000	0.000000
Sum	8.653106	1.029336	3.875432
Sum Sq. Dev.	137.4773	97.72130	1.238742
Observations	30	30	30

Source :Authors calulation

The dataset constitutes a time-series of observations from 2010 to 2024. The variables under analysis are Gross value added, Co2 and GHG emission. The data on Gross Value added has been taken from Hand book of Statistics –RBI. While the data of Co2 and GHG emission have been taken from GHG platform India and IPCC for the period of 2010 to 2024.

The data which was collected from the RBI and GHG platform has been classified into three sectors Mining and Quarrying, Manufacturing and Construction. Manufacturing includes Chemical , Textile and Leather, Food and Beverages , metal , Iron and steel , Non Ferrous Manufacturing of jewelry, sports and Musical instrument. Thus the total number of observation is 3*14*3= 126. These observations were put to test based on panel data regression. The dependent variable for return was cross sectional. For this purpose GVA was the dependent variable for Cross-section fixed (dummy variables) in the below table:

Table 7: Statistical analysis of GVA as dependent variable on Carbon emission

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-1.27E-12	1.32E-12	-9.56E-01	3.47E-01
C02	1.16E-13	7.07E-14	1.64E+00	1.12E-01
GHG	-3.51E-14	8.43E-15	-4.16E+00	3.00E-04
GVA	1.00E+00	9.76E-17	1.02E+16	0.00E+00
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	1	Mean dependent var		6026.728
Adjusted R-squared	1	S.D. dependent var		4995.25
S.E. of regression	1.06E-12	Akaike info criterion		-52.14759
Sum squared resid	3.02E-23	Schwarz criterion		-51.8755
Log likelihood	866.4352	Hannan-Quinn criter.		-52.05604
F-statistic	1.43E+32	Durbin-Watson stat		0.750504
Prob(F-statistic)	0			

Source :Authors calulation

Methodology:

To understand the relevant properties of the data, a number of analytical tools were employed such as mean and standard deviation. The mean indicates average value of the sample and standard deviation is the positive square root of the variance. It is a measure of dispersion, that is, it shows the extent of the deviation from the mean. The study applies panel data regression. For this purpose before applying the statistics we take logs of the variables to allow for an easier interpretation and comparison of the size of the estimated coefficients, and to control for heteroskedasticity and achieve linearity. The study uses panel data regression techniques taking into account the transversal information and the time period of ten years, in order to determine whether the variable CO2 and CHG emission of t has an effect on Gross Value added for different sectors. This methodology has the advantage of being able to take into account the individual characteristics of every sector. In our model Gross value added , is our dependent variable, It has following model:

The equation is GVA= $\alpha+\beta C02 +\omega$ GHG-------------------(1)

- Where GVA denotes Gross value added of different sectors selected for research with respect to this paper.
- Co2 refers to carbon dioxide emission of the specific sector
- GHG refers to GHG of the specific sector can be done by fixed or Random method.

The analysis is based on balanced panel data, in that it enables the observation of all the individual units in all the periods of time (Ti = T for all i), and it is considered short. The error term is undertaken as independent.

Dependent Variable: RETURNGVA				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.116779	0.041792	2.794291	0.0112
RETURNCO2	-0.0027	0.025593	-0.105502	0.0457
RETURNGHG	0.002317	0.029506	0.078535	0.0382
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	0.033509	Mean dependent var		0.115725
Adjusted R-squared	-0.159789	S.D. dependent var		0.188145
S.E. of regression	0.202621	Akaike info criterion		-0.178107
Sum squared resid	0.821101	Schwarz criterion		0.065668
Log likelihood	7.226343	Hannan-Quinn criter.		-0.110495
F-statistic	0.173353	Durbin-Watson stat		2.622464
Prob(F-statistic)	0.949487			

As a next step, we compared the fixed-effect model to the random-effect model using the Hausman test. In most cases, the test preferred, the specification with random effects for countries and fixed effects for periods. Given the relatively small number of observations, we have used the fixed effect. In fixed effect ,the individual effects are incorporated into the general model in order to capture the characteristics the unobserved factor of each sector, which are assumed as fixed on the time .However, the results from these two models were qualitatively and quantitatively similar, leading to same conclusions. The panel data controls individual heterogeneity. It also combines the time series with cross section observation thus providing additional information about them. Panel data contributes improved accuracy while calculating the regression model. The above analysis indicates an inverse relationship between emission of CO2 and Gross value added. However a direct relationship between GHG emission and Gross value added. However, an increase in GDP growth will lead to an increase in CO_2 emissions at high levels of income due perhaps to increasing presence of manufacturing industries. In other words, during the early stages of development, CO_2 emissions would decrease but increases at later stages after GDP exceeds the threshold parameter. Again since being in upper regime connotes economic boom period, individuals as well as firms will have more income and this may lead to increased consumption of energy from electric devices, transportation, appliances among others that contribute to high pollution. The absolute sizes of the economic growth coefficient suggest that the correlation between economic growth and CO_2 is stronger when economic growth is higher. The effect of initial CO_2 emission is negative albeit not significant.

Conclusions

Although the literature on economic growth, energy consumption, population and CO_2 emission has grown over the last few years, there is no known study that examined the effect of economic growth on CO_2 emission using the dynamic panel threshold framework. This study investigated this relationship using data from 2010 to 2024 based on a panel of 31 developing countries. The results show that economic growth has negative effect on CO_2 emission when the economy is in the low growth regime but positive effect when in the high growth regime. The effect in the high growth regime is however stronger and energy consumption and population exert positive and significant effect on CO_2 emission. Robustness check with the inclusion of a financial development indictor and separation of middle- and low-income countries produced qualitatively similar results. In addition, the study performed causality analysis and it is concluded based on two alternative approaches that economic growth, energy consumption and financial development have significant causal relationship with CO_2 emission.

References

1. Abbasi, F., & Riaz, K. (2016). CO_2 emissions and financial development in an emerging economy: An augmented VAR approach. *Energy Policy, 90*, 102–114. https://doi.org/10.1016/j.enpol.2015.12.017
2. Ahmad, A., Zhao, Y., Shahbaz, M., Bano, S., Zhang, Z., Wang, S., & Liu, Y. (2016). Carbon emissions, energy consumption and economic growth: An aggregate and disaggregate analysis of the Indian economy. *Energy Policy, 96*, 131–143. https://doi.org/10.1016/j.enpol.2016.05.032
3. Ahmed, K., Rehman, M. U., & Ozturk, I. (2017). What drives carbon dioxide emissions in the long run? Evidence from selected South Asian countries. *Renewable and Sustainable Energy Reviews, 70*, 1142–1153. https://doi.org/10.1016/j.rser.2016.12.018
4. Akalpler, E., & Hove, S. (2019). Carbon emissions, energy use, real GDP per capita and trade matrix in the Indian economy: An ARDL approach. *Energy, 168*, 1081–1093.
5. Al-Mulali, U., Tang, C. F., & Ozturk, I. (2015). Estimating the Environmental Kuznets Curve hypothesis: Evidence from Latin America and the Caribbean countries. *Renewable and Sustainable Energy Reviews, 50*, 918–924. https://doi.org/10.1016/j.rser.2015.05.017
6. Antonakakis, N., Chatziantoniou, I., & Filis, G. (2017). Energy consumption, CO_2 emissions, and economic growth: An ethical dilemma. *Renewable and Sustainable Energy Reviews, 68*, 808–824. https://doi.org/10.1016/j.rser.2016.09.105
7. Ascui, F., & Lovell, H. (2011). As frames collide: Making sense of carbon accounting. *Accounting, Auditing & Accountability Journal, 24*(8), 978–999. https://doi.org/10.1108/09513571111184724

8. Boutabba, M. A. (2014). The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy. *Economic Modelling, 40*, 33–41. https://doi.org/10.1016/j.econmod.2014.03.005
9. Burritt, R. L., Schaltegger, S., & Zvezdov, D. (2011). Carbon management accounting: Explaining practice in leading German companies. *Australian Accounting Review, 21*(1), 80–98. https://doi.org/10.1111/j.1835-2561.2010.00121.x
10. Burritt, R. L., & Tingey-Holyoak, J. (2012). Forging cleaner production: The importance of academic–practitioner links for successful sustainability embedded carbon accounting. *Journal of Cleaner Production, 36*, 39–47. https://doi.org/10.1016/j.jclepro.2012.02.001
11. Charfeddine, L. (2017). The impact of energy consumption and economic development on ecological footprint and CO_2 emissions: Evidence from a Markov switching equilibrium correction model. *Energy Economics, 65*, 355–374. https://doi.org/10.1016/j.eneco.2017.05.009
12. Charfeddine, L., & Khediri, K. B. (2016). Financial development and environmental quality in UAE: Cointegration with structural breaks. *Renewable and Sustainable Energy Reviews, 55*, 1322–1335. https://doi.org/10.1016/j.rser.2015.07.059
13 Goswami, M., Premkumar, A., Kishan, R., & Nautiyal, S. (2024). A methodological perspective on inclusive assessment of household carbon footprint. *Environment, Development and Sustainability, 28*, 12255–12282. https://doi.org/10.1007/s10668-024-05390-y
14. Kasman, A., & Duman, Y. S. (2015). CO_2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling, 44*, 97–103. https://doi.org/10.1016/j.econmod.2014.10.022
15 Khoshnevis Yazdi, S., & Dariani, A. G. (2019). CO_2 emissions, urbanisation and economic growth: Evidence from Asian countries. *Economic Research-Ekonomska Istraživanja, 32*(1), 510–530. https://doi.org/10.1080/1331677X.2018.1556107
16 Le Breton, M., & Aggeri, F. (2018). Counting before acting? The performativity of carbon accounting called into question: Calculation acts and dispositifs in a big French construction company. *M@n@gement, 21*(2), 834–857. https://doi.org/10.3917/mana.212.0834
17 Narayan, P. K., & Narayan, S. (2010). Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. *Energy Policy, 38*, 661–666. https://doi.org/10.1016/j.enpol.2009.09.005
18 Parikh, J., Panda, M., Ganesh-Kumar, A., & Singh, V. (2009). CO_2 emissions structure of Indian economy. *Energy, 34*(8), 1024–1031.
19 Rajpurohit, S. S., & Sharma, R. (2021). Impact of economic and financial development on carbon emissions: Evidence from emerging Asian economies. *Management of Environmental Quality: An International Journal, 32*(2), 145–159. https://doi.org/10.1108/MEQ-03-2020-0043
20 Schaltegger, S., & Csutora, M. (2012). Carbon accounting for sustainability and management: Status quo and challenges. *Journal of Cleaner Production, 36*, 1–16. https://doi.org/10.1016/j.jclepro.2012.06.024
21 Shahbaz, M., Nasreen, S., Ahmed, K., & Hammoudeh, S. (2017). Trade openness–carbon emissions nexus: The importance of turning points of trade openness for country panels. *Energy Economics, 61*, 221–232. https://doi.org/10.1016/j.eneco.2016.11.008
22 Shahbaz, M., Solarin, S. A., Sbia, R., & Bibi, S. (2015). Does energy intensity contribute to CO_2 emissions? A trivariate analysis in selected African countries. *Ecological Indicators, 50*, 215–224.
23 Tukhtamurodov, M., Tufail, M., & Balcilar, M. (2024). Renewable energy consumption and environmental degradation: A dynamic panel analysis for developing countries. *Journal of Environmental Management, 339*, 117121. https://doi.org/10.1016/j.jenvman.2023.117121