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Empirical study of Carbon emission and economic development of Indian economy

Dr. Anurag Agnihotri

assistant professor

College of vocational studies, University of Delhi

Email: anurag.agnihotri@cvs.du.ac.in

Abstract

The economic development is important but clean environment is essential for the human survival however growth in one is loss of other. There is need to find a balance between the two. There is a need for measuring and managing the carbon emissions of different socio-economic spheres of mankind. Carbon accounting covers a wide range of activities related to the calculation, measurement, verification, reporting, etc. of carbon emissions. This paper explain the Relationship of Carbon emission accounting and Gross value added for selected sectors of Indian economy by taking the secondary data from the IEA and RBI website and further the Multiple regression is used and it was aimed at finding out the relationship between the carbon emission and gross value added by the different sectors along with other objectives. It was found that carbon emission accounting help in carbon management and it also impact the gross value added of different sectors. The results indicate that economic growth has negative effect on CO_2 emission in the low growth regime but positive effect in the high growth regime with the marginal effect being higher in the high growth regime. The findings emphasize the need for transformation of low carbon technologies aimed at reducing emissions and sustainable economic growth. This may include energy efficiency and switch away from non-renewable energy to renewable energy.

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

Introduction

There is a need for measuring and managing the carbon emissions of different socio-economic spheres of mankind and for this purpose carbon accounting can play an important role in the measurement and management of carbon emission. Burritt-Tingey-Holyoak (2012) explained that carbon accounting covers a wide range of activities related to the calculation, measurement, verification, reporting, etc. of carbon emissions. Schaltegger and Csutora (2012) extended the definition and explained that scientific carbon accounting covers the major tendencies in emissions, raises awareness and offers references for how carbon emissions can be managed and reduced to remain within the scope of sustainability. Ascui and Lowell (2011) explained that carbon accounting includes estimation, calculation, measurement, monitoring, reporting, validation, verification and editing of emission of carbon dioxide and greenhouse gases. Buritt et al. (2011) and Ascui and Lowell (2012) introduced the link between the physical and monetary aspects of carbon accounting. The development of carbon accounting has seen the Carbon accounting as environmental management accounting, then it developed as separate focus topic, covering supply chain and product issues and lastly from carbon accounting to climate accounting.According to GHG Protocol, carbon accounting refer to a larger set of greenhouse gas groups, which are covered by Kyoto Protocol: nitrous oxide (N2O), methane (CH4), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs) and sulfur hexafluoride (SF6) (CCAR 2008; OPEN:EU 2010). So carbon accounting not only covers the calculation, measurement, management of carbon but also covers the major tendencies in emissions. It also covers the monetary and strategic aspects of carbon emission. It extend to complete supply chain of a product and further its scope is extended from environmental management accounting to climate accounting. Production level carbon emissions can be directly collected based on a bottom-up approach and to determine further supply chain-level carbon emissions. Carbon accounting plays an important role in the carbon management and protect the interests of various stakeholders. There are many frameworks and schemes which can be used to report the carbon emissions of businesses to investors or other stakeholders and one can also find out the relationship of carbon and GHG emission and with the growth of country (the gross value added) The motivations behind organizational-level carbon management are Regulatory-driven, Efficiency-driven and Market-driven.

There have been many studies in this area but there is no specific study which may cover the Carbon emission and GHG sector wise for Indian economy. It was also observed that there are not enough studies on the role of carbon accounting in managing the carbon. Further there is no study on the comparison of carbon emission and GDP with respect to USA and China.

Objectives

This paper has following objectives:

- To study the carbon emission and GHG sector wise and year wise.
- To find out the relationship between the carbon emission and gross value added by the different sectors.
- To compare the carbon emission and GDP with respect to USA and China.

- To findout 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). The data is classified according to the need of objectives.

Data analysis

The date presented in the table 1, explain the growth in GDP of India in USD terms (The value of USD) pegged at the rates of 2010 for bringing uniformity to the data.

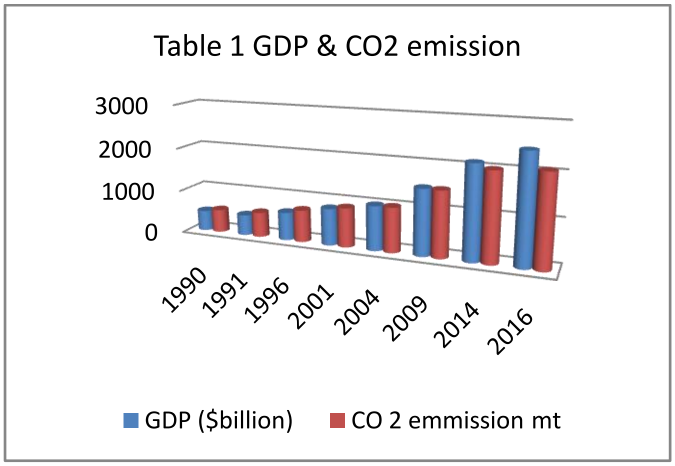
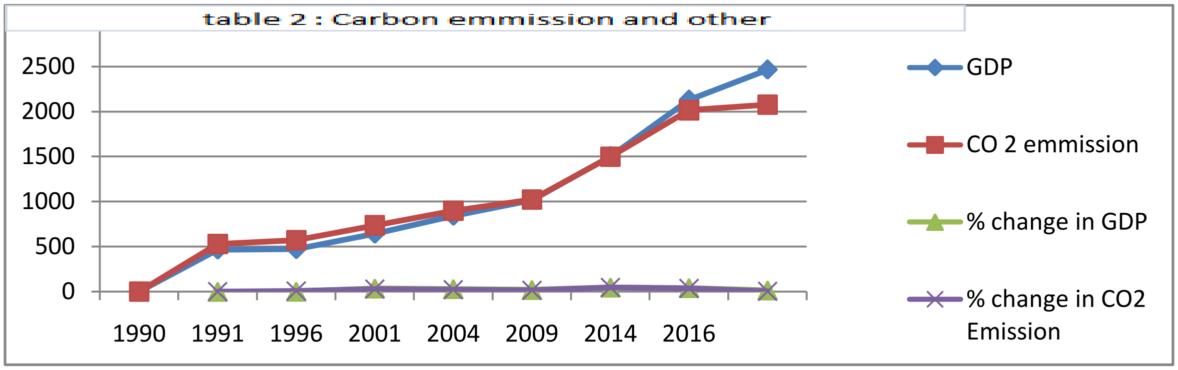


Table 1 GDP & CO2 emission		
Year	GDP ($billions)	CO 2 emission (Mt)
1990	466.53	529.06
1991	471.46	570.36
1996	642.84	736.18
2001	841.48	899.11
2004	1016.8	1022.03
2009	1502.47	1498.03
2014	2130.7	2015.29
2016	2464.93	2076.83

Source: https://webstore.iea.org/world-energy-2019

The data shows that growth of GDP and CO2 is growing however from the 2014 onwards it was found that growth in GDP has not resulted in the equal amount of growth in CO2 emission.



Source: IEA World Energy Balances 2019 https://webstore.iea.org/world-energy-balances-2019

Table 2 : Carbon emission and other				
Year	**GDP ($billions)**	**CO 2 emission(Mt)**	**% change in GDP**	**% change in CO2 Emission**
1990	466.53	529.06	0.0	0.0
1991	471.46	570.36	1.1	7.8
1996	642.84	736.18	36.4	29.1
2001	841.48	899.11	30.9	22.1
2004	1016.8	1022.03	20.8	13.7
2009	1502.47	1498.03	47.8	46.6
2014	2130.7	2015.29	41.8	34.5
2016	2464.93	2076.83	15.7	3.1

Source: IEA World Energy Balances 2019 https://webstore.iea.org/world-energy-balances-2019

The table 2 confirm that increase in the GDP is not directly proportion to the CO2 emission. As in the year 1991 GDP is grown by 1% but CO2 has grown by 7.8% but 2001 the trend is reverse as government has introduced various measures to reduce the CO2 emission which can be seen from the data of 2014 where GDP growth for the period 2009 to 2014, is 41.8% whereas CO2 emission is 34.5%. Further in 2016 GDP growth was 15.7 and CO 2 emission is 3.1 for the same period.

Table 3 : Carbon emission VS GDP in India with US and China			
Year	**India**	**USA**	**China**
	CO2/ GDP kg	**CO2/ GDP** kg	**CO2/ GDP** kg
1990	1.13	0.53	2.52
2001	1.07	0.44	1.34
2009	1	0.35	1.29
2014	0.95	0.31	1.1
2016	0.84	0.29	0.95

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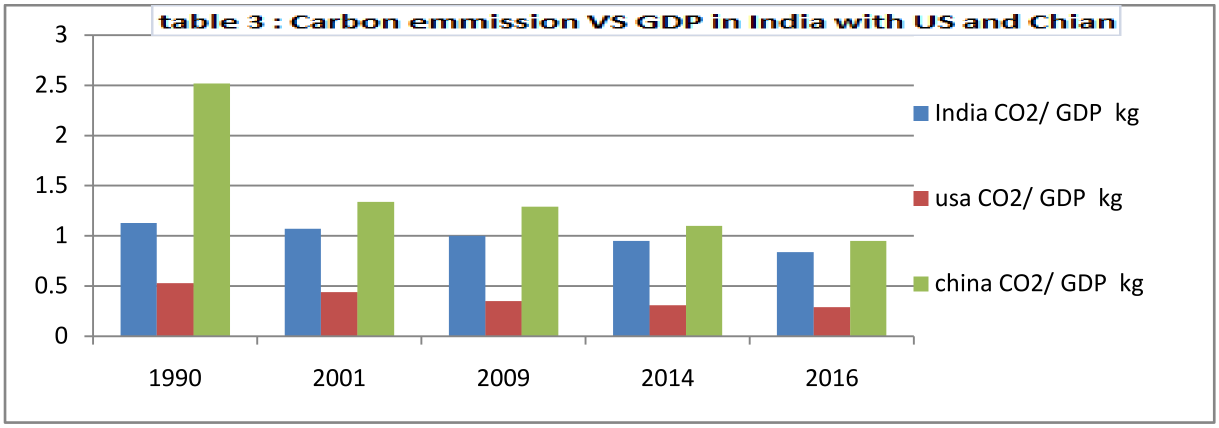
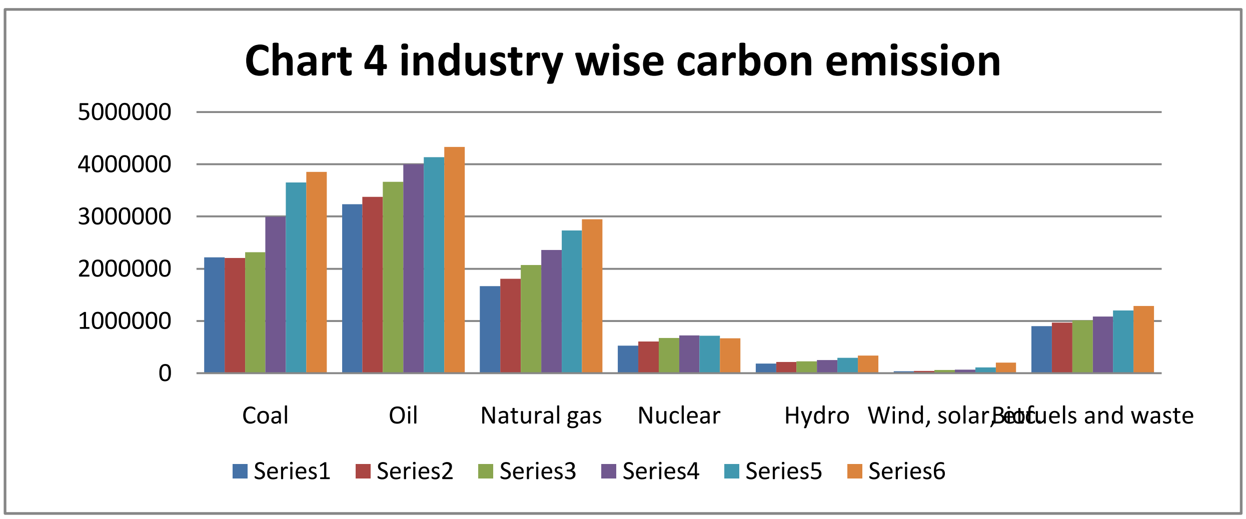
Source: IEA World Energy Balances 2019 https://webstore.iea.org/world-energy-balances-2019



Further, when we compare the CO2 emission with compare to their GDP for the different periods as shown in table 3 which compare it from 1990 as the liberalization started from the 1991 then for 2001, 2009, 2014 and 2016. The data reveal few things : One all the three economies are trying to reduce the carbon emission as in the 1990 India have 1.13kg as opposed to USA .053kg and 2.52 kg in China. So China have most among the three. Further, In 2016, India has reduced considerably up to .84 per kg whereas .29kg in USA and China is .95. So, it can be said that India is working very hard to reduce the carbon emission.



Source: IEA World Energy Balances 2019 https://webstore.iea.org/world-energy-balances-2019

The above chart reveal that out of the different sources of energy Coal and Oil are the major contributors in carbon emission whereas hydro, wind and solar are the least carbon emission source.

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

Table 6 Return series CO2, GHG and GVA

	RETURNCO2	RETURNGHG	RETURNGVA
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

The table 6 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 CO2is 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.

The dataset constitutes a time-series of observations from 2005 to 2015. 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 2005 to 2015 as data was only available for the 2015-16 after this audited data was not available.

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*11*3=99. 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			

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= α+βC02 +ω 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 1970 to 2019 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.

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