Estimation of Carbon Emission using Panel Data Analysis

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STUDENT DECLARATION

I Anshuman Behera hereby declare that the work entitled '**Estimation of Carbon Emission using Panel Data Analysis'** is my original work and that to the best of my knowledge and belief. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

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Abstract

It is imperative to have a look at various sources of carbon emission one of the major greenhouse gases which have a substantial role in global climate change. Major part of the carbon emission is generated from anthropogenic sources, which is because of our economic activities inside the global life support system. Thus, it was of utmost important to identify major macroeconomic factors which can predict carbon emission from various sources in developed and developing countries. These macroeconomic factors in predicting carbon emission from various sources will play important role in considering informed climatic policy decisions and will have a major impact on policy makers, regulators, scientist and other stakeholders in legalizing global agreements in their own legal systems with proclaimed intention of mitigating climate change. Thus in order to achieve we have collected data from World Bank website on India, China, UK and USA for the time period from 1990 to2011. We used fixed effect model of panel data analysis in terms of pooled OLS using country specific dummy and their interaction with macroeconomic factors to allow intercept and slope coefficient to vary across countries. Thus estimating the panel data models effort has been made to establish the relationship between various environmental degradation indicators and macroeconomic factors in this study.

Key Words: Global climate change, Environmental degradation, Carbon emission, Greenhouse gases

1. **Introduction**

Since the 21st century, there has been a paradigm shift in regulation and governance in energy and environmental sector with the objective of mitigating global climate change. Promotions of sustainable development and defying climate change have become an integral aspect of energy planning, analysis and policy making of both developed and developing nations. To reduce emissions and mitigate climate change, efforts have been made through global dialogue in terms of conferences, workshops, training programmes both at micro and macro level.Two-thirds of total greenhouse gas emissionsand around 80% of CO2 emission is derived from energy.Concentrations of carbon dioxide in the atmosphere have been increasing more significantly during recent periods than any other period of human history. Empirical evidence shows that China (30%), the United States (15%), the European Union (EU-28) (10%) and India (6.5%) are the top 4 greenhouse gas emitter contributing substantially to global climate change. Global communities are now more consensus regarding climate change and agreed to mitigate it, example of which is 2015 United Nations Climate Change Conference, popularly known as Conference of Parties or COP 21. The conference was attended by 196 parties with the proclaimed intention of negotiation of Paris Agreement on reduction of climate change. To make Paris agreement legally binding at least 55 countries, which together contribute 55% of total greenhouse gas emissions need to meet at New York between 22 April 2016 in Earth day and 21 April 2017 to sign the agreement with the intention of adopting this in their own legal systems. The agreement is targeting to limit global warming to less than 2 degree Celsius and by second half of 21st century to achieve zero net anthropogenic greenhouse gas emission.

In view of this it is imperative to have a look at various sources of carbon emission one of the major greenhouse gases which have a substantial role in global climate change. As mentioned above major part of the carbon emission is generated from anthropogenic sources, which is because of our economic activities inside the global life support system. Thus, it was of utmost important to identify major macroeconomic factors which can predict carbon emission from various sources in developed and developing countries. These macroeconomic factors in predicting carbon emission from various sources will play important role in considering informed climatic policy decisions and will have a major impact on policy makers, regulators, scientist and other stakeholders in legalizing global agreements in their own legal systems with proclaimed intention of mitigating climate change.

Thus with this background the paper aims at predicting the indicators of environmental degradations viz. various sources of carbon emission with the help of major macroeconomic variables taking into account countries like India, China, UK and USA. The remaining part of the paper is as follows: section 2 contains literature review followed by methodology and data source in section 3. Descriptive data analysis is presented in section 4 with result and discussion in section 5. Section 6 concludes the study.

2. **Literature Review**

There is a gross inconsistency between current valuations of fossil fuel assets and the path governments have committed to take in order to manage the huge risks of climate change(Leaton, James ; Ward, Bob, 2014). Carbon Tracker's report "makes it clear that 'business-as-usual' is not a viable option for the fossil fuel industry in the long term. Management should be looking to new business models that reduce the risk of stranded assets destroying shareholder value so that capital allocation should emphasize shareholder returns rather than investing for growth(Leaton, James ; Ward, Bob, 2014). The carbon bubble - the notion that a significant amount of fossil fuel reserves must be left in the ground if we are to keep to the 2 degrees global warming threshold - is becoming increasingly accepted by policymakers(Ferrer & Kiparisov).

The carbon bubble has significant implications for finance and investment, particularly within the fossil fuel sector. Therefore, it is financial policymakers and regulators, in addition to those in the climate and energy communities, who need to consider its effects (Ferrer & Kiparisov). The fossil fuel sector seems to be over-capitalized and the capital market has made decisions about financing the future production of fossil fuels based on an incorrect assumption: that was has been financed could actually be used, which constitutes a great and presently unheeded risk for the capital market and a risk for the whole of humanity. Uncontrolled climate change must be regarded as ten times worse than a financial carbon bubble (Schlyter, 2014). The world is agreed that the temperature of the atmosphere must not rise by more than 2°C. However, this means that most oil, gas and coal reserves are valueless.When investors realize that a large part of fossil fuel reserves cannot be burned, energy undertakings could lose 40-60% of their value on stock exchanges (Bütikofer, 2015).

Scientists, investors, NGOs and politicians are warning of the danger of a bubble. A movement is coming into being which is calling on investors to withdraw their money from fossil fuels.Banks, insurance companies and pension funds have invested more than a trillion Euros in fossil fuels – money that also comes from taxpayers (Bütikofer, 2015). Emission trading scheme was devised to lower the cost of achieving greenhouse gas emission reductions: emissions are reduced where it is cheapest and emission certificates are then traded to meet the nominal targets for each participant(Ermoliev, et al., 2015). Carbon markets react to stochastic disequilibrium spot prices, which may be affected by inadequate policies, speculations and bubbles. The market-based emission trading, therefore, does not necessarily minimize abatement costs and achieve emission reduction goals(Ermoliev, et al., 2015). Introduction of a basic stochastic trading model allowing analysis of the robustness of emission reduction policies under irreversibility, asymmetric information and other multiple anthropogenic and natural uncertainties. In particular, knowledge about uncertainties may affect portfolios of technological and trade policies and how uncertainty characteristics may influence market prices and change the market structure (Ermoliev, et al., 2015).

The stock market's reaction to the Nature journal of science paper (2009) concluded that only a fraction of the world's existing oil, gas, and coal reserves could be emitted if global warming by 2050 were not to exceed 2 °C above pre-industrial levels. Analysis indicates that this publication prompted an average stock price drop of 1.5% to 2% for the sample of 63 largest U.S. oil and gas firms and in 2012–2013, the press discovered this article which contrasts with the predictions of some analysts and commentators of a substantial decline in the shareholder value of fossil fuel companies from a carbon bubble (Griffin, Jaffe, Lont, & Faus, 2015).

International CO2 emission quota markets using marginal abatement cost functions and the Copenhagen 2020 climate policy targets for selected countries strategically allocate emissions in a bid to manipulate the quota price. Quota exporters and importers generally have conflicting interests about admitting more countries to the trading coalition, and results indicate that some countries may lose substantially when the coalition expands in terms of new countries (Böhringera, Dijkstrab, & Rosendahlc, 2014). Expanding sectoral coverage for a given coalition, makes most countries better off, but some countries (notably the USA and Russia) may lose out due to loss of strategic advantages. In general, exporters tend to have stronger strategic power than importers, but their influence decreases when more sectors are added to the scheme (Böhringera, Dijkstrab, & Rosendahlc, 2014).

During the first few years of empirical investigation of the effect of the European Union's Emissions Trading Scheme on German stock returns, firms that received free carbon emission allowances on average significantly outperformed firms that did not, which suggests the presence of a large and statistically significant ‘‘carbon premium,’’ which is mainly explained by the higher cash flows due to the free allocation of carbon emission allowances(Oestreich & Tsiakas, 2015). A carbon risk factor can also explain part of the cross-sectional variation of stock returns as firms with high carbon emissions have higher exposure to carbon risk and exhibit higher expected returns (Oestreich & Tsiakas, 2015).The high level of fossil fuel exports from Australia, and the absence of a domestic carbon budget, it is more relevant to consider the global picture i.e. in 2012, the International Energy Agency (IEA) acknowledged that, in the absence of carbon capture and storage (CCS) technology, more than two thirds of coal, oil and gas reserves cannot be burnt before 2050 if we are to have a 50% chance of limiting global warming to 2°C(Sussams, Leaton, Poulter, & Skewes, 2013). The Bloomberg Carbon Risk Valuation Tool (CRVT), available on the Bloomberg Professional service at XLTP XCO2 is a first-cut tool that helps illustrate the potential impact of stranding on a company's earnings and share price (Bloomberg Finance L.P., 2013).

Much of the concern expressed to date over stranded assets is focused on the investor-owned oil and gas companies, presumably because of the leverage that investors, regulators, and lenders have over the economic and regulatory environment in which these companies operate (Heedea & Oreskesa, 2015). The financial risk faced by investor-owned oil and gas majors may be ameliorated by prudent shedding of high-cost reserves, or by a comprehensive change in investment priorities (including in non-carbon energy sources), the objective of limiting future production of fossil fuels in order to achieve the 2° C temperature target will not succeed if production of reserves held by state-owned oil, natural gas, and coal companies is not also brought under control (Heedea & Oreskesa, 2015). The regulators should be capable of ensuring financial stability, tackling systemic risks and promoting long-term investment need to produce a common understanding of the financial consequences of unburnable carbon (Leaton). In Scotland, these same ingredients are clear as big companies reliant on buoyant investment and high values in fossil fuels play a strong role in both the financial and energy sectors, both of which are critical to the Scottish economy where financial sector focuses on pension funds and longer term investments, is heavily reliant on the fossil fuel industry and carbon based assets (Scottish Environment LINK, 2014).

Thus, to keep temperature at 2° C is today's concern of the globalized world. In order to keep our planet with a controlled temperature of 2° C, we must know to control the macroeconomic factors responsible for carbon emission and thus contributing to global climate change. In line with this effort has been made in this study to predict and estimate various sources of carbon emission with the help of identified macroeconomic factors.

3. Methodology and Data Source

In this study we have consider four countries viz. India, China, UK and USA for the time period 1990 to 2011 to estimate indicators of environmental degradation responsible for global climate change using identified macroeconomic factors which we obtained from World Bank data base available online. We have considered carbon emission from sources like gaseous fuel consumption; liquid fuel consumption; solid fuel consumption; residential buildings and commercial and public services; electricity and heat production; manufacturing industries and construction; transport; other sectors (excluding residential buildings and commercial and public service) as the major environmental degradation indicators. All these environmental degradation indicators are considered as dependent variables which are responsible for global climate change and the level of which are rising due mostly to macroeconomic activities. We used fixed effect model of panel data analysis in terms of pooled OLS using country specific dummy and their interaction with macroeconomic factors to allow intercept and slope coefficient to vary across countries. Thus estimating the panel data models effort has been made to establish the relationship between various environmental degradation indicators and macroeconomic factors. In this study all the variables are taken in their real terms. We formulated Eq.1 to Eq.8 to estimate eight indicators of environmental degradation using macroeconomic factors.

$$
\begin{aligned}
lnCO_2\_G = {} & \alpha_{11} + \alpha_{12}D_{2i} + \alpha_{13}D_{3i} + \alpha_{14}D_{4i} + \beta_{11}lnGDP + \beta_{12}lnRFDI + \beta_{13}lnRGS \\
& + \beta_{14}lnGFCF + \beta_{15}lnTRO + \gamma_{11}(D_2lnGDP) + \gamma_{12}(D_2lnRFDI) + \gamma_{13}(D_2lnRGS) \\
& + \gamma_{14}(D_2lnGFCF) + \gamma_{15}(D_2lnTRO) + \gamma_{16}(D_3lnGDP) + \gamma_{17}(D_3lnRFDI) \\
& + \gamma_{18}(D_3lnRGS) + \gamma_{19}(D_3lnGFCF) + \gamma_{110}(D_3lnTRO) + \gamma_{111}(D_4lnGDP) \\
& + \gamma_{112}(D_4lnRFDI) + \gamma_{113}(D_4lnRGS) + \gamma_{114}(D_4lnGFCF) + \gamma_{115}(D_4lnTRO) + u_{it}
\end{aligned}
$$

(Eq. 1)

$$
\begin{aligned}
lnCO_2\_L = {} & \alpha_{21} + \alpha_{22}D_{2i} + \alpha_{23}D_{3i} + \alpha_{24}D_{4i} + \beta_{21}lnGDP + \beta_{22}lnRFDI + \beta_{23}lnRGS \\
& + \beta_{24}lnGFCF + \beta_{25}lnTRO + \gamma_{21}(D_2lnGDP) + \gamma_{22}(D_2lnRFDI) + \gamma_{23}(D_2lnRGS) \\
& + \gamma_{24}(D_2lnGFCF) + \gamma_{25}(D_2lnTRO) + \gamma_{26}(D_3lnGDP) + \gamma_{27}(D_3lnRFDI) \\
& + \gamma_{28}(D_3lnRGS) + \gamma_{29}(D_3lnGFCF) + \gamma_{210}(D_3lnTRO) + \gamma_{211}(D_4lnGDP) \\
& + \gamma_{212}(D_4lnRFDI) + \gamma_{213}(D_4lnRGS) + \gamma_{214}(D_4lnGFCF) + \gamma_{215}(D_4lnTRO) + u_{it}
\end{aligned}
$$

(Eq. 2)

$$
\begin{aligned}
lnCO_2\_S = {} & \alpha_{31} + \alpha_{32}D_{2i} + \alpha_{33}D_{3i} + \alpha_{34}D_{4i} + \beta_{31}lnGDP + \beta_{32}lnRFDI + \beta_{33}lnRGS \\
& + \beta_{34}lnGFCF + \beta_{35}lnTRO + \gamma_{31}(D_2lnGDP) + \gamma_{32}(D_2lnRFDI) + \gamma_{33}(D_2lnRGS) \\
& + \gamma_{34}(D_2lnGFCF) + \gamma_{35}(D_2lnTRO) + \gamma_{36}(D_3lnGDP) + \gamma_{37}(D_3lnRFDI) \\
& + \gamma_{38}(D_3lnRGS) + \gamma_{39}(D_3lnGFCF) + \gamma_{310}(D_3lnTRO) + \gamma_{311}(D_4lnGDP) \\
& + \gamma_{312}(D_4lnRFDI) + \gamma_{313}(D_4lnRGS) + \gamma_{314}(D_4lnGFCF) + \gamma_{315}(D_4lnTRO) + u_{it}
\end{aligned}
$$

(Eq. 3)

$$lnCO_2\_R = \alpha_{41} + \alpha_{42}D_{2i} + \alpha_{43}D_{3i} + \alpha_{44}D_{4i} + \beta_{41}lnGDP + \beta_{42}lnRFDI + \beta_{43}lnRGS + \beta_{44}lnGFCF + \beta_{45}lnTRO + \gamma_{41}(D_2lnGDP) + \gamma_{42}(D_2lnRFDI) + \gamma_{43}(D_2lnRGS) + \gamma_{44}(D_2lnGFCF) + \gamma_{45}(D_2lnTRO) + \gamma_{46}(D_3lnGDP) + \gamma_{47}(D_3lnRFDI) + \gamma_{48}(D_3lnRGS) + \gamma_{49}(D_3lnGFCF) + \gamma_{410}(D_3lnTRO) + \gamma_{411}(D_4lnGDP) + \gamma_{412}(D_4lnRFDI) + \gamma_{413}(D_4lnRGS) + \gamma_{414}(D_4lnGFCF) + \gamma_{415}(D_4lnTRO) + u_{it}$$

(Eq. 4)

$$lnCO_2\_E = \alpha_{51} + \alpha_{52}D_{2i} + \alpha_{53}D_{3i} + \alpha_{54}D_{4i} + \beta_{51}lnGDP + \beta_{52}lnRFDI + \beta_{53}lnRGS + \beta_{54}lnGFCF + \beta_{55}lnTRO + \gamma_{51}(D_2lnGDP) + \gamma_{52}(D_2lnRFDI) + \gamma_{53}(D_2lnRGS) + \gamma_{54}(D_2lnGFCF) + \gamma_{55}(D_2lnTRO) + \gamma_{56}(D_3lnGDP) + \gamma_{57}(D_3lnRFDI) + \gamma_{58}(D_3lnRGS) + \gamma_{59}(D_3lnGFCF) + \gamma_{510}(D_3lnTRO) + \gamma_{511}(D_4lnGDP) + \gamma_{512}(D_4lnRFDI) + \gamma_{513}(D_4lnRGS) + \gamma_{514}(D_4lnGFCF) + \gamma_{515}(D_4lnTRO) + u_{it}$$

(Eq. 5)

$$lnCO_2\_I = \alpha_{61} + \alpha_{62}D_{2i} + \alpha_{63}D_{3i} + \alpha_{64}D_{4i} + \beta_{61}lnGDP + \beta_{62}lnRFDI + \beta_{63}lnRGS + \beta_{64}lnGFCF + \beta_{65}lnTRO + \gamma_{61}(D_2lnGDP) + \gamma_{62}(D_2lnRFDI) + \gamma_{63}(D_2lnRGS) + \gamma_{64}(D_2lnGFCF) + \gamma_{65}(D_2lnTRO) + \gamma_{66}(D_3lnGDP) + \gamma_{67}(D_3lnRFDI) + \gamma_{68}(D_3lnRGS) + \gamma_{69}(D_3lnGFCF) + \gamma_{610}(D_3lnTRO) + \gamma_{611}(D_4lnGDP) + \gamma_{612}(D_4lnRFDI) + \gamma_{613}(D_4lnRGS) + \gamma_{614}(D_4lnGFCF) + \gamma_{615}(D_4lnTRO) + u_{it}$$

(Eq. 6)

$$lnCO_2\_O = \alpha_{71} + \alpha_{72}D_{2i} + \alpha_{73}D_{3i} + \alpha_{74}D_{4i} + \beta_{71}lnGDP + \beta_{72}lnRFDI + \beta_{73}lnRGS + \beta_{74}lnGFCF + \beta_{75}lnTRO + \gamma_{71}(D_2lnGDP) + \gamma_{72}(D_2lnRFDI) + \gamma_{73}(D_2lnRGS) + \gamma_{74}(D_2lnGFCF) + \gamma_{75}(D_2lnTRO) + \gamma_{76}(D_3lnGDP) + \gamma_{77}(D_3lnRFDI) + \gamma_{78}(D_3lnRGS) + \gamma_{79}(D_3lnGFCF) + \gamma_{710}(D_3lnTRO) + \gamma_{711}(D_4lnGDP) + \gamma_{712}(D_4lnRFDI) + \gamma_{713}(D_4lnRGS) + \gamma_{714}(D_4lnGFCF) + \gamma_{715}(D_4lnTRO) + u_{it}$$

(Eq. 7)

$$lnCO_2\_T = \alpha_{81} + \alpha_{82}D_{2i} + \alpha_{83}D_{3i} + \alpha_{84}D_{4i} + \beta_{81}lnGDP + \beta_{82}lnRFDI + \beta_{83}lnRGS + \beta_{84}lnGFCF + \beta_{85}lnTRO + \gamma_{81}(D_2lnGDP) + \gamma_{82}(D_2lnRFDI) + \gamma_{83}(D_2lnRGS) + \gamma_{84}(D_2lnGFCF) + \gamma_{85}(D_2lnTRO) + \gamma_{86}(D_3lnGDP) + \gamma_{87}(D_3lnRFDI) + \gamma_{88}(D_3lnRGS) + \gamma_{89}(D_3lnGFCF) + \gamma_{810}(D_3lnTRO) + \gamma_{811}(D_4lnGDP) + \gamma_{812}(D_4lnRFDI) + \gamma_{813}(D_4lnRGS) + \gamma_{814}(D_4lnGFCF) + \gamma_{815}(D_4lnTRO) + u_{it}$$

(Eq. 8)

Where,

$CO2\_G$	: Carbon emission from gaseous fuel consumption;
$CO2\_L$	: Carbon emission from liquid fuel consumption;
$CO2\_S$	: Carbon emission from solid fuel consumption;
$CO2\_R$	: Carbon emission from residential buildings and commercial and public services;
$CO2\_E$	: Carbon emission from electricity and heat production;
$CO2\_I$	: Carbon emission from manufacturing industries and construction; transport;
$CO2\_O$	: Carbon emission from other sectors
GDP	: Gross Domestic Products (constant 2005 US$)
RFDI	: Real Foreign direct investment, net inflows (BoP, constant 2005 US$)
RGS	: Gross savings (constant 2005 US$)
GFCF	: Gross fixed capital formation (constant 2005 US$)
TRO	: Trade openness (constant 2005 US$)

Here, the γ's are the differential slope coefficients, just as α's are the differential intercepts and β's are slope coefficients of the explanatory variables of the bench marking country. In this study we have considered India as the bench marking country. If one or more of the γ coefficients are statistically significant, it will tell us that one or more slope coefficients are different from the base group.

4. Descriptive Data Analysis

4.1 Indicators of Environmental Degradation

4.1.1 CO_2Emissions From Gaseous Fuel Consumption

There are two broad classes of gaseous fuel, based not on their chemical composition, but their source and the way they are produced.They are those found naturally and those manufactured from other materials.Manufactured gaseous fuels includecoal gas, water gas, wood gas, bio gas etc. whereas petroleum and natural gas are found naturally.

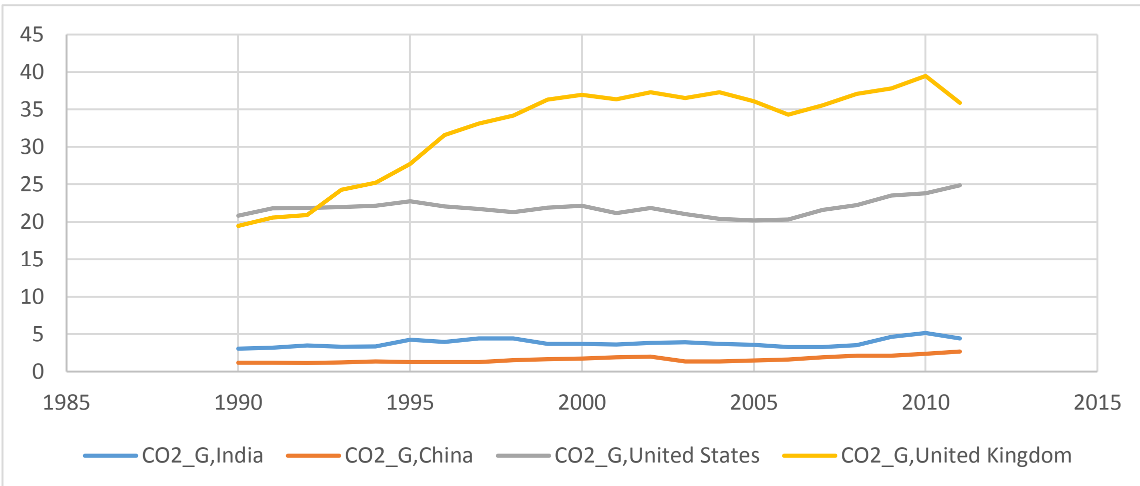

Fig.1: CO_2 emissions from gaseous fuel consumption

The growth rate of CO2 emission from gaseous fuel consumption in India stood highest at 31.9% during 2009 while in China it stood at 19.35% during 1998 followed by United Kingdom at 16.14% during 1993 and then by United states at 6.29% during 2007. China has a maximum fall of growth rate in this sector which is 31.98% observed during 2003 followed by India 19.72% during 1999.

4.1.2 *CO_2 emissions from liquid fuel consumption:*

Greenhouse gas emissions from liquid fuels such as hydrogen fuel (for automotive uses), ethanol, and biodiesel etc. play a primary role in transportation sector of the economy.

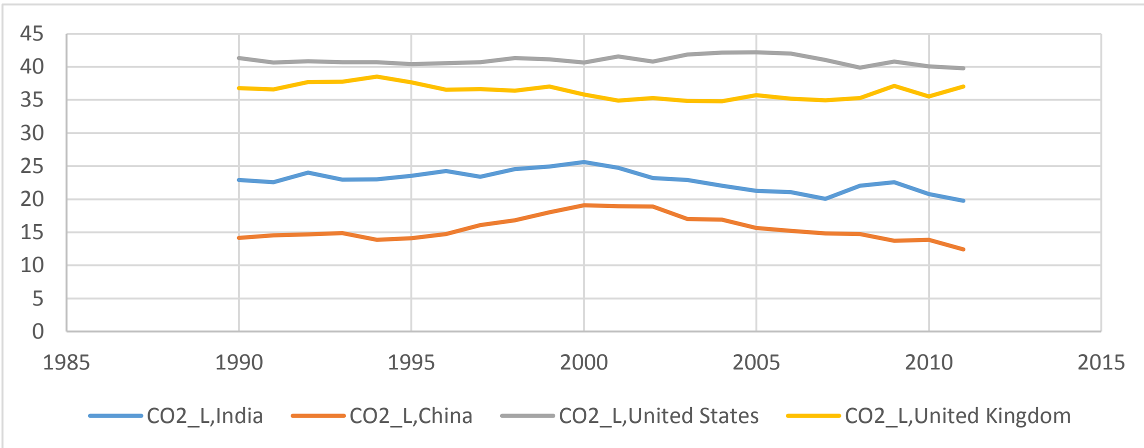

Fig.2: CO_2 emissions from liquid fuel consumption.

The highest growth rate of CO2 emission from liquid fuel consumption is observed to be 9.75% in India during 2008, closely followed by China with 9.07% during 1997. United Kingdom is having a growth rate of 5.2% during 2009 and United States during 2003 is having 2.57% growth rate. China is having the lowest growth rate in this sector with -10.53% during 2011 followed by India with -7.96% during 2010.

4.1.3 *CO_2 emissions from solid fuel consumption*

Carbon dioxide emissions from solid fuels such as Wood, Biomass, Peat, Lignite, Bituminous coal, Anthracite, Coke, Briquettes etc. are used to do major economic activities of any economy.

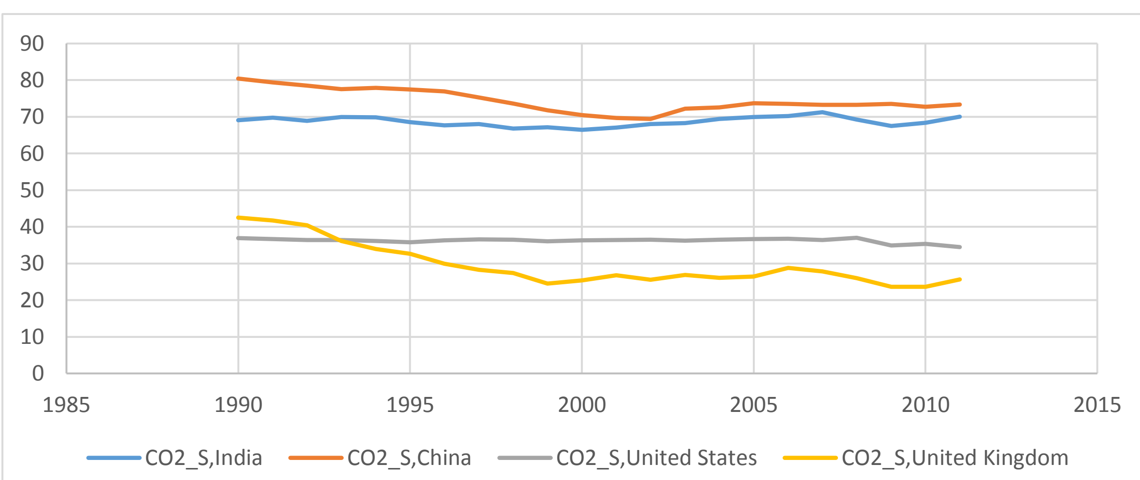

Fig.3: CO_2 emissions from solid fuel consumption.

Table 1: Descriptive Statistics of Environmental Degradation Indicators

Country	Variable	Obs.	Mean	Std. Dev.	Min.	Max.
India	CO2_G	22	3.808322	0.538485	3.057529	5.142013
China	CO2_G	22	1.626217	0.429066	1.12255	2.657823
United States	CO2_G	22	21.87587	1.129832	20.16218	24.87915
United Kingdom	CO2_G	22	32.4484	6.329762	19.44774	39.46671
India	CO2_S	22	68.6816	1.28554	66.44747	71.23934
China	CO2_S	22	74.36841	3.113881	69.35943	80.39449
United States	CO2_S	22	36.23068	0.610522	34.46955	36.96764
United Kingdom	CO2_S	22	29.54919	5.812174	23.64143	42.4721
India	CO2_R	22	7.634469	1.397314	5.47092	9.971231
China	CO2_R	22	8.729924	3.447088	5.114529	16.19522
United States	CO2_R	22	10.50897	0.717	9.046802	11.61443
United Kingdom	CO2_R	22	19.05414	1.029079	17.21803	21.1292
India	CO2_E	22	54.13063	4.215607	44.28481	58.51126
China	CO2_E	22	45.58944	7.043125	31.75298	53.62857
United States	CO2_E	22	47.0026	1.128158	43.92995	48.44599
United Kingdom	CO2_E	22	43.27654	1.696871	40.55268	45.87417
India	CO2_I	22	23.78243	2.39895	20.58512	29.56742
China	CO2_I	22	35.64369	3.676048	31.27349	41.6605
United States	CO2_I	22	11.43431	1.147625	9.495436	14.43621
United Kingdom	CO2_I	22	13.02689	1.619131	10.37774	15.20801
India	CO2_O	22	4.368287	0.86	2.217896	5.491836
China	CO2_O	22	3.318272	1.719898	1.554786	7.470491
United States	CO2_O	22	0.929175	0.14782	0.744672	1.343696
United Kingdom	CO2_O	22	1.509278	0.651851	0.780521	2.93409
India	CO2_T	22	10.0843	0.588986	9.231681	11.17424
China	CO2_T	22	6.718726	1.41291	4.696472	8.504889
United States	CO2_T	22	30.12502	0.810879	28.80095	31.4571
United Kingdom	CO2_T	22	23.13308	1.381239	20.29055	25.96275
India	CO2_L	22	22.83039	1.568864	19.74158	25.59718
China	CO2_L	22	15.59928	1.872175	12.40866	19.06556
United States	CO2_L	22	40.96226	0.679761	39.79329	42.21476
United Kingdom	CO2_L	22	36.27471	1.112687	34.81404	38.5359

Sources: Compiled by authors from World Bank website

In case of CO2 emission from solid fuel consumption United Kingdom is having the highest growth rate of 8.91% during 2006, whereas, China in the year 2003 is having 4.03%. India in this sector is having its highest growth rate of 2.37% during 2011 and United States during 2008 is showing a growth rate of 1.47%. The maximum fall of growth rate in this sector is shown by United Kingdom which is 10.59% during 1993 followed by United States of 5.52% during 2009, while India is having its lowest growth rate of -2.88% during 2008 and China is showing lowest growth rate of -2.52% during 1999.

4.1.4 CO_2 emissions from residential buildings and commercial and public services

Greenhouse gas emissions from businesses and homes arise primarily from fossil fuels burned for heat, the use of certain products that contain greenhouse gases, and the handling of waste.

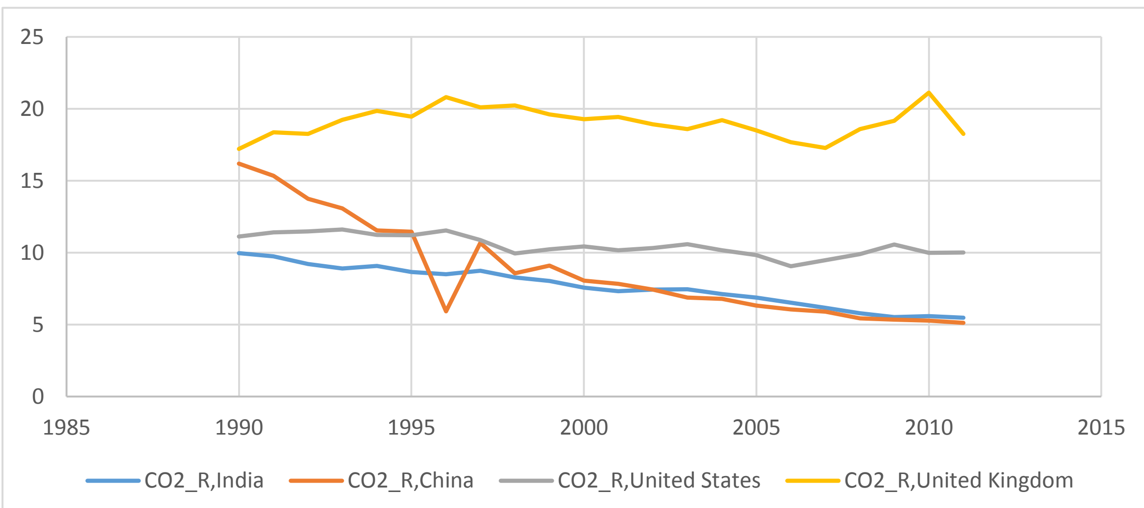

Fig.4: CO_2 emissions from residential buildings and commercial and public services.

In case of CO_2 emissions from residential buildings and commercial and public services, China is having the lowest growth rate of -48.28% during 1996 and highest growth rate of 80.29% during 1997. On the contrary United Kingdom is having its highest growth rate of 10.22% during 2010 and lowest growth rate of -13.6% during 2011. The highest growth rate of United States is 6.81% in 2009 and of India is 2.20% in 1994. The lowest growth rate of United States is -8.51% in 1998 and of India is -6.27% in 2008.

4.1.5 CO_2 emissions from electricity and heat production:

As our electricity comes from burning fossil fuels, mostly coal and natural gas, hence carbon dioxide level also increases when consumption level of electricity increases.

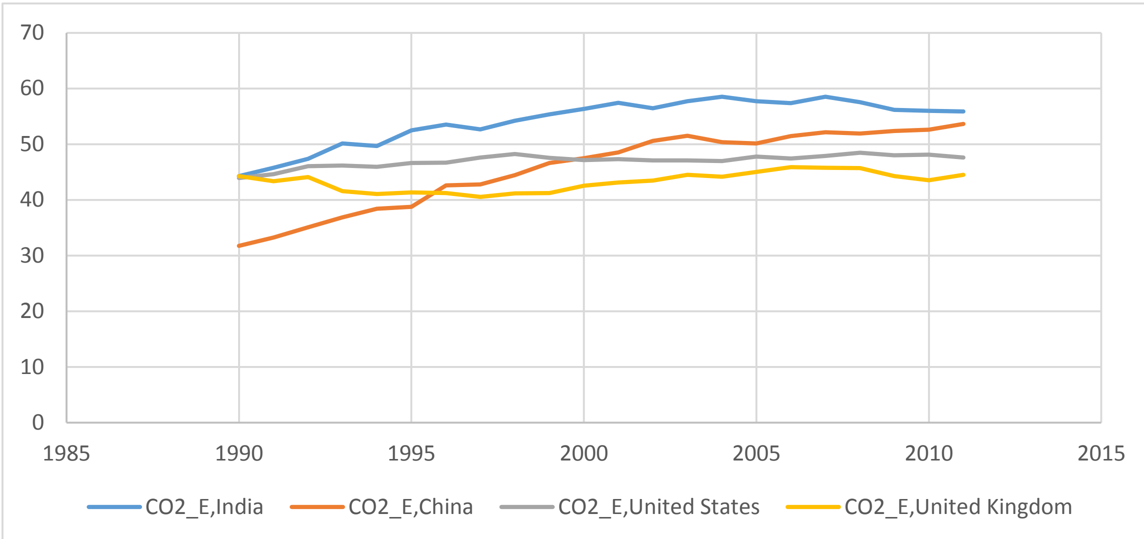

Fig.5: CO_2 emissions from electricity and heat production.

The growth rate of CO2 emission from electricity and heat production is highest in China, which stood at 10.02% during 1996 while in India it stood at5.91% during 1993 followed by United States at 3.20% during 1992 and then by United Kingdom at 3.19% during 2000. United Kingdom is having the highest growth rate drop during 1993 which is observed to be 5.74%. India during 2009 is having a growth rate drop of 2.4%, China 2.21% and United States 1.4% during 1999.

4.1.6 CO_2 Emissions from Manufacturing Industries and Construction

Carbon dioxide emissions from industry primarily come from burning fossil fuels for energy as well as greenhouse gas emissions from certain chemical reactions necessary to produce goods from raw materials.

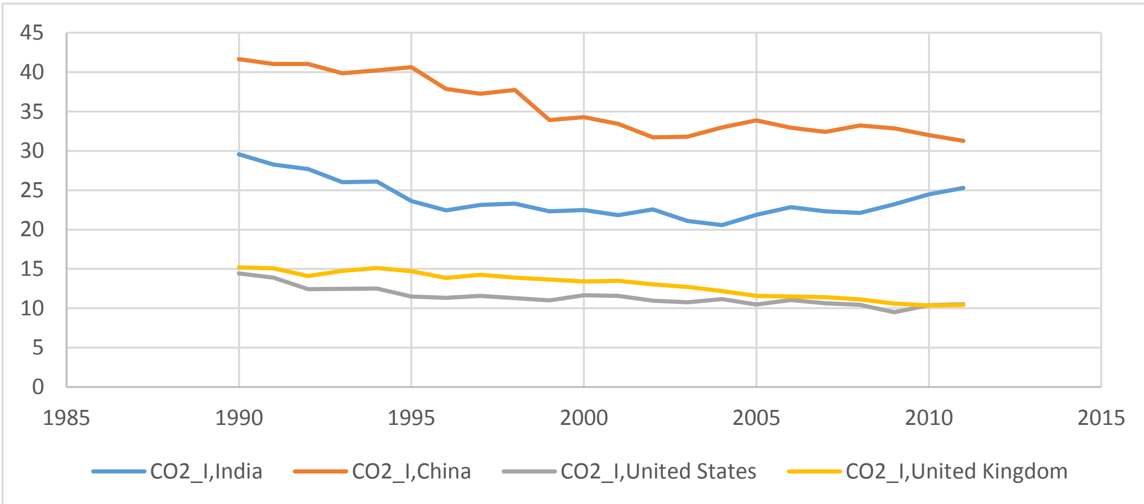

Fig.6: CO_2 emissions from manufacturing industries and construction.

United States has reached the lowest growth rate of -10.49% during 1992 closely followed by China of -10.06% during 1999 in carbon emission from manufacturing industries. India during 1995 is showing a growth rate drop of 9.42% and United Kingdom 6.32% during 1992. United States is also showing the highest growth rate in this sector during 2010 which stood at 9.57%, followed by India 6.18% during 2005. United Kingdom is having a positive growth rate of 4.4% during 1993. China is having the highest growth rate of 3.79 during 2004.

4.1.7 *CO_2 Emissions from Transport*

Transportation of a country primarily depends on burning of fossil fuels again for our cars, trucks, ships, trains, planes etc. About 90% of the fuel used for transportation is petroleum based, which includes gasoline and diesel.

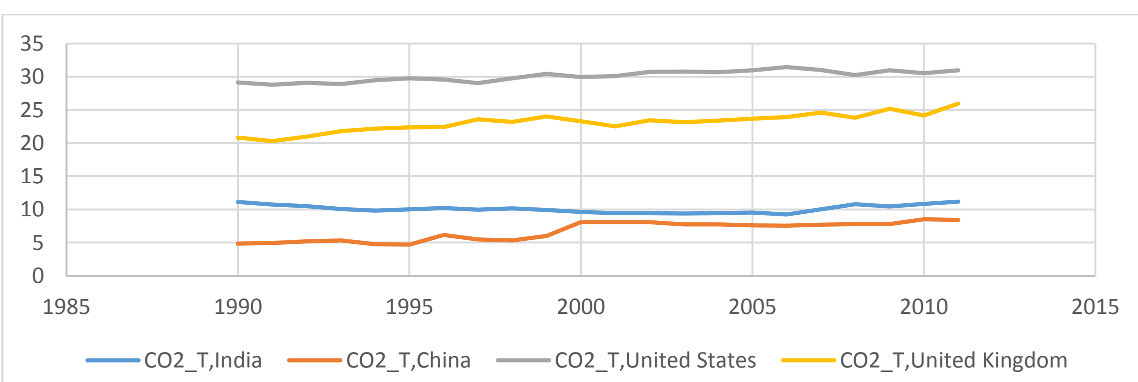

Fig.7: CO_2 emissions from transport.

In case of CO_2 emissions from transport, China is having the highest growth rate of 34.75% during 2000, followed by India of 8.26% during 2007. United Kingdom is having a positive growth rate of 7.4% during 2011 and United States is having a positive growth rate of 2.44% in 1998. -10.88% is the lowest growth rate by China in 1997, followed by India of -4.17% during 1993. United Kingdom is having the lowest growth rate of -3.99% during 2010 and United States of -2.43% during 2008.

4.1.7 CO_2Emissions from other Sectors

Greenhouse gas emissions from agriculture come from livestock such as cows, agricultural soils, and rice production. Land areas can act as a sink (absorbing CO_2 from the atmosphere) or a source of greenhouse gas emissions.

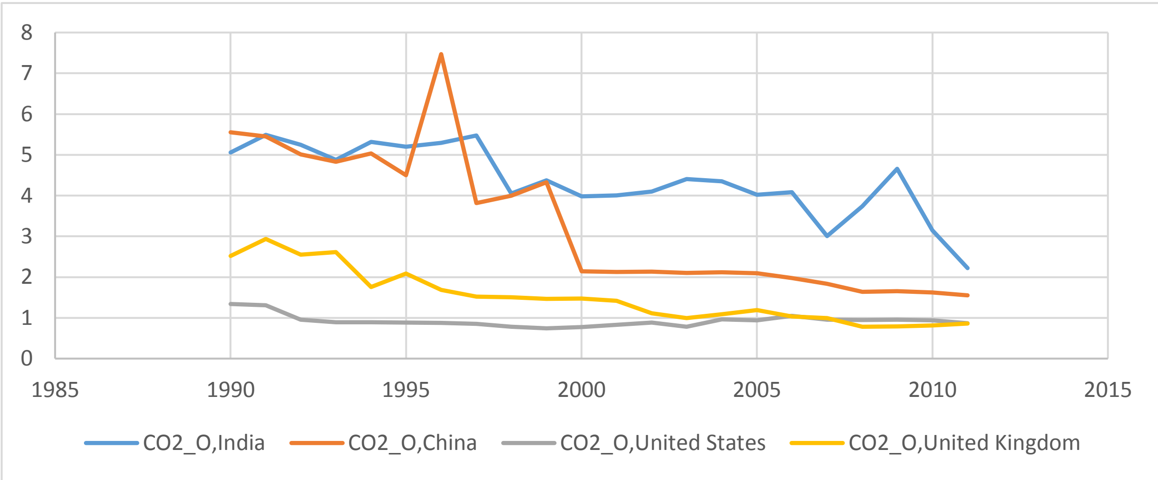

Fig.8: CO_2 emissions from other sectors.

In case of Carbon emission from other sectors excluding residential building, commercial and public services, China is having the highest growth rate of 66.12% during 1996 followed by India of 24.46% during 2009, trailing behind India is United States of 22.39% in 2004 and finally United Kingdom of 18.76% in 1995. China is also having the highest drop of 50.49 in 2005. United Kingdom in 1994 is having highest drop of 32.79% followed by India in 2010 of 32.59%. The highest drop of United States is 26.66% in 1992.

4.2 **Macroeconomic Variables**

4.2.1 Gross Domestic Product (GDP):

The value of a country's overall production of goods and services (typically during a fiscal year) at market prices excluding the net income from abroad is known as the Gross Domestic Product (GDP) of that country. The GDP growth rate of China is highest among the considered countries which is 14.27% and 14.19% during 1992 and 2007 respectively, while India is having the highest growth rate of 10.25% during 2010. United States is having highest growth rate during 1999 i.e. 4.68% and United Kingdom is having its highest growth rate during 2003 i.e. 4.3%. In 2009 both United Kingdom and United States were having highest fall in GDP growth rate i.e. 4.31% and 2.77% respectively.

4.2.2 *Real Foreign Direct Investment (RFDI)*

A foreign direct investment (FDI) is an investment made by a company or entity based in one country, into a company or entity based in another country. Foreign direct investments differ substantially from indirect investments such as portfolio flows, wherein overseas institutions invest in equities listed on a nation's stock exchange. Entities making direct investments typically have a significant degree of influence and control over the company into which the investment is made. In the years 2005 and 2010 United Kingdom is having the highest growth rate of 330.33% and 322.99% in real foreign direct investment. United States is having a positive growth rate of 153.33% during 1993 and in 1992, India is having a growth rate of 245.07% and China is having a growth rate of 136.19%. United Kingdom experienced a FDI growth rate drop of 94.04% during 2009. During 1991 India experienced a FDI growth rate drop of 72.68%.

Table 2: Descriptive Statistics of Macroeconomic Factors

Country	Variable	Obs.	Mean	Std. Dev.	Min.	Max.
India	GDP	22	6.94E+11	2.99E+11	3.50E+11	1.33E+12
China	GDP	22	1.82E+12	1.12E+12	5.28E+11	4.23E+12
United States	GDP	22	1.13E+13	1.99E+12	8.23E+12	1.38E+13
United Kingdom	GDP	22	2.10E+12	3.36E+11	1.63E+12	2.55E+12
India	IMP	22	1.38E+11	1.15E+11	2.55E+10	4.13E+11
China	IMP	22	4.84E+11	4.19E+11	6.55E+10	1.41E+12
United States	IMP	22	1.49E+12	5.53E+11	6.76E+11	2.21E+12
United Kingdom	IMP	22	5.22E+11	1.72E+11	2.78E+11	7.52E+11
India	EXP	22	1.11E+11	8.94E+10	2.26E+10	3.10E+11
China	EXP	22	5.80E+11	5.42E+11	7.03E+10	1.75E+12
United States	EXP	22	1.14E+12	3.50E+11	6.11E+11	1.80E+12
United Kingdom	EXP	22	5.04E+11	1.45E+11	2.90E+11	7.15E+11
India	GFCF	22	1.97E+11	1.20E+11	7.69E+10	4.65E+11
China	GFCF	22	7.13E+11	5.26E+11	1.28E+11	1.90E+12
United States	GFCF	22	2.33E+12	5.21E+11	1.48E+12	3.05E+12
United Kingdom	GFCF	22	3.74E+11	6.45E+10	2.63E+11	4.72E+11
India	GCF	22	2.17E+11	1.43E+11	7.64E+10	5.23E+11
China	GCF	22	7.68E+11	5.44E+11	1.79E+11	2.01E+12
United States	GCF	22	2.36E+12	5.29E+11	1.47E+12	3.11E+12
United Kingdom	GCF	22	3.78E+11	7.33E+10	2.43E+11	4.86E+11
India	NFDI	22	1.41E+10	1.54E+10	2.57E+08	5.34E+10
China	NFDI	22	6.93E+10	5.39E+10	6.87E+09	2.03E+11
United States	NFDI	22	1.64E+11	1.06E+11	2.58E+10	3.61E+11
United Kingdom	NFDI	22	7.83E+10	7.65E+10	1.38E+10	2.54E+11
India	NGS	22	3.36E+11	1.56E+11	1.81E+11	6.40E+11
China	NGS	22	7.93E+11	6.32E+11	2.70E+11	2.23E+12
United States	NGS	22	2.04E+12	3.26E+11	1.49E+12	2.58E+12
United Kingdom	NGS	22	3.04E+11	7.58E+10	1.70E+11	4.61E+11

Sources: Compiled by authors from World Bank website

4.2.3 Trade Openness (TRO)

Trade (both imports and exports) is vital to any successful modern economy. Trade is crucial for the competitiveness of a country's economy in the long run. By exposing firms and products to international competition, economies are encouraged to focus on areas of comparative advantage. This helps ensure that scarce skills and resources are deployed where they are most productive. According to economic theory, trade openness is a measure of economic policies that either restrict or invite trade between countries. The growth rate in Trade Openness is highest in India during 1995 i.e. 20.39%, followed by China during 1991 of 14.14%. United States has experienced the highest growth rate of 9.57% during 2010 and United Kingdom of 7.79% during 2006. During 2009 all the considered countries have experienced the lowest growth rate i.e. -12.02% for China, -10.81 for India, -9.06% for United States and -4.93% for United Kingdom.

4.2.4 *Gross Capital Formation (GCF)*

Gross Capital formation refers to the net additions of capital stock such as equipment, buildings and other intermediate goods. A nation uses capital stock in combination with labor to provide services and produce goods; an increase in this capital stock is known as capital formation. China is having the highest growth rate of Gross capital Formation (GCF) of 33.88% in 1993 while India in 2004 is having 31.74%. United Kingdom is having a positive growth rate of 18.88% during 1995 and United States of 9.69% during 1997. The highest fall in GCF is experienced by United Kingdom of 18.32% and United States of 16.89% during 2009 followed by India of 9.97% during 1991.

4.2.5 *Gross Fixed Capital Formation (GFCF)*

Gross Fixed Capital Formation measures the value of acquisitions of new or existing fixed assets by the business sector, governments and "pure" households (excluding their unincorporated enterprises) *less* disposals of fixed assets. GFCF is a component of the expenditure on gross domestic product (GDP), and thus shows something about how much of the new value added in the economy is invested rather than consumed. The highest growth rate in Gross Fixed Capital Formation (GFCF) is experienced by China which is 34.31% during 1993 followed by India which stood at 24.98% during 2004. United Kingdom has experienced the highest growth rate of 18.81% during 1995 and United States of 8.89% during 1998. The highest fall of growth rate GFCF was experienced by United Kingdom i.e. 14.38% and by United States of 13.07% during 2009. India has experienced the highest fall in growth rate of GFCF during 1991 which stood at 5.56%.

4.2.6 *Real Gross Saving (RGS)*

Gross Saving is disposable income less consumption. It can be calculated for each institutional sector and the total economy. It is also equal to the sum of gross capital formation, net capital inflows from the rest of the world and changes in foreign reserves. 31.2% was the highest growth rate of real gross saving experienced by United Kingdom during 1994 followed by India of 29.2% during 2007. The highest growth rate of China was 24.11 during 2006 and of United States was 10.82 during 1997. The highest drop in growth rate of RGS was experienced by United Kingdom which stood at 30.59% during 2009 followed by India which stood at 28.46% in 1991. The Highest drop of growth rate of RGS in United States was 10.77% during 2008 and in China was 0.85% during 1991.

5 Result and Discussion

We have considered carbon emission from sources like gaseous fuel consumption; liquid fuel consumption; solid fuel consumption; residential buildings and commercial and public services; electricity and heat production; manufacturing industries and construction; transport; other sectors (excluding residential buildings and commercial and public service) as the major environmental degradation indicators. All these environmental degradation indicators are considered as dependent variables which are responsible for global climate change and the level of which are rising due mostly to macroeconomic activities. We used fixed effect model of panel data analysis in terms of pooled OLS using country specific dummy and their interaction with macroeconomic factors to allow intercept and slope coefficient to vary across countries. Thus estimating the panel data models effort has been made to establish the relationship between various environmental degradation indicators and macroeconomic factors.

In this study we have considered India as the bench marking country with which environmental degradation indicators of China, USA and UK are compared. The result table 2 shows that most of the macroeconomic factors predict environmental degradation indicators statistically at various levels of significance in each country. Say for example, in case of India lnRGS is negatively affecting lnCO2_L and lnCO2_E at 5% and 10% significance level. The coefficient of lnRGS indicates that 1 % increase in Indian real gross savings leads to on an average 0.24% decline in carbon emission from liquid fuel consumption sources and 0.14% decline in carbon emission from electricity and heat production sources respectively keeping all other macroeconomic factors constant.Thus real gross savings have environmental protection effect in India. However, lnTRO of India is positively affecting lnCO2_E and negatively affecting lnCO2_I at 1% and 10% significance level. The coefficients of lnTRO indicates that 1 % increase in Indian trade openness leads to on an average 0.14% increase in carbon emission from electricity and heat production sources and 0.23% decline in carbon emission from manufacturing industries and construction sources respectively keeping all other macroeconomic factors constant. Thus trade openness has both environmental protection and detrimental effect in India.

Table 2: Estimation of Environmental Degradation Indicators

Variables	lnCO2_G	lnCO2_L	lnCO2_S	lnCO2_R	lnCO2_E	lnCO2_I	lnCO2_O	lnCO2_T
D2i	-13.03269 (11.92084)	-6.388715 (4.05485)	1.358303 (4.58645)	8.420595 (9.755496)	-11.22215 (2.775244)***	13.39544 (5.687349)	-10.85035 (18.0516)	-1.724198 (6.553413)
D3i	35.85429 (34.20106)	-11.2416 (11.63342)	.3623197 (13.1586)	21.26699 (27.98865)	6.250633 (7.962211)	-8.098106 (16.31708)	-126.6685 (51.79027)	-5.18102 (18.80183)
D4i	27.61676 (26.33853)	8.700988 (8.958997)	-11.86767 (10.1335)	9.102641 (21.5543)	-20.62819 (6.131768)***	22.2202 (12.56593)	34.8719 (39.88414)	13.86495 (14.47945)
D2lnGDP	1.920514 (1.203693)	1.366257*** (.4094337)	-.3312187 (0.46311)	-.7042328 (0.9850497)	.6377635 (0. 280227)	-.5654525 (0. 574273)	.0342141 (1. 822739)	.9153043 (0. 6617232)
D2lnRFDI	0.0424598 (.1001383)	-0.15175*** (.0340618)	.0397574 (0.38527)	.0250006 (0. 081949)	-.0593938 (0. 0233128)	.1010624 (0. 047775)	.2560197 (0. 151638)	-.1842077 (0. 0551)***
D2lnRGS	0.1909178 (.2743099)	-.493262*** (.093306)	.1073009 (0.105539)	.2022606 (0. 224483)	-.201047 (0. 063861)**	.0140282 (0. 130871)	.296063 (0. 415384)	-.4472291 (0. 15080)**
D2lnGFCF	-1.878018 (1.016035)	-.7619083 (.3456022)	.2247383 (0.390912)	.1466702 (0. 831479)	.1012038 (0. 236539)	-.1671435 (0. 484743)	.5405458 (1. 53857)	-.665564 (0. 5585592)
D2lnTRO	0.0948781 (.2105819)	.2143574** (.071629)	-.0757536 (0.08102)	.0702991 (0. 172331)	-.1073815 (0. 0490247)	.1773019 (0. 100467)	-.7515463 (0. 318882)	.4025535 (0. 1158)***
D3lnGDP	-1.306973 (1.824945)	.3025367 (.6207512)	-.1147355 (0.7021341)	-.9883368 (1. 493455)	-.5507272 (0. 4248581)	.8132475 (0. 870668)	6.508318 (2. 763493)	.5841852 (1.003253)
D3lnRFDI	-0.060391 (.0763057)	-.0286333 (.0259552)	.0128013 (0.0293581)	-.0247187 (0. 062445)	-.0180106 (0. 0177644)	.0678121 (0. 036405)	.040173 (0. 115549)	-.0049598 (0. 0419486)
D3lnRGS	0.236292 (.6340686)	.3578554 (.2156771)	-.1773748 (0.2439532)	-.4949397 (0. 518894)	.0574425 (0. 147615)	.103927 (0. 30251)	.7384771 (0. 960163)	.0792242 (0. 3485755)
D3lnGFCF	-0.765021 (1.099783)	-.1906419 (.374089)	.3398508 (0.4231336)	.6161962 (0. 900015)	.2747945 (0. 2560362)	-.5623037 (0. 524699)	-1.520997 (1.665389)	-.5866746 (0. 6045995)
D3lnTRO	0.752476 (.4906544)	-.0537384 (.1668951)	-.0868749 (0.1887757)	.2771095 (0. .401530)	.0526845 (0. 1142273)	-.2494527 (0. 234088)	-1.826739 (0. 742992)	.1027981 (0. 2697344)
D4lnGDP	-3.096813 (1.316111)	-.3501575 (.4476726)	1.921663 (0.5063642)***	-.9515105 (1. 077048)	1.002563 (0. 306398)**	-1.034828 (0. 627907)	-.7875581 (1.992972)	-.4213773 (0. 7235245)
D4lnRFDI	-0.105516 (.0557889)	-.0339561 (.0189765)	.047145 (.0214644)	-.0107017 (0. 045655)	.0061602 (0. 012988)	.0168271 (0. 026617)	.0424034 (0.0844805)	-.0226627 (0. 0306696)
D4lnRGS	-0.107218 (.3541496)	.2394969 (.1204633)	.3608264 (0. 1362565)*	-.2280087 (0. 289821)	.1924308 (0. 0824482)	-.1404239 (0. 168962)	-.074656 (0. 536285)	-.0198286 (0. 1946917)
D4lnGFCF	1.454586 (1.048007)	-.3640672 (.3564775)	-1.352295 (0. 403213)***	.6760332 (0. 857643)	-.145528 (0. 2439824)	.2971352 (0. 499997)	.0256023 (1.586986)	-.4840079 (0. 5761359)
D4lnTRO	1.1103 (.4615942)	.2281168 (.1570103)	-.7081951 (0. 177595)***	.2952613 (0. 377749)	-.3771495 (0. 10747)***	.0829583 (0. 220223)	-.5036128 (0. 698987)	.510894 (0. 2537587)
lnGDP	1.046764 (.8477601)	.0978443 (.2883639)	-.1276287 (0. 3261695)	-.3057113 (0. 693769)	.0083712 (0. 1973636)	.1362044 (0. 404461)	-.5253107 (1.283753)	-.0466042 (0. 4660512)
lnRFDI	0.061914 (.0456824)	.0267113 (.0155388)	-.0095423 (0. 017576)	-.0093052 (0. 037385)	.0090085 (0. 0106351)	-.0204412 (0. 021795)	.0528874 (0. 069176)	.0044598 (0. 0251136)
lnRGS	-0.290331 (.2292754)	-.2372274** (.0779876)	.0800616 (.088212)	.0531907 (0. 187629)	-.1412556 (0. 0533767)*	.1940357 (0.1093857)	.1519287 (0. 347189)	.0313186 (0. 1260428)
lnGFCF	0.2948644 (.8034316)	.2011049 (.2732856)	-.0816065 (.3091144)	-.2317488 (0. 657493)	-.1227475 (0. 1870437)	.2094215 (0. 383312)	-.4763139 (1.216627)	.4850506 (0. 4416819)
lnTRO	-0.426318 (.1789645)	-.1206308 (.0608744)	.0700041 (.0688553)	.0557547 (0. 146457)	.1436339 (0. 04166)***	-.2281594 (0. 08538)*	.1596239 (0.271004)	-.2298586 (0. 0983847)
Const	-18.49855 (10.1705)	3.759312 (3.459476)	6.268904 (3.913027)	13.81457 (8.323096)	7.105349 (2. 367755)**	-5.282157 (4.852276)	19.0896 (15.40108)	-4.512056 (5.591176)
no. of obs.	88	88	88	88	88	88	88	88
F(23,64)	717.35	612.54	530.25	118.23	129.88	449.23	94.62	594.61
R^2	0.9961	0.9955	0.9948	0.9770	0.9790	0.9938	0.9714	0.9953

Note: 1) Standard errors are given in parentheses

*2) *sig. at 10%, **sig. at 5%, ***sig. at 1%*

GDP in this study is taken as the proxy for economic growth. The result in table 2 shows that D2lnGDP of China is positively affecting LnCO2_L at 1% level of significance. The slope coefficient of D2lnGDP indicates that 1% increase in economic growth of China leads to increase carbon emission from liquidity fuel consumption sources by 1.37% more than India keeping other macroeconomic factors constant. Thus China's economic growth is significantly contributing more pollution in terms of fuel consumption from liquid sources and thus contributing more towards global climate change as compared to India holding other macroeconomic factors constant.lnRFDI of China is negatively affecting both lnCO2_L and lnCO2_T at 1% level of significance. The slope coefficients of lnRFDI shows that carbon emission from liquid fuel consumption sources and transport sourcesare declined more significantly by 0.15% and 0.18% in China as compared to India with 1% increase in foreign direct investment inflows holding other macroeconomic factors constant in each cases respectively. Thus real foreign direct investment inflows have significantly environmental protection effect in China as compared to India. The table 2 further shows that lnTRO of China is positively affecting lnCO2_L and lnCO2_T at 5% and 1% level of significance. The slope coefficients of lnTRO are positive and show that carbon emission from liquid fuel consumption sources and transport sourcesareincreased more significantly by 0.21% and 0.40% in China as compared to India when trade openness goes up by 1% holding other macroeconomic factors constant. Ceteris paribus the trade openness has significantly environmentally detrimental effect in China as compared to India. China's trade openness helps in increasing carbon emission from liquid fuel consumption sources and transport sources and thus China is significantly more responsible for global climate change as compared to India holding other macroeconomic factors constant.The table 2 further shows that lnRGS of China is a negative predictor oflnCO2_L , lnCO2_E, and lnCO2_T at 10%, 5% and 5% level of significances. The slope coefficients of lnRGS are negative and shows that carbon emission from liquid fuel consumption sources, electricity and heat production sources and transport sourcesare declined more significantly by 0.49%, 0.21% and 0.45% respectively in China as compared to India when real gross savings goes up by 1% holding other macroeconomic factors constant in each cases. Thus ceteris paribus the real gross savings has more environmentalprotection effect in China as compared to India.

The result in table 2 shows that D4lnGDP of UK is positively affecting lnCO2_S and lnCO2_E each at 1% and 5% level of significance respectively. The slope coefficient of D4lnGDP indicates that 1% increase in economic growth of UK leads to increase carbon emission from solid fuel consumption sources and electricity and heat production sources by 1.92% and 1% more than in India respectively keeping other macroeconomic factors constant. Thus economic growth of UK is significantly more likely to be responsible for global climate change as compared to India by contributing more towards rising carbon emission from solid fuel consumption and electricity and heat production sources respectivelykeeping other macroeconomic factors constant.Similarly, D4lnRGS of UK is also positively affecting LnCO2_S but at 1% level of significance. The slope coefficient of

D4lnRGS is positive which indicates that 1% increase in real gross savings of UK leads to increase carbon emission from solid fuel consumption sources by 0.36% more than India while other macroeconomic factors are held constant. Thus real gross savings of UK is also significantly more likely to be responsible for global climate change as compared to India by contributing more towards rising carbon emission from solid fuel consumption while other macroeconomic factors are held constant.However, both D4lnGFCF and D4lnTRO of UK are negative predictor of LnCO2_S each at 1% level of significance. The slope coefficient of D4lnGFCF indicates that 1% increase in gross fixed capital formation of UK leads to reduce carbon emission from solid fuel consumption sources by 1.35%more than Indiakeeping other macroeconomic factors constant. Thus,gross fixed capital formation of UKis having more environmental protection effect than of India. However, D4lnTRO of UK is negative predictor of both lnCO2_S and lnCO2_E each at 1% level of significance. The slope coefficients of D4lnTRO indicate that 1% increase in trade openness of UK leads to reduce carbon emission from solid fuel consumption sources and from electricity and heat production sources by 0.71% and 0.38% more than of India respectively in each case keeping other macroeconomic factors constant. Thus, trade openness of UK is having more environmental protection effect than of India.

USA remains insignificant in this study because not a single macroeconomic factor of it could predict indicators of environmental degradation. Similarly, carbon emission from gaseous sources and other sources could not be predicted by their respective macroeconomic factors. Thus, further study can be undertaken on why USA remains insignificant in predicting indicators of environmental degradations and why carbon emission from gaseous sources and other sources could not be predicted using macroeconomic factors.

6 Conclusion

Using fixed effect model of panel data analysis in terms of pooled OLS, introducing country specific dummies and their interaction with macroeconomic factors in allowing intercept and slope coefficient to vary across countries we predicted indicators of environmental degradation responsible for global climate change. Estimating the panel data models for the time period from 1990 to 2011 effort has been made to establish the relationship between various environmental degradation indicators and macroeconomic factors for countries like India, China, USA and UK. In this study we have considered India as the bench marking country with which environmental degradation indicators of China, USA and UK are compared.

In this study we investigated that real gross savings have environmental protection effect in India. Trade openness has both environmental protection and detrimental effect in India. China's economic growth is significantly contributing more pollution in terms of fuel consumption from liquid sources and thus contributing more towards global climate change as compared to India holding other macroeconomic factors constant. Real foreign direct investment inflows have significantly environmental protection effect in China as compared to India. Ceteris paribus the trade openness has significantly environmentally detrimental effect in China as compared to India. China's trade openness helps in increasing carbon emission from liquid fuel consumption sources and transport sources and thus China is significantly more responsible for global climate change as compared to India holding other macroeconomic factors constant. Ceteris paribus the real gross savings has more environmental protection effect in China as compared to India. Economic growth of UK is significantly more likely to be responsible for global climate change as compared to India by contributing more towards rising carbon emission from solid fuel consumption and electricity and heat production sources respectively keeping other macroeconomic factors constant. Real gross savings of UK is also significantly more likely to be responsible for global climate change as compared to India by contributing more towards rising carbon emission from solid fuel consumption while other macroeconomic factors are held constant. Gross fixed capital formation of UK is having more environmental protection effect than of India. Trade openness of UK is having more environmental protection effect than of India.

This study opens door for further research as to why USA remains insignificant in predicting indicators of environmental degradations and why carbon emission from gaseous sources and other sources could not be predicted using macroeconomic factors.

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