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Relationship Between Gross Doomestic Product and CO2 Emissions in the World Economy – An Emprical Analysis

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ABSTRACT

Economic growth typically refers to increase in the levels of goods and services produced by an economy. The quality of environment determines the welfare function of an economy. Various studies have shown that an increase in GDP in high-income countries has not resulted with a subsequent increase in the levels of happiness and welfare of individuals. But Stevenson and Wolfers (2008) found a robust relationship between increase in GDP and increase in the wellbeing of people in both developed and developing countries. The Environmental Kuznets Curve (EKC) is often used to describe the relationship between economic growth and environmental quality. It refers to the hypothesis of an inverted U-shaped relationship between economic output per capita and some measures of environmental quality. An increase in per capita GDP is accompanied by an increase in environmental degradation. However, beyond a certain point, an increase in per capita GDP leads to reductions in environmental damage. In this backdrop, an attempt is made to empirically analyse the relationship between gross domestic product and CO2 emissions in the world economy using compound growth rate and regression analysis for the period 1990-2011. The findings of the study show that in 1990, the emissions of CO2 in US was 4.99 billion tonnes . It was the largest emissions compared to other countries. China was the second largest country in CO2 emissions followed by Russia. Till the year 2005, the United States was the top most country in CO2 emissions. In the year 2006, China crossed United States and China was the top most country in emitting CO2. Thailand was the least CO2 emission country in the world. In 2011, the CO2 emission of China was 9.7 2 billion tonnes. It was the highest quantity of CO2 emissions in the world economy. It was on account of highest Gross Domestic Product of China and related increase in fossil fuel consumption. The regression coefficient of Gross Domestic Product was statistically significant at 1 percent level. It had positive relationship with CO2 emissions. It implies that with increase in the Gross Domestic Product , the CO2 emissions will also increase. If the Gross Domestic product increases by $1 million, the CO2 emission would increase by 0.000000769 billion tonnes across countries

INTRODUCTION

Economic growth typically refers to increase in the levels of goods and services produced by an economy. The quality of environment determines the welfare function of an economy. Various studies have shown that an increase in GDP in high-income countries has not resulted with a subsequent increase in the levels of happiness and welfare of individuals. But Stevenson and Wolfers (2008) found a robust relationship between increase in GDP and increase in the wellbeing of people in both developed and developing countries. The Environmental Kuznets Curve (EKC) is often used to describe the relationship between economic growth and environmental quality. It refers to the hypothesis of an inverted U-shaped relationship between economic output per capita and some measures of environmental quality. An increase in per capita GDP is accompanied by an increase in environmental degradation. However, beyond a certain point, an increase in per capita GDP leads to reductions in environmental damage.

The Environmental Kuznets Curve relationship was initially observed for some elements of air pollution. Initially, the turning point beyond which increases in GDP per capita would not cause CO2 emissions was estimated to be $5,000. More recent evaluations estimated the turning point to be generally higher which was $34,000. According to these studies, most moderately developed countries can expect to reach their pollution peak by the middle of this century. Only 10 percent of the countries had reached this level now. Moderately developed countries were expected to reach the pollution peak level only after the 21st century. The policy implication of Kuznets Curve relationship is not to curtail the development of the developed countries due to costly environmental measures. In this back drop, the studies were attempted to analyse the relationship between the Gross Domestic Product and CO2 emissions.

Caviglia-Harris, (2009) found that the Environmental Kuznets relationship appears strongest for pollutants with significant local impacts. For carbon and other greenhouse gases, on the other hand, where the impacts were global and diffuse, emissions have continued to rise with increases in the Gross Domestic Product even in the richest countries. Ekins (2000) compares GDP growth with the growth in emissions of CO2, SO2, and NOX in seven developed countries between 1970 and 1993, and finds that while GDP rose by between 50% and 150% across the seven countries, emissions rose by less than GDP in the majority of countries (relative decoupling) and fell in the others (absolute decoupling).

In this backdrop, an attempt is made to empirically analyse the relationship between gross domestic product and co2 emissions in the world economy. The following are the specific objectives of the study.

1. To analyse the growth and trend in the CO2 emissions of countries in the world economy
2. To compare the Gross Domestic Product and CO2 emissions in the world economy
3. To assess the impact of development of the world economy on CO2 emissions.

METHODOLOGY

The data for the study were purely secondary in nature. The data on CO2 emissions were collected from the trends

in global CO2 emissions report, (2012),background studies, Netherland. The data on Gross Domestic of Product of various countries were collected from the World Economic Outlook Database,(2012), Gross Domestic Product nominal, International Monetary Fund. The period of the study was confined to 1990-2011. The following were the statistical techniques used to fulfil the objectives.

COMPOUND GROWTH RATE

To analyse the trend and growth in the CO2 emissions, the compound growth rate was estimated. The form of the equation estimated in the compound growth rate was

Y = AB t
Y = the variable under study for compound growth rate
A = constant
t = time period
B = co- efficient of time trend
Compound growth rate =[Antilog (B)-1]*100

REGRESSION ANALYSIS

To assess the relationship between the CO2 emissions and Gross Domestic Product, the following form of the regression equation was estimated.

Y = b0 + b1x1 + u
Y = CO2 emissions in billion tonnes
X1 = Gross Domestic Product of world economies ($ million)
bi = Regression coefficients
u = Error term

RESULTS AND DISCUSSIONS

Global emissions of carbon dioxide (CO_2) is the main cause of global warming. It had increased by 3% in 2011, reached 34 billion tonnes in 2011. The table-1 shows the trend in the CO2 emissions

TABLE - 1
TREND IN THE CO2 EMISSIONS IN DIFFERENT COUNTRIES OF WORLD ECONOMY (1990-1999) (in billion tonnes)

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
USA	4.99	4.96	5.04	5.18	5.26	5.26	5.44	5.58	5.65	5.69
EU27	4.32	4.27	4.12	4.04	4.02	4.08	4.15	4.06	4.07	4.01
EU15	3.33	3.36	3.29	3.22	3.23	3.27	3.34	3.28	3.32	3.29
France	0.39	0.42	0.41	0.39	0.38	0.39	0.40	0.39	0.42	0.41
Germany	1.02	0.99	0.94	0.93	0.92	0.92	0.94	0.91	0.90	0.87
Italy	0.43	0.42	0.42	0.42	0.41	0.44	0.42	0.42	0.43	0.43
Spain	0.23	0.24	0.25	0.23	0.24	0.25	0.24	0.26	0.27	0.29
United Kingdom	0.59	0.60	0.58	0.56	0.56	0.56	0.57	0.55	0.55	0.54
Netherlands	0.16	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.17
EU12 (new) MemberSstates)	1.00	0.91	0.83	0.81	0.79	0.81	0.80	0.78	0.75	0.71
Poland	0.31	0.31	0.30	0.31	0.31	0.32	0.30	0.30	0.29	0.28
Japan	1.16	1.17	1.18	1.18	1.23	1.25	1.26	1.26	1.22	1.26
Australia	0.27	0.28	0.28	0.28	0.29	0.30	0.31	0.33	0.35	0.36
Canada	0.45	0.44	0.45	0.45	0.47	0.48	0.49	0.51	0.52	0.53
Russian Federation	2.44	2.30	2.08	2.00	1.76	1.75	1.72	1.59	1.57	1.62
Ukraine	0.77	0.71	0.63	0.55	0.45	0.45	0.39	0.38	0.36	0.36
China	2.51	2.65	2.78	3.02	3.19	3.52	3.62	3.59	3.65	3.57
cement production in China	0.09	0.11	0.13	0.16	0.18	0.20	0.21	0.21	0.22	0.24
India	0.66	0.70	0.74	0.76	0.81	0.87	0.92	0.96	0.97	1.03
Brazil	0.22	0.23	0.23	0.24	0.25	0.27	0.29	0.31	0.32	0.33
Mexico	0.31	0.32	0.32	0.32	0.34	0.33	0.34	0.35	0.38	0.37
Iran	0.21	0.23	0.24	0.24	0.27	0.28	0.29	0.30	0.31	0.32
Saudi Arabia	0.17	0.17	0.19	0.20	0.21	0.21	0.23	0.23	0.24	0.25
South Africa	0.27	0.26	0.27	0.27	0.27	0.29	0.30	0.31	0.32	0.30
Asian tigers**	0.71	0.79	0.84	0.92	0.99	1.07	1.17	1.24	1.17	1.25
South Korea**	0.25	0.28	0.30	0.33	0.37	0.40	0.43	0.45	0.39	0.42
Indonesia**	0.16	0.17	0.18	0.19	0.20	0.21	0.23	0.26	0.26	0.28
Taiwan**	0.13	0.14	0.14	0.16	0.16	0.17	0.18	0.19	0.21	0.22
Thailand**	0.09	0.10	0.11	0.13	0.14	0.16	0.18	0.18	0.17	0.17
International transport	0.66	0.66	0.69	0.68	0.69	0.72	0.73	0.76	0.77	0.82
Total	22.7	22.7	22.6	22.8	22.9	23.6	24.2	24.4	24.6	24.8

Source: Trends in global CO2 emissions report, (2012), Background studies, Netherland.

TABLE - 1
TREND IN THE CO2 EMISSIONS IN DIFFERENT COUNTRIES OF WORLD ECONOMY (2000-09) (in billion tonnes)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
USA	5.87	5.75	5.83	5.87	5.94	5.94	5.84	5.91	5.74	5.33
EU27	4.06	4.13	4.11	4.22	4.23	4.19	4.21	4.15	4.09	3.79
EU15	3.33	3.39	3.39	3.47	3.47	3.43	3.43	3.37	3.32	3.07
France	0.41	0.42	0.41	0.42	0.41	0.41	0.40	0.39	0.40	0.38
Germany	0.87	0.89	0.87	0.88	0.88	0.85	0.86	0.84	0.86	0.80
Italy	0.46	0.46	0.47	0.48	0.48	0.48	0.49	0.47	0.46	0.41
Spain	0.31	0.31	0.33	0.33	0.35	0.36	0.35	0.37	0.33	0.30
United Kingdom	0.55	0.56	0.55	0.56	0.55	0.55	0.56	0.54	0.53	0.49
Netherlands	0.17	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.16
EU12 (new) MemberSstates)	0.73	0.73	0.72	0.75	0.76	0.76	0.78	0.78	0.77	0.72
Poland	0.29	0.28	0.28	0.29	0.31	0.31	0.32	0.32	0.32	0.31
Japan	1.28	1.26	1.30	1.31	1.31	1.32	1.30	1.33	1.25	1.18
Australia	0.36	0.36	0.37	0.38	0.40	0.41	0.42	0.42	0.44	0.44
Canada	0.55	0.54	0.55	0.57	0.57	0.57	0.55	0.59	0.57	0.53

Russian Federation	1.66	1.67	1.66	1.72	1.73	1.72	1.79	1.81	1.80	1.74
Ukraine	0.35	0.35	0.35	0.38	0.36	0.34	0.33	0.35	0.34	0.28
China	3.56	3.64	3.90	4.50	5.28	5.85	6.51	7.01	7.79	8.27
cement production in China	0.24	0.27	0.29	0.34	0.38	0.42	0.48	0.53	0.54	0.64
India	1.06	1.08	1.12	1.15	1.24	1.29	1.38	1.48	1.56	1.75
Brazil	0.35	0.35	0.35	0.34	0.36	0.37	0.37	0.39	0.41	0.39
Mexico	0.38	0.38	0.38	0.39	0.40	0.42	0.44	0.45	0.45	0.44
Iran	0.34	0.35	0.37	0.40	0.43	0.45	0.48	0.51	0.37	0.38
Saudi Arabia	0.26	0.27	0.28	0.30	0.31	0.32	0.34	0.36	0.38	0.40
South Africa	0.31	0.29	0.31	0.34	0.36	0.36	0.36	0.37	0.37	0.35
Asian tigers**	1.31	1.36	1.41	1.46	1.53	1.57	1.61	1.65	1.68	1.68
South Korea**	0.45	0.46	0.48	0.49	0.51	0.50	0.51	0.52	0.54	0.54
Indonesia**	0.29	0.32	0.32	0.33	0.35	0.36	0.38	0.40	0.41	0.44
Taiwan**	0.23	0.24	0.25	0.25	0.26	0.27	0.28	0.28	0.27	0.26
Thailand**	0.17	0.18	0.19	0.20	0.22	0.23	0.23	0.22	0.23	0.22
International transport	0.83	0.80	0.84	0.85	0.93	0.95	1.00	1.05	1.04	1.01
Total	25.4	25.4	26.1	27.2	28.5	29.3	30.3	31.4	31.7	31.3

Source: Trends in global CO2 emissions report, (2012) Background studies, Netherland.

TABLE - 1
TREND IN THE CO2 EMISSIONS IN DIFFERENT COUNTRIES OF WORLD ECONOMY (2010-11)
(in billion tonnes)

Country	2010	2011
USA	5.53	5.42
EU27	3.91	3.79
EU15	3.16	3.02
France	0.38	0.36
Germany	0.84	0.81
Italy	0.42	0.41
Spain	0.29	0.30
United Kingdom	0.50	0.47
Netherlands	0.17	0.16
EU12 (new) MemberSstates)	0.75	0.76
Poland	0.34	0.35
Japan	1.26	1.24
Australia	0.40	0.43
Canada	0.54	0.56
Russian Federation	1.78	1.83
Ukraine	0.30	0.32
China	8.90	9.70
cement production in China	0.73	0.82
India	1.86	1.97
Brazil	0.44	0.45
Mexico	0.44	0.45
Iran	0.40	0.41
Saudi Arabia	0.43	0.46
South Africa	0.36	0.36
Asian tigers**	1.81	1.84
South Korea**	0.59	0.61
Indonesia**	0.49	0.49
Taiwan**	0.27	0.27
Thailand**	0.23	0.23
International transport	1.04	1.04
Total	33.0	33.9

Source: Trends in global CO2 emissions report, (2012) Background studies, Netherland.

In 1990, the CO2 emissions of US was 4.99 billion tonnes . It was the largest emissions compared to other countries. China was the second largest country in Co2 emissions followed by Russia. Till the year 2005, the United States was the top most country in CO2 emissions. In the year 2006, China crossed United States and China was the top most country in emitting CO2. Thailand was the least CO2 emission country in the world.

In 2011, the CO2 emission of China was 9.7 2 billion tonnes. It was the highest quantity of CO2 emissions of world economies. It was on account of highest Gross Domestic Product of China and related increases in fossil fuel consumption. This increase in fuel consumption in 2011 was mainly driven by the increase in building construction and expansion of infrastructure, as indicated by the growth in cement and steel production. Domestic coal consumption grew by 9.7% and coal import increased by 10%, making China the world's largest coal importer, overtaking Japan. The CO2 emission of United States was 5.42 billion tonnes in 2011. The CO2 emissions of Thailand was only 0.23 billion tonnes in the same year.

In 2011, China's average per capita carbon dioxide (CO_2) emissions increased to 7.2 billion tonnes. The per capita emissions for European Union was 7.5 billion tonnes in 2011. In 2011, the United States was still one of the largest emitters of CO_2, with 17.3 tonnes in per capita emissions, after a steep decline mainly caused by the recession in 2008–2009, high oil prices compared to low fuel taxes and an increased share of natural gas.

Since 2000, an estimated total of 420 billion tonnes CO2 was cumulatively emitted due to human activities (including deforestation). Scientific literature suggested that limiting average global temperature rise to 2 °C above pre-industrial levels, the target internationally adopted in UN climate negotiations, is possible if cumulative emissions in the 2000–2050 period do not exceed 1,000 to 1,500 billion tonnes CO2 . If the current global increase in CO_2 emissions continues, cumulative emissions will surpass this total within the next two decades.

The compound growth rate was calculated to analyse the trend and growth of CO2 emissions in the study period. The table - 2 shows the compound growth rate of CO2 emissions in the study period.

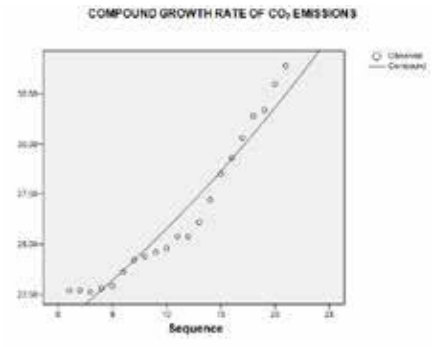
TABLE - 2
COMPOUND GROWTH RATE OF CO2 EMISSIONS IN THE WORLD ECONOMY 1990-2011

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	Compound Growth (Percentage)
Compound Growth	.942	310.749	1	19	.000	20.875	2.1

Source: Estimation based on Trends in global CO2 emissions report, (2012), Background studies, Netherland.

The compound growth rate of CO2 emission was 2.1 percent in the study period. It means that CO2 emissions had grown at the rate of 2.1 percent per annum. This growth

was statistically significant at one percent level. It indicated that the world production activity had significantly increased the CO2 emissions.



To analyse the relationship between the Gross Domestic Product and the CO2 emissions, initially the percentage increase in Gross Domestic Product and the CO2 emissions were calculated. The table - 3 shows the percentage increase in CO2 emissions and World Gross Domestic Product.

TABLE - 3
PERCENTAGE INCREASE IN CO2 EMISSIONS AND WORLD GROSS DOMESTIC PRODUCT

Year	Percentage increase in Co_2 emissions	Percentage increase in World GDP
1990	0	NA
1991	-0.44053	NA
1992	0.884956	NA
1993	0.438596	NA
1994	3.056769	NA
1995	2.542373	NA
1996	0.826446	3.9
1997	0.819672	2.2
1998	0.813008	3.7
1999	2.419355	4.7
2000	0	2.2
2001	2.755906	2.6
2002	4.214559	3.4
2003	4.779412	4.9
2004	2.807018	4.5
2005	3.412969	5
2006	3.630363	5
2008	0.955414	2.3
2009	-1.26183	-1.5
2010	5.43131	4.4
2011	2.727273	3.2

Source: Trends in global CO2 emissions report, (2012) Background studies, Netherland and World Economic Outlook Database,(2012), Gross Domestic Product nominal, International Monetary Fund.

NA. The actual data on world Gross Domestic Product was not available

The table- 3 showed that the percentage increase in CO2 emissions was higher than the GDP increase in the year 2003 and 2010. The percentage increase in both CO2 emissions and GDP were negative in the year 2009. It was on account of economic recession in that year.

The above statistical fact revealed that there is a positive relationship between CO2 emission and Gross Domestic Product. The percent increase in CO2 emission was maximum in the year 2003, which was accounted to be 4.8 percent .

The share of countries in the world CO2 emissions and world gross domestic product could reflect the relationship between the CO2 emissions and gross domestic product. The table -4 shows the share of countries in CO2 emissions and in the world Gross Domestic Product.

TABLE - 4
SHARE OF COUNTRIES IN CO2 EMISSIONS AND GROSS DOMESTIC PRODUCT IN THE WORLD ECONOMY

Source: Estimation based on trends in global CO2 emissions report, (2012), Background studies, Netherland and World Economic Outlook Database,(2012), Gross Domestic Product Nominal, International Monetary Fund.

In 2011, the share of china in co2 emission was 37.44 percent. It was the highest percentage compared to other world economies. The share of United States was 20.92 percent. It was the second largest percentage compared to other world economies. Thailand was the least polluting country. The percentage share of Thailand was only 0.88 percentage.

The top 5 emitters are China, the United States , the European Union (EU27), India and the Russian Federation , followed by Japan. The CO2 emissions in many OECD countries had decreased. In the European Union, it had declined by 3%, in the United States by 2% and in Japan by 2%. It was on account of weak economic conditions in many countries, mild winter weather in several countries and high oil prices. However, the CO2 emissions from OECD countries accounted for only one third of global emissions – the same share as that of China and India, where emissions increased by 9% and 6%, respectively, in 2011.

Highest percentage Gross Domestic Product was observed with United States in 2011 in the world economy. In the world economy, the percentage share of Gross Domestic Product of United States was 64.94 percentage. The second highest share of Gross Domestic Product was observed with China. It accounted for 6.8 percent followed by Japan. It showed that if the gross domestic product of the country was higher, the CO2 emission was also higher.

To test the relationship between the gross domestic product and co2 emissions, the regression equation was estimated. The results of the regression is shown in table- 5.

Country	Co_2 Emissions in 2011 (billion tonnes)	Percentage	GDP in 2011 ($ million)	Percentage
USA	5.42	20.91856	69659626	64.93500443
France	0.36	1.389425	2776324	2.588021521
Germany	0.81	3.126206	3577031	3.334421058
Italy	0.41	1.582401	2198730	2.049602481
Spain	0.30	1.157854	1493513	1.392216393
United Kingdom	0.47	1.813971	241570	0.225185662
Netherlands	0.16	0.617522	840433	0.783431145
Poland	0.35	1.35083	513821	0.478971405
Japan	1.24	4.785797	5869471	5.471377716
Australia	0.43	1.659591	1488221	1.38728332
Canada	0.56	2.161328	1755680	1.636602077
China	9.70	37.43728	7295147	6.800358112
India	1.97	7.603242	1676143	1.562459625
Brazil	0.45	1.736781	2492908	2.323828038
Mexico	0.45	1.736781	1154784	1.076461481
Iran	0.41	1.582401	482445	0.449723463
Saudi Arabia	0.46	1.775376	577595	0.538419972
South Africa	0.36	1.389425	408074	0.38039663
South Korea**	0.61	2.354303	1116247	1.040538229
Indonesia**	0.49	1.891162	845680	0.788322271
Taiwan**	0.27	1.042069	466832	0.435169405
Thailand**	0.23	0.887688	345649	0.322205568

TABLE - 5
RELATIONSHIP BETWEEN CO2 EMISSIONS AND GROSS DOMESTIC PRODUCT - REGRESSION ANALYSIS

Variable	Regression Coefficients	T value	Significant Level

Intercept	0.803	1.833	Significant at 10 percent level
Gross domestic Product	0.000000769	2.645	Significant at 1 percent level
R2		0.30	
F Value		6.996	Significant at 1 percent level

Source: Estimation based on Trends in global CO2 emissions report, (2012) Background studies, Netherland.

The estimated co2 emission equation was statistically significant at 1 percent level. It could be identified from the significant F value. Hence the model had better fit. The regression coefficient of Gross Domestic Product was statistically significant at 1 percent level. It had positive relationship with CO2 emissions. It implied that if the Gross Domestic Product increased, the CO2 emissions had also increased. If the Gross Domestic product increased by 1 $ million, the CO2 emission would increase by 0.000000769 billion tonnes across countries.

CONCLUSION

In 1990, the CO2 emissions of US was 4.99 billion tonnes .It was the largest emissions compared to other countries. China was the second largest country in CO2 emissions followed by Russia. Till the year 2005, the United States was the top most country in CO2 emissions. In the year 2006, China crossed United States and China was the top most country in emitting CO2. Thailand was the least CO2 emission country in the world.

In 2011, the CO2 emission of China was 9.7 2 billion tonnes. It was the highest quantity of CO2 emissions of world economies. It was on account of highest Gross Domestic Product of China and related increases in fossil fuel consumption. The regression coefficient of Gross Domestic Product was statistically significant at 1 percent level to determine CO2 emissions. It had positive relationship with CO2 emissions. It implied that if the Gross Domestic Product increased, the CO2 emissions had also increased. If the Gross Domestic product increased by 1 $ million, the CO2 emission would increase by 0.000000769 billion tonnes across countries.

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