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Identifying the major players behind increasing global carbon dioxide emissions: a decomposition analysis

Ratnakar Pani · Ujjaini Mukhopadhyay

Abstract The paper using data on 114 countries during 1992–2004 identifies the major perpetrators of escalating global emissions. Using the LMDI decomposition technique, we examine the contribution of the major factors in changing the level of emissions. The effect of GDP on emission is found to be substantially more than that of population. However, the income effect shows high fluctuation over time, while the population effect has been roughly constant. The upper middle-income countries, particularly of Europe and Central Asia, despite high economic growth have reduced their emissions substantially, while in the countries of North America, East Asia Pacific and South Asia increase in income have been significantly accompanied by increase in emission. Apart from few low emitting countries, almost all others have been successful in increasing emission efficiency, but their energy efficiencies have not been remarkable. Although emission efficiency has been more instrumental in curtailing emission, in some cases the path of change in emission follows that of change in energy intensity. Thus, both energy and emission intensity have crucial roles in determining the level of emissions. It may be suggested that emphasis should be given on policies oriented towards sufficient counteractive energy and emission efficiencies before embarking on a path towards economic growth.

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1 Introduction

In the last hundred years, the global average temperature has increased about 0.4 to 0.8°C and is estimated to rise by an additional 1.4 to 5.8°C by 2100 (NASA report 2007). A common predicament among scientists is that human society and natural ecosystems are subject to an impending jeopardy due to rapid surge in global temperature. The Fourth Assessment Report "Climate Change 2007" of the Intergovernmental Panel on Climate Change (IPCC) considers emissions of greenhouse gases to be the main cause of global warming, carbon dioxide (CO_2) being the prime among them, and the accelerating emissions to be the result of rapid economic growth in the last few decades. The recent World Bank data shows that global emissions have increased by 25% over the last decade to reach nearly 30 billion metric tons in 2005.

There exist a plethora of studies from different dimensions to investigate the crucial factors that foster the surge in emissions of carbon dioxide. Its main source is the use of energy in production and consumption. Since total consumption depends on the levels of population and GDP, which is the measure of the total production in a country, the latter two have been identified as the primary determinants of emissions. However, the nature, pattern and efficiency of energy also play a pivotal role. Ehrlich and Holdren (1971) were the first to posit a fundamental relation between environmental impact (I) in terms of CO_2 emissions with population size (P), affluence (A) in terms of per capita GDP and technology (T) in terms of environmental impact per unit of economic activity, in the form

of an identity known as 'IPAT'.[1] Later on, Dietz and Rosa (1997) developed a stochastic version of the IPAT model.

Based on the IPAT model, a number of authors, like Shi (2003), Martínez-Zarzoso et al. (2006), applied regression analysis to decompose carbon dioxide emission into different determining factors. However, an alternative approach was forwarded by Ang (2005) for the decomposition of change in emissions using the logarithmic mean divisia index (LMDI) method. This method of decomposition is considered to be the most preferable one due to its ability to handle zero and negative values, the absence of any residual term and the ease of calculation. It is also invariant under time and factor reversal and fulfils aggregate consistency and proportionality. Following these frameworks, the relative contributions of each of the determinants have subsequently been quantified in a number of empirical analyses.

The existing literature largely considers population to be a significant factor towards aggravating emissions[2] (Bongaarts 1992; Dietz and Rosa 1994; Engleman 1998; O'Neill et al. 2001; Smil 1990; Onozaki 2009). Dietz and Rosa (1997) have shown that the impact of population is roughly proportional to its size, while Shi (2001) found that on average, a 1% increase in population leads to a 1.28% increase in carbon dioxide emissions.

A number of studies have demonstrated that the effect of population is not uniform across the world; rather it differs substantially on the basis of geographic location and income level of the country. In the study of the European Union (EU) during the period 1975–1999 using the Dietz and Rosa (1997) formulation, Martínez-Zarzoso et al. (2006) found that for the old EU members the emissions-population elasticity is lower than unity, while for the new members it is 2.73. Following the same stochastic model, Shi (2003) using a panel data of 93 countries during 1975–1995 period concluded that population growth has been more instrumental behind increasing carbon dioxide emissions in developing countries than the developed ones with the emissions-population elasticity 1.58 and 0.83, respectively.

Almost all of the above studies, particularly those using the IPAT-regression framework propose that although GDP is a factor for raising emissions, its effect is less than that of population. There also exist different views on the nature of relationship between emissions and GDP. While Dietz and Rosa (1997) have shown that the impact of GDP is inverse U shaped[3] reaching its maximum at $10,000 per capita, Shi (2003) shows that rising income levels are associated with a monotonically upward trend in emissions.

The existing literature on decomposition analysis, particularly using LMDI method, mainly focuses on energy consumption. Whatever studies do exist on CO_2 emissions concentrate either on time series data of a specific country or region (China and EU in most cases) or on few selected countries[4] over two time periods. Panel data analysis of CO_2 emissions is nearly absent. Since there exists high dispersion in both regional and inter-temporal emission patterns, analysis of a particular country or a region and/or over two points of time is not likely to portray the accurate scenario. To identify any major fluctuation or break within countries/region/periods, a cross-section time series analysis is imperative.

The present paper uses decomposition technique to examine the nature, direction and extent of linkages that tend to exist between emissions of CO_2 and its major driving forces, namely, population and GDP. It also examines how far different countries have been successful in offsetting emissions due to the above factors through improvements in emission and energy efficiencies. The paper provides a comparative analysis to check whether a common pattern of contributing factors to emissions can be identified among the countries based on their income levels and geographical location. The decomposition is carried out for successive years, so that the changing importance of factors can also be traced out.

2 Data and preliminary observations

The data source for emissions of CO_2, energy consumption and GDP is the United Nations database.[5] The emissions of CO_2 are measured in metric tons; energy consumption is given in terms of Kg equivalent to oil and GDP by expenditure is measured at constant 2000 US dollars. Data on population has been taken from the World Bank database.[6] The original database revealed that figures on the required variables were missing for a number of countries and/or years. However, through elimination of countries and years with missing values from the database, complete data on all variables was available for 114 countries during the period 1992–2004. The composition of the sample is presented in Table 1. (The abbreviations used in the

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[1] In 'IPAT', it is considered that I = P × A × T.

[2] Birdsall (1992) has specified two mechanisms through which population growth could contribute to emissions. First, a larger population could result in increased demand for energy for power, industry and transportation, hence the increasing emissions. Second, population growth could contribute to emissions through its effect on deforestation. The destruction of the forests, changes in land use, and combustion of fuel wood could significantly contribute to emissions.

[3] The concept is similar to environmental Kuznets hypothesis.

[4] A notable among them is World Bank (2007) that provides a decomposition of the change in fossil fuel CO_2 emissions between 1994 and 2004 for 70 countries.

[5] See data.un.org.

[6] See worldbank.org.

classifications[7] indicate–HIO: high-income OECD, HINO: high-income non-OECD, UMI: upper middle income, LMI: lower middle income and LI: lower income countries).

The final sample stood at matrix of order 114 × 13 (countries and years, respectively), and our analysis is based on that particular matrix data for different variables. On testing its representation of the population, it was found that total emissions for 2004 from these countries represent about 96% of the total world emissions.[8] Since the primary focus of the paper is to analyse different issues relating to CO_2 emissions, we believe that this sample can fairly be conceived as a representative one of the population. In the remaining part of the paper, we use 'world'/'global' to indicate these 114 countries and a region/income-group to indicate the number of countries in the specific region/income-group presented in Table 1.

The primary observation reveals that there exists a high dispersion in CO_2 emissions among the countries. In 2004, the top 5% emitting countries contribute about 61% of global emissions (of which only United States and China account for more than 23 and 19%, respectively), while the lowest 5% contribute only less than 0.05%. On the other hand, the top 5% countries with rising emissions account for about 80% of the increase in global emissions from 1992 to 2004 (of which China and United States contribute nearly 40 and 21%, respectively), whereas the top 5% emission reducing countries contribute about 12% in lowering global emissions (of which Russian Federation alone accounts for nearly 8%). During the period 1992–2004, global emissions increased by 29.41%. The increase in yearly emissions was highest during 2003–2004, while during 1997–1998 there was a fall in global emissions. Despite the fact that maximum number of countries had lowered their respective emissions, total emissions increased considerably during 1998–1999. Therefore, it is explicit that few countries mostly influence global emissions whereas a large number of countries have a very little impact (See Tables 2, 3 and 4 for details).

Table 5 shows the absolute levels of CO_2 emissions of the sample countries in 1992 and 2004 and the percentage change in emissions over that period along with their corresponding rank orders. The salient features observed are as follows:

- The top three emitters in both 1992 and 2004 were USA, China and Russian Federation, respectively (accounting nearly half of the total emissions) with their ranks remaining unchanged, despite the fact that there has been a fall in absolute emissions during the period in Russian Federation.

- Most of the countries of Europe and Central Asia have been found to improve their position in emissions tally, while all the South Asian and North American, and most of the Middle East and North African countries lowered their position.

- One of the top emitters, India, had lower emissions than Japan and Germany in 1992, but it outdid them in 2004.

- Global emissions increased by nearly 30% during the period, of which China alone contributed about 12% followed by USA with 6% and India with 3%.

- Namibia has experienced the maximum emission growth of 16750% (from 0.015 to 2.471 million metric tons) followed by Viet Nam with 341%, while other 17 countries experienced more than 100% growth in emissions over the period. On the other hand, Tajikistan and Gabon have reduced their emissions to less than half over the same period. However, the shares of all these countries in total emissions are insignificant in absolute terms.

- The countries that have grown more than 100% in their emissions over the period constitute, 60% in South Asia, 37% in Sub-Saharan Africa, 25% in East Asia and Pacific, 20% in Middle East and North Africa, 10% in Latin America and Caribbean, and only Norway (out of 40 countries) in Europe and Central Asia.

- All the South Asian, about two-thirds of Middle East and North African and Sub-Saharan African, half of the Latin America and Caribbean, East Asia and Pacific and North American countries, while only 8% countries of Europe and Central Asia, experienced growth in emissions above 50% over the period.

- Among the highest emitting countries, the fast growing economies of India and China have experienced a higher growth rate of emissions, while USA, Japan and UK have a lower growth rate, and Russia has reduced its total emissions.

- The top 20 countries with the highest levels of emissions in both the years include 37% of HIO, 21% of UMI, 13% of LMI and 8% of HINO. The regionwise composition shows 100% of North America, 42% of East Asia and Pacific, 20% of South Asia, 13% of Middle East and North Africa and 5% of Sub-Saharan Africa in both the years, while 20 and 18% of Europe and Central Asia, and 5% and 10% of Latin America and Caribbean, in 1992 and 2004, respectively.

- The top 50 countries with the highest levels of emissions in 2004 constitute 74% of HIO and 20% of LI countries, whereas the corresponding figures for 1992 were 78 and 15%, respectively, while it included 54% of UMI, 32% of LMI and 25% of HINO for both the years. The regionwise composition was 100% of North America, 75% of East Asia and Pacific, 40% of South Asia and 11% of Sub-Saharan Africa for both the

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[7] Based on the World Bank classifications.

[8] Calculated from available UN data for 204 countries.

years, while 63 and 55% of Europe and Central Asia, 24 and 29% of Latin America and Caribbean, and 33 and 47% of Middle East and North Africa in 1992 and 2004, respectively.

- 26 countries (constituting 23% of the total) experienced a fall in the absolute CO_2 emission levels, which include 21 from Europe and Central Asia, 2 each from Middle East and North Africa and Sub-Saharan Africa and only 1 from Latin America and Caribbean countries. The corresponding figures on the basis of income groupwise classification are 38% of UMI, 30% of HIO, 25% of HINO, 15% of LI and only 10% of LMI.

- While all of the East Asia and Pacific, South Asian and North American countries had increasing trends, most remarkably, 80% of the UMI, 67% of both LMI and LI, and about 33% of the high-income (both OECD and non-OECD) countries among the Europe and Central Asian countries have experienced negative growth.[9]

The correlation coefficient matrix in Table 6 shows that except GDP–population relationship, there exist a high degree of inter relations between the variables. From the GDP–population correlations, it may be contended that the distribution of income among countries is uneven; growth in GDP does not necessarily sustain additional population, rather it intends increases the standards of living. There exists very strong direct relationship between total energy consumption and CO_2 emissions, implying the former to be the main source of emission; the correlation in incremental terms is slightly lesser indicating a possibility of improvement in emission efficiency with higher uses of energy. The correlations of emission with both GDP and population are significant; correlation between emission and GDP is greater than that between population and emission in absolute terms; however, both are more or less equal in incremental terms. It reflects the fact that countries with higher income as well as higher population are subject to more emissions; however, the former is more instrumental than the latter. The relationship between CO_2 emission and GDP is stronger in the absolute values than the incremental values, indicating that higher GDP brings about higher emission efficiency.

Figure 1 reveals that, except the top six emitters, almost all the countries have very insignificant role in global emissions. Among the six countries, USA and China are far ahead in both total and incremental emissions. Statistically, there exists a high correlation ($r = 0.84$) between the contribution of countries in total CO_2 emissions in 2004 and their contribution in total change in emissions from 1992 to 2004 (Table 6). This indicates that the countries with higher total emission experience higher rate of growth as well. However, while USA exceeds China in terms of contribution to total emissions in 2004, the latter has a higher contribution to increase in emissions. Similarly, both Japan and India are almost in the same position regarding to total emissions, while Japan's contribution to growth in emissions is much lower than that of India. Again, although in terms of contribution to total emissions, Russian Federation and Germany stand 3rd and 6th in the top order, they have highest negative contribution to growth in global emissions. Thus, it may be stated that the statistical relation between total CO_2 emissions and its change does not hold good for the top order countries.

The top 20 countries with highest per capita CO_2 emissions constitute, 67% among HINO, 37% among HIO, and 8% among UMI countries; while 100% among North America, 33% among Middle East and North Africa, 25% among East Asia and Pacific, 23% among Europe and Central Asia and 7% among Latin America and Caribbean (Fig. 2). The top 20 countries with highest CO_2 emissions per dollar GDP constitute, 25% among UMI, 23% among LMI, 20% among LI and 17% among HINO countries; while 25% among both Europe and Central Asia and East Asia and Pacific, 20% among both Middle East and North Africa and South Asia, 11% among Sub-Saharan Africa, and 5% among Latin America and Caribbean (Fig. 3). Among the top 20 countries with highest CO_2 emissions per unit energy consumption constitute, 42% among HINO, 21% among UMI, 16% among LMI, 11% among HIO and 10% among LI; while 53% among Middle East and North Africa, 17% among East Asia and Pacific, 15% among Europe and Central Asia, 11% among Sub-Saharan Africa and 10% among Latin America and Caribbean (Fig. 4). The analysis shows that, at the top order, although per capita emission depends upon income level, emission and energy efficiency do not. While North America has high per capita emission with higher emission and energy efficiency; Sub-Saharan Africa is completely opposite to it; South Asia has low per capita emission, higher energy efficiency but lower emission efficiency, while others are moderate in all the respects.

3 Decomposition methodology

Following Kaya (1990), we propose an identity that explains the decomposition of emissions into four factors:

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[9] Karakaya and Özcag (2005) in their analysis argued that the reduction in emissions of former Soviet Union countries is mainly due to the crisis experienced by them after gaining their independence; population effect is mainly stable, while with energy-saving and carbon-reduction plans most of the countries have improved their energy intensities. However, in some countries like Germany, Poland, Switzerland, etc. though the feature is not applicable, they have reduced their emissions.

$$CO_2\text{emissions from energy} \equiv CO_2 \text{ emissions per unit of energy consumed, } (CO_2/ENG)$$
$$\times \text{ energy consumed per unit of GDP, } (ENG/GDP)$$
$$\times \text{ GDP per capita, } (GDP/POP)$$
$$\times \text{ population, } (POP)$$

(1)

Hence, CO_2 emissions in country 'i' can be expressed as

$$CO_{2i} \equiv (CO_{2i}/ENG_i) \times (ENG_i/GDP_i)$$
$$\times (GDP_i/POP_i) \times POP_i$$
$$\equiv C_i E_i Y_i P_i$$

(2)

where C_i = quantum of carbon dioxide emissions per unit of energy use, E_i = quantum of energy consumed per \$ GDP, Y_i = per capita GDP, P_i = total population.

The change in a country's emissions (ΔCO_{2i}) between a base year 0 and an end year T can be decomposed into the effects of: (i) the change in rate of emissions per unit of energy consumed, termed as the emissions intensity effect, (C_{eff}) (ii) the change in rate of energy consumed per unit of GDP, that is, the energy intensity effect, (E_{eff}) (iii) the change in the GDP per capita effect, (Y_{eff}) and (iv) the change in population effect (P_{eff}). Thus,

$$\Delta CO_{2i} \equiv CO_{2i}(T) - CO_{2i}(0) \equiv C_{eff} + E_{eff} + Y_{eff} + P_{eff}$$

(3)

Following the LMDI method of decomposition proposed by Ang (2005), we have:

$$C_{eff} = \sum_i L(CO_{2i}(T), CO_{2i}(0)) \ln(C_i(T)/C_i(0))$$

$$E_{eff} = \sum_i L(CO_{2i}(T), CO_{2i}(0)) \ln(E_i(T)/E_i(0))$$

$$Y_{eff} = \sum_i L(CO_{2i}(T), CO_{2i}(0)) \ln(Y_i(T)/Y_i(0))$$

$$P_{eff} = \sum_i L(CO_{2i}(T), CO_{2i}(0)) \ln(P_i(T)/P_i(0))$$

where, 'logarithmic mean function' $L(CO_2(T), CO_2(0)) = \frac{CO_2(T) - CO_2(0)}{\ln(CO_2(T)) - \ln(CO_2(0))}$.

In the case of time series analysis, time period T and 0 are to be substituted by $t + 1$ and t, respectively. The interpretation of the decomposition is that each factor effect in Eq. 3 shows the change in CO_2 emissions during the period that is attributable to the change in the respective factor.

4 Decomposition results analysis

The decomposition of increase in global CO_2 emissions (Fig. 5) shows that the population effect has been positive and the increasing rate remained roughly constant, whereas the income effect has been the largest emission-increasing factor throughout the period. On an average, the income effect is more than three times than that of the population effect, and even the ratio between the former and the latter has been increasing over time (Table 7). This indicates that GDP is the more dominant driving force behind emissions. On the other hand, the energy effect has been negative only during the period 1996–2001. The more remarkable fact is that energy intensity has improved till 2001 and has actually deteriorated thereafter, indicating inefficiency in energy use in recent years. The emission efficiency has been improving throughout and has been instrumental in pulling down the extent of emission, indicating that there has been a continuous shift towards less emitting energy choice. It has been considered that population and GDP are the emission increasing factors, while the emission and energy efficiency neutralize the positive effects of them. During the period, on an average, increases in emission efficiency offset about 50% of increase in emission due to population and GDP, a corresponding increase in energy intensity (inefficiency) fuelled up emissions by about 7%. This indicates that while choosing less emitting energy, the rate of energy consumption has been rising.

The countrywise decomposition of CO_2 emissions (Table 8) shows that among the countries with increasing emissions, in 44% cases Y_{eff} has been predominant, e.g. China, USA, India, Canada among the important emitters; in 24% of the cases the major share of emissions can be attributed to E_{eff}, for example, Japan, Iran, Saudi Arabia, Italy, etc.; in 24% cases P_{eff} is predominant, for example, United Arab Emirates, Mexico, etc. and in only 8% cases C_{eff} is the largest contributor (Algeria, Norway, Ethiopia, etc.). The regionwise analysis shows that Y_{eff} is the largest contributor in North America (100%), East Asia and Pacific (75%), Europe and Central Asia (74%) and South Asia (60%), while P_{eff} in Middle East and North Africa (46%) and Sub-Saharan Africa (41%), and E_{eff} in Latin America and Caribbean (50%). However, C_{eff} is the largest contributor in Sub-Saharan Africa (24%), Middle East and North Africa (8%), Europe and Central Asia (5%) and Latin America and Caribbean (5%). The income levelwise analysis shows that the largest contributors in HINO are Y_{eff} in 56% cases, P_{eff} in 33% and E_{eff} in 11%; in HIO, Y_{eff} in 74%, E_{eff} in 21% and C_{eff} in 5%; in LI, Y_{eff} in 18%, P_{eff}

in 53%, E_{eff} in 18% and C_{eff} in 12%; in LMI, Y_{eff} in 39%, P_{eff} in 21%, E_{eff} in 25% and C_{eff} in 14%; in UMI, Y_{eff} in 40%, P_{eff} in 20%, and E_{eff} in 40%. It is evident that increases in income in the largest emitting, high income and newly industrialized countries; increases in population in the lower income countries, mostly in Middle East and Africa; while decline in energy efficiency in the Latin American and upper middle-income countries have been the foremost contributing factors in intensifying carbon dioxide emissions.

Among these countries, 15 have experienced positive growth effect regarding all the factors. The countries constitute 60% of South Asia, 21% of Sub-Saharan Africa, 20% of Middle East and North Africa, 17% of East Asia and Pacific, 10% of Latin America and Caribbean, 3% of Europe and Central Asia, and 25% of LI, 23% of LMI, 8% of HINO, 4% both of UMI and HIO. These countries seem to have a noticeable lack of planning and policies towards improvements in emission or energy efficiencies to combat the push effects of GDP and population.

Among the countries where average emissions have declined, in 96% of the cases C_{eff}, in 54% cases E_{eff} (in 50% cases both), in 46% cases P_{eff} and in only 19% cases Y_{eff} have been negative. However, C_{eff} and E_{eff} have been the predominant contributors in lowering the emissions in 73 and 27% cases, respectively. In general, GDP and population are found to contribute in increasing emissions. The regionwise analysis shows that the predominant factors that reduced emissions in Europe and Central Asia are C_{eff} in 67% cases and E_{eff} in 33% cases (in 57% cases both effects are negative), and in other regions only C_{eff} is predominant (in 20% cases both effects are negative). The income levelwise analysis shows that the ratio of predominant contributors, C_{eff} and E_{eff}, respectively in each of HINO, LI and LMI are 67%: 37% and in UMI it is 56%: 44%. However, in HIO the only predominant factor is C_{eff}. In UMI, both the factors are negative in about four-fifths of cases, whereas it is only about one-third in other cases. In 11% of the countries, income effect of emission has been negative. The countries include income groupwise 35% of LI, 10% of LMI, 8% of HINO and 4% of UMI, and regionwise 26% of Sub-Saharan Africa, 14% of Latin America and Caribbean, 8% of Europe and Central Asia and 7% of Middle East and North Africa. Among the countries, in 58% cases total emissions was positive, in which 57% cases E_{eff}, in 30% cases C_{eff} and only 13% cases P_{eff} are predominant. Population effect was negative in 12% of the countries, with 14% among them experiencing increase in emissions in which solely Y_{eff} is dominating.

Of the 114 countries, in 61% of the cases, Y_{eff} has been higher than P_{eff}. In 66% cases, the combined effects of C_{eff} and E_{eff} is negative, and in only less than 4% cases the combined effects of Y_{eff} and P_{eff} is negative. In 32% cases, the combined effects of C_{eff}, E_{eff} and Y_{eff} is negative. In 33% cases, population effect is greater than the combined effects of C_{eff}, E_{eff} and Y_{eff}.

By examining the coefficient of variations of the countries, it is found that those with high mean emissions in absolute terms, namely China, USA and India have low variations in emissions as well as the factor effects. However, a few countries have low mean emission with high fluctuations, like Netherlands, Hungary, Armenia and Denmark; United Arab Emirates and Syrian Arab Republic have low C_{eff} with high variation; Bulgaria, Panama, Ethiopia, Angola, Uzbekistan show high variation with low E_{eff}; Zambia, Paraguay, Togo and Russian Federation have low Y_{eff} with high variation, and Slovenia and Croatia have low P_{eff} with high fluctuations.

In the high-income non-OECD countries, the movement of emissions is dominated mainly by changes in emission efficiencies; energy efficiency has been considerably low, and the income effect is relatively insignificant (Fig. 6). In the high-income OECD countries, the income effect has significant role in emissions. Its positive effects are countered mainly by improvements in emission efficiencies (Fig. 7). The energy efficiency has been high enough to have a reducing effect on emission only between 1996 and 1999. In the upper middle-income countries, the carbon dioxide emission shows a declining trend up to 2002 and has been increasing thereafter (Fig. 8). They have maintained impressive emission efficiency throughout the period, while the energy efficiency has improved since 1996. Although the income effect has been considerably high since 1998, the combined effects of emission and energy efficiencies have had a sufficiently neutralizing effect on emissions up to 2002. The lower middle-income countries show a steadily increasing growth in emissions (Fig. 9). The income effect has been prominent throughout; they have achieved a moderate level of emission efficiency. The energy efficiency has been remarkable till 2001, but the intensity of energy use has been rapidly rising thereafter. In the low-income countries, emissions, though low in absolute terms, has been increasing, with a dramatic rise in 2003–2004 (Fig. 10). Both energy and emission efficiencies are highly fluctuating. The income effect was negligible till 2002 but dominant thereafter.

In East Asia and Pacific, the income effect has been significant, while emission efficiency has been maintained throughout (Fig. 11). Although the energy intensity has been low, since 2002 it has been rising steadily, resulting in accelerating emissions. In Europe and Central Asia, the emissions has been significantly low, with declines in certain periods, mainly due to the efficiencies in emission and energy use that outweigh the strong positive income effects (Fig. 12). In Latin America and Caribbean, the rate

of growth of emission has been falling, but since 2002 there has been a steep rise (Fig. 13). The emission efficiency has been remarkable throughout, while the income effect has been fluctuating and energy intensity has been high. The growth in emissions in Middle East and North America is highly fluctuating having strong correlations with emission efficiency (Fig. 14). The income effect is low and relatively energy-intensive activities contribute in pushing up emissions. In North America, in the pre-1997 period, emission intensity was the dominant factor for emissions, while since 1997 energy intensity played a major role (Fig. 15). The influence of income has been completely neutralized by emission and energy efficiencies. In South Asia, income effect has been strong, while the emission effect has been negative in most of the period (Fig. 16). The energy efficiency has been fluctuating, considerably affecting emissions. The income effect in Sub-Saharan Africa is not much significant (Fig. 17). However, emission and energy intensities move in opposite directions resulting in high fluctuations in emissions.

Among the countries with highest emissions, China had a remarkable surge in emission since 2001, triggered by increases in income and accelerating energy intensity (Fig. 18). In USA, the declining trend in growth of emission despite increases in income has been facilitated by maintaining high emission efficiency (Fig. 19). Since 1998, emissions has been mainly dependent on the energy intensity. In India, increases in income appear to be the most important factor behind emissions; although both emission and energy efficiencies have been exerting pull effects, but since 2000 the effects have failed to offset the income effect (Fig. 20). Fluctuations in growths in emissions in Japan are mainly due to fluctuations in income effect (Fig. 21). It has maintained high energy intensity and low emission intensity throughout the period. However, the dominant factor in this case is difficult to ascertain. In the Russian Federation, income effect has been dominant till 1998; thereafter in spite of high income, increases in both emission and energy efficiencies have been instrumental in reducing emissions since 1998 (Fig. 22). In Germany, the emission efficiency has been remarkable throughout; in spite of high income effect, the change in emission correspond to change in energy efficiency (Fig. 23). The population effects of all these countries are more or less constant and not very significant relative to other effects. The income effect is countered by emission and energy efficiencies; in many of the cases, although the countries have achieved emission efficiency, they could not increase their energy efficiency. Only the countries that achieved efficiencies in both emission and energy have been successful in reducing their emission in spite of high income.

Of the 114 countries, the combined effects of GDP and population on emission are negative only in Azerbaijan,

Tajikistan, Kyrgyzstan and Haiti[10] (Table 9). Among the remaining ones, in about 65% of the countries, the effects of increases in GDP and population are offset by improvements in energy and emission efficiencies, while in 35% cases there is negative offsetting (the increase due to GDP and population is reinforced). The countries with negative offsetting consist of 71% of LI, 50% of LMI, 25% of HINO, 17% of UMI and 15% of HIO. The corresponding figures on the basis of regional classification are 80% of South Asia, 58% of Sub-Saharan Africa, 53% of Middle East and North Africa, 50% of North America, 40% of Latin America and Caribbean, 33% of East Asia and Pacific and 5% of Europe and Central Asia.

In about 21% of the total countries, there is more than 100% offsetting, implying that the emission reducing effects of C_{eff} and E_{eff} outweigh the emission increasing effects of Y_{eff} and P_{eff}. The countries include 38% of UMI, 30% of HIO, 25% of HINO, 7% of LMI and 6% of LI, and 46% of Europe and Central Asia, 5% of Latin America and Caribbean, 13% of Middle East and North Africa, 11% of Sub-Saharan Africa. Therefore, the level of offsetting depends on the income level of the country, that is, higher income group with higher income effect offsets more than the lower income group, which in many cases reinforces emission instead of offsetting. However, the upper middle-income group, particularly in Europe and Central Asia, show even higher offsetting than high-income group.

5 Conclusion

In the present paper, we identify the different countries, income groups and regions that play crucial roles in accelerating global emissions. We also examine the contribution of the major factors in changing the level of emission by using the LMDI decomposition technique. We find that contrary to the conventional view that population growth is the major perpetrator of escalating emissions, the effect of increase in income is, on an average, about three times more instrumental than the population effect in augmenting emission. In recent years, the income effect has been found to be much more, for example, in 2003–2004 it has been six times more than the effect of population.

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[10] Except in case of Haiti, in the other three countries the combined effects of emission and energy intensities reinforce the negative effects of income and population.

However, the effects of economic growth can be substantially offset by improvements in emission and energy efficiencies; the upper middle-income countries of Europe and Central Asia are the typical examples. Of the top order emitting countries, the Russian Federation and Germany are the glaring examples of countries that have been able to actually reduce their emissions despite high income levels. Apart from few low emitting countries, almost all the countries have been successful in increasing emission efficiency, but their energy efficiencies have not been remarkable. Although emission efficiency has been more instrumental in curtailing carbon dioxide emission, in most cases the path of change in emission follows that of change in energy intensity. Both energy and emission intensity have crucial roles in determining the level of emissions. It is also found that in some cases although the mean efficiencies are impressive, they have been subject to high fluctuations, indicating lack of consistent efforts towards reducing emissions. Many countries belonging to lower-middle and low-income groups, particularly the newly industrializing ones of East Asia Pacific, South Asia and Sub-Saharan Africa, have been showing increasing growth in emissions due to accelerating income effects and increasing emission and energy intensities. However, these countries too in some occasions have reduced their emissions despite higher income by successfully reducing energy and emission intensities; but in the recent years, they have emphasized on economic growth even at the cost of their environment. It may be suggested that emphasis should be given on policies oriented towards sufficient counteractive energy and emission efficiencies before embarking on a path towards economic growth. By achieving high energy and emission efficiencies through technological development and shifting towards least emitting fuel, a country can maintain a balance between low emission, and high economic growth and natural population growth.

Appendix

See Tables 1, 2, 3, 4, 5, 6, 7, 8, 9 and Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23.

Table 1 Classification of sample countries

Region	Income groups					Total
	HINO	HIO	LI	LMI	UMI	
East Asia and Pacific	2	4	1	4	1	12
Europe and Central Asia	3	21	3	3	10	40
Latin America and Caribbean	1		1	10	9	21
Middle East and North Africa	6		1	7	1	15
North America		2				2
South Asia			3	2		5
Sub-Saharan Africa			11	5	3	19
Total	12	27	20	31	24	114

Table 2 Percentage contribution of high- and low-emitting countries to total emissions in 2004

Countries	5%	10%	20%	30%	40%	50%
High	60.87	70.69	85.61	91.81	95.45	97.48
Low	0.05	0.10	0.31	0.61	1.27	2.52

Table 3 Percentage contribution of countries to increase in emissions from 1992 to 2004

Countries	5%	10%	20%	23%	30%	40%	50%	60%	70%	77%
Top emissions increasing	79.79	90.32	105.20	106.90	109.85	111.86	112.96	113.57	113.88	113.98
Top emissions reducing	−11.58	−13.15	−13.97	−13.98	–	–	–	–	–	–

Table 4 Percentage change in yearly emissions from 1992 to 2004 and percentage of countries with decreasing emissions

Year	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	1992–2004
Change in emissions	1.79	1.24	1.48	3.64	1.81	−1.17	2.14	3.15	0.60	2.05	4.37	5.11	29.41
Countries with decreasing emissions	35.96	41.23	34.21	24.56	35.96	42.11	42.98	30.70	30.70	34.21	23.68	26.32	22.81

Table 5 CO$_2$ emissions (million metric tons) in 1992 and 2004, percentage change over the period and their corresponding rank orders

Country	Inc.gr.	1992	Rank	2004	Rank	%change	Rank
United States	HIO	4807.32	1	6049.44	1	25.84	69
China	LMI	2644.57	2	5010.17	2	89.45	23
Russian Federation	UMI	1985.33	3	1524.99	3	−23.19	105
India	LMI	776.42	6	1342.96	4	72.97	33
Japan	HIO	1105.97	4	1257.96	5	13.74	80
Germany	HIO	866.11	5	808.77	6	−6.62	95
Canada	HIO	419.83	9	639.40	7	52.30	48
United Kingdom	HIO	580.92	7	587.26	8	1.09	86
Korea, Republic of	HIO	290.35	15	465.64	9	60.37	39
Italy	HIO	404.53	10	449.95	10	11.23	81
Mexico	UMI	433.73	8	438.02	11	0.99	87
South Africa	UMI	323.41	14	437.03	12	35.13	59
Iran (Islamic Republic)	LMI	238.00	19	433.57	13	82.17	26
Indonesia	LMI	275.11	17	378.25	14	37.49	57
France	HIO	364.82	11	373.69	15	2.43	85
Brazil	UMI	222.89	21	331.79	16	48.86	49
Spain	HIO	227.06	20	330.50	17	45.55	52
Australia	HIO	286.99	16	326.76	18	13.86	79
Saudi Arabia	HINO	358.85	12	308.39	19	−14.06	100
Poland	UMI	339.37	13	307.24	20	−9.47	98
Thailand	LMI	126.80	25	268.08	21	111.42	18
Turkey	UMI	146.56	22	226.13	22	54.29	46
Kazakhstan	UMI	259.40	18	200.28	23	−22.79	104
Algeria	LMI	80.56	33	194.00	24	140.82	11
Malaysia	UMI	74.37	34	177.58	25	138.77	12
Venezuela	UMI	119.95	27	172.62	26	43.91	53
Egypt	LMI	80.96	32	158.24	27	95.46	20
United Arab Emirates	HINO	60.97	39	149.19	28	144.68	10
Netherlands	HIO	140.81	23	142.06	29	0.89	88
Argentina	UMI	118.97	28	141.79	30	19.18	73
Uzbekistan	LI	118.16	29	137.91	31	16.71	77
Pakistan	LI	72.72	36	125.67	32	72.82	34
Czech Republic	HIO	138.45	24	116.99	33	−15.50	101
Nigeria	LI	64.87	37	114.02	34	75.77	30
Belgium	HIO	103.99	30	100.72	35	−3.15	92
Viet Nam	LI	22.38	61	98.66	36	340.80	2
Bangladesh	LI	16.19	68	37.17	58	129.50	14
Slovakia	HIO	44.33	50	36.29	59	−18.14	103
Trinidad and Tobago	HINO	20.96	64	32.56	60	55.30	43
New Zealand	HIO	24.37	60	31.57	61	29.53	68
Peru	LMI	20.41	66	31.49	62	54.33	45
Azerbaijan	LMI	49.84	46	31.37	63	−37.06	109
Oman	HINO	12.00	74	30.90	64	157.50	8
Ecuador	LMI	22.22	62	29.27	65	31.69	63
Croatia	UMI	17.43	67	23.50	66	34.86	60
Tunisia	LMI	15.01	69	22.88	67	52.50	47
Yemen	LI	14.37	70	21.11	68	46.91	50
Dominican Republic	LMI	11.20	77	19.64	69	75.29	32
Estonia	HINO	24.88	59	18.94	70	−23.85	106
Bahrain	HINO	10.28	79	16.95	71	64.93	36
Jordan	LMI	12.27	73	16.47	72	34.22	62
Lebanon	UMI	11.35	76	16.26	73	43.24	54
Slovenia	HINO	12.32	72	16.21	74	31.57	64
Lithuania	UMI	21.37	63	13.31	75	−37.73	110
Guatemala	LMI	6.02	81	12.22	76	103.11	19
Sri Lanka	LMI	5.05	85	11.53	77	128.30	15
Luxembourg	HIO	11.79	75	11.28	78	−4.32	93
Jamaica	UMI	8.10	80	10.59	79	30.84	66
Kenya	LI	5.46	83	10.59	80	93.83	21
Sudan	LMI	4.45	87	10.37	81	132.84	13
Ethiopia	LI	2.90	99	7.98	82	175.22	6
Angola	LMI	4.41	88	7.90	83	79.05	28
Honduras	LMI	3.08	98	7.61	84	147.56	9
Ghana	LI	3.93	91	7.19	85	82.93	25
Latvia	UMI	12.74	71	7.10	86	−44.27	111
Bolivia	LMI	5.90	82	6.97	87	18.28	75
Cyprus	HINO	4.98	86	6.75	88	35.47	58
Costa Rica	UMI	3.74	92	6.40	89	71.11	35
El Salvador	LMI	3.42	96	6.17	90	80.47	27
Kyrgyzstan	LI	11.05	78	5.73	91	−48.16	112
Panama	UMI	4.01	90	5.66	92	41.13	55
Uruguay	UMI	5.08	84	5.48	93	7.79	82

Table 5 continued

Country	Inc.gr.	1992	Rank	2004	Rank	%change	Rank	Country	Inc.gr.	1992	Rank	2004	Rank	%change	Rank
Greece	HIO	73.97	35	96.69	37	30.72	67	Cote d'Ivoire	LI	4.34	89	5.16	94	18.82	74
Romania	UMI	122.27	26	90.43	38	−26.05	107	Tajikistan	LI	20.58	65	5.00	95	−75.69	114
Norway	HIO	30.54	57	87.60	39	186.84	3	Senegal	LI	3.43	95	4.99	96	45.67	51
Philippines	LMI	50.22	45	80.51	40	60.33	40	United Republic of Tanzania	LI	2.33	106	4.35	97	86.93	24
Israel	HINO	39.84	53	71.25	41	78.83	29	Botswana	UMI	3.27	97	4.30	98	31.50	65
Austria	HIO	56.25	41	69.85	42	24.17	71	Paraguay	LMI	2.62	102	4.18	99	59.44	41
Syrian Arab Republic	LMI	42.48	52	68.42	43	61.05	38	Nicaragua	LMI	2.48	103	4.01	100	61.45	37
Finland	HIO	47.85	47	65.80	44	37.50	56	Cameroon	LMI	3.63	94	3.84	101	5.76	83
Belarus	UMI	94.66	31	64.89	45	−31.45	108	Albania	LMI	2.38	105	3.67	102	54.63	44
Chile	UMI	35.57	54	62.42	46	75.48	31	Armenia	LMI	3.68	93	3.65	103	−0.90	91
Portugal	HIO	47.15	48	58.91	47	24.94	70	Congo	LMI	1.24	109	3.54	104	184.96	5
Hungary	HIO	57.27	40	57.18	48	−0.16	89	Nepal	LI	1.33	108	3.04	105	128.02	16
Colombia	LMI	62.22	38	53.63	49	−13.81	99	Namibia	LMI	0.01	114	2.47	106	16750	1
Sweden	HIO	51.47	43	53.03	50	3.03	84	Malta	HINO	2.64	101	2.45	107	−7.08	97
Denmark	HIO	53.39	42	52.96	51	−0.81	90	Benin	LI	0.91	112	2.39	108	163.56	7
Singapore	HINO	45.25	49	52.25	52	15.47	78	Togo	LI	0.81	113	2.31	109	185.07	4
Bulgaria	UMI	50.95	44	42.56	53	−16.47	102	Zambia	LI	2.46	104	2.29	110	−6.87	96
Ireland	HIO	31.44	56	42.35	54	34.70	61	Iceland	HIO	1.81	107	2.23	111	22.83	72
Morocco	LMI	26.04	58	41.17	55	58.11	42	Mozambique	LI	1.00	110	2.17	112	117.28	17
Switzerland	HIO	42.76	51	40.46	56	−5.39	94	Haiti	LI	0.91	111	1.76	113	93.15	22
Hong Kong, China	HINO	31.68	55	37.41	57	18.10	76	Gabon	UMI	2.78	100	1.37	114	−50.66	113

Table 6 Correlation coefficients for the year 2004 and change from 1992

	CO_2	Energy	GDP	Population	ΔCO_2	ΔEnergy	ΔGDP	ΔPopulation
CO_2	1.00							
Energy	0.99	1.00						
GDP	0.81	0.73	1.00					
Population	0.68	0.78	0.28	1.00				
ΔCO_2	0.84	0.90	0.51	0.81	1.00			
ΔEnergy	0.90	0.96	0.56	0.85	0.97	1.00		
ΔGDP	0.91	0.85	0.95	0.42	0.68	0.71	1.00	
ΔPopulation	0.52	0.61	0.20	0.94	0.67	0.68	0.33	1.00

Table 7 Decomposition of global CO_2 emissions (in million metric ton)

	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004
C_{eff}	−433.00	−432.13	−636.68	−270.55	−176.96	−632.61	−271.94	−263.08	−453.74	−504.82	−351.71	−679.34
E_{eff}	339.06	24.72	205.76	160.15	−397.15	−220.20	−172.54	−157.62	−91.13	191.82	277.45	561.85
Y_{eff}	244.39	453.08	529.26	677.94	759.64	382.31	711.37	919.30	477.94	593.76	921.26	1187.69
P_{eff}	212.82	210.83	210.62	205.88	212.88	207.28	207.03	214.90	207.41	200.39	200.08	208.07
Total (ΔCO_2)	363.27	256.49	308.96	773.41	398.41	−263.22	473.91	713.49	140.48	481.15	1047.07	1278.28

Table 8 Countrywise summary results of decomposition

Country	ΔCO_2				C_{eff}				E_{eff}				Y_{eff}				P_{eff}			
	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max
China	197.13	1.32	−181.53	758.78	−47.80	−1.70	−215.42	90.89	−68.01	−2.84	−228.46	394.66	283.79	0.20	207.95	396.45	29.16	0.14	23.36	34.28
United States	103.51	1.39	−84.49	404.34	−81.25	−1.57	−188.26	255.89	5.76	12.59	−117.33	85.72	116.28	0.56	−14.46	188.61	62.71	0.06	54.93	66.42
India	47.21	0.45	15.51	83.29	−10.04	−1.72	−31.37	35.41	−6.76	−2.54	−44.09	14.74	46.41	0.45	23.20	87.14	17.60	0.09	14.68	19.25
Canada	18.30	1.45	−18.75	87.82	−2.22	−12.56	−42.32	73.25	2.78	4.66	−17.53	30.78	12.60	0.60	2.31	25.63	5.14	0.17	3.79	7.19
Iran, Islamic Rep.	16.30	1.31	−15.28	60.82	−8.06	−2.79	−43.71	30.90	11.77	1.20	−10.56	30.85	7.45	1.24	−7.36	21.39	5.13	0.17	3.70	6.35
Korea, Rep.	14.61	1.78	−60.44	34.95	−13.44	−0.63	−30.01	−2.56	7.74	1.11	−3.12	23.45	17.19	0.95	−30.14	31.78	3.12	0.27	2.21	5.12
Japan	12.67	2.28	−39.42	52.61	−23.98	−0.91	−56.70	20.56	24.12	0.77	−5.09	68.69	9.83	1.64	−23.03	31.88	2.71	0.35	0.42	4.33
Thailand	11.77	1.06	−23.68	23.18	−2.68	−1.80	−12.92	5.70	6.96	0.72	−0.94	13.74	5.59	1.94	−23.89	14.09	1.90	0.12	1.54	2.31
South Africa	9.47	1.19	−10.06	30.55	−9.73	−1.03	−36.68	0.31	7.66	2.31	−21.59	42.20	4.10	1.34	−6.07	14.75	7.43	0.26	3.80	9.78
Algeria	9.45	2.56	−8.60	83.03	3.13	7.49	−18.92	71.42	1.65	2.19	−4.81	6.96	2.50	1.54	−3.44	9.90	2.18	0.28	1.42	2.90
Brazil	9.08	1.15	−12.21	26.55	−6.10	−1.38	−22.02	7.07	7.00	0.66	−0.69	13.48	3.86	1.42	−4.58	13.57	4.31	0.11	3.49	4.75
Spain	8.62	1.36	−19.22	22.76	−5.02	−1.51	−15.57	6.81	5.56	0.86	−4.11	12.26	5.98	0.67	−3.07	11.40	2.10	0.88	0.53	5.18
Malaysia	8.60	1.30	−10.97	26.45	0.69	14.49	−18.48	23.41	1.29	6.48	−14.14	11.74	3.87	1.50	−12.08	8.69	2.76	0.11	2.09	3.14
Indonesia	8.59	4.16	−71.62	54.83	−9.98	−3.02	−56.53	40.42	6.04	2.17	−7.26	36.62	7.81	2.50	−51.03	21.14	4.72	0.09	4.16	5.52
United Arab Emirates	7.35	4.86	−33.89	82.07	−0.36	−104.67	−49.56	78.67	1.13	4.97	−7.64	14.26	0.68	6.74	−4.13	9.94	5.90	0.40	1.85	9.25
Turkey	6.63	1.78	−21.80	22.12	−3.58	−0.96	−9.66	0.77	3.39	1.33	−3.85	10.20	3.69	3.21	−19.97	16.90	3.13	0.19	1.38	3.55
Egypt,	6.44	1.36	−10.94	15.74	−1.15	−7.69	−18.37	13.65	2.66	1.96	−6.75	11.03	2.78	0.46	0.85	4.95	2.15	0.19	1.62	2.73
Vietnam	6.36	0.92	0.59	21.50	2.48	1.21	−1.13	8.14	0.47	4.52	−1.45	6.77	2.75	0.44	1.32	5.38	0.66	0.46	0.08	1.21
Norway	4.76	1.24	−2.12	19.65	2.80	2.35	−2.25	22.11	0.55	4.94	−3.18	6.78	1.13	0.57	0.38	2.36	0.28	0.39	0.18	0.50
Pakistan	4.41	1.68	−6.58	24.04	−1.02	−6.19	−13.49	13.13	1.91	0.67	0.02	4.20	1.19	1.48	−1.26	5.37	2.34	0.11	1.89	2.73
Venezuela, RB	4.39	4.25	−26.48	38.10	−0.61	−28.78	−28.09	29.65	3.73	3.23	−11.68	28.47	−1.92	−5.77	−17.35	23.78	3.20	0.11	2.63	3.66
Nigeria	4.10	3.00	−13.40	34.87	1.15	9.96	−13.11	30.96	0.21	12.20	−6.56	3.80	0.88	3.12	−1.37	8.36	1.86	0.31	1.28	2.69
Italy	3.78	2.61	−13.54	23.83	−10.99	−0.44	−20.58	−5.40	9.10	1.10	−4.79	30.03	4.80	1.25	−3.58	15.56	0.88	1.69	0.01	4.43
Australia	3.31	4.29	−27.44	23.45	−9.60	−1.34	−39.74	5.07	0.85	8.41	−10.74	15.26	8.29	0.37	2.76	14.36	3.78	0.11	2.85	4.45
Israel	2.62	1.16	−1.05	8.37	−0.27	−9.98	−4.41	4.38	0.84	2.16	−2.48	4.45	0.70	2.03	−1.91	2.80	1.34	0.11	1.11	1.62
Philippines	2.52	1.64	−2.86	11.39	−1.35	−1.74	−7.31	2.51	1.14	2.05	−2.59	5.31	1.26	1.17	−2.04	3.06	1.48	0.12	1.15	1.63
Chile	2.24	1.74	−4.29	7.67	−1.20	−1.63	−4.39	1.83	1.03	2.87	−2.86	8.46	1.70	0.75	−1.20	3.66	0.71	0.08	0.64	0.79
Syrian Arab Republic	2.16	2.87	−3.49	19.76	0.18	34.27	−7.13	18.17	0.26	8.74	−2.99	4.25	0.51	2.60	−2.94	1.92	1.21	0.13	1.01	1.59
Argentina	1.90	3.67	−9.06	11.67	−3.05	−1.27	−8.63	5.22	2.65	1.71	−3.82	11.07	0.86	9.46	−15.73	10.56	1.44	0.09	1.20	1.57
Greece	1.89	0.84	−0.18	4.98	−1.87	−0.57	−3.65	−0.22	1.02	1.35	−1.19	2.87	2.30	0.76	−1.86	4.13	0.44	0.33	0.27	0.68
Bangladesh	1.75	0.85	−0.87	4.51	0.08	13.42	−2.18	1.80	0.36	1.86	−0.51	1.81	0.79	0.42	0.29	1.52	0.52	0.20	0.37	0.68
Uzbekistan	1.65	4.12	−11.51	17.48	−1.60	−2.41	−6.99	4.54	0.07	97.32	−10.44	10.20	1.28	3.73	−8.50	8.56	1.89	0.21	1.31	2.74

Table 8 continued

Country	ΔCO₂				C_eff				E_eff				Y_eff				P_eff			
	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max
Oman	1.57	1.29	−1.20	6.32	0.14	11.70	−2.53	3.56	0.73	2.15	−2.57	2.98	0.38	1.22	−0.42	1.35	0.33	0.28	0.19	0.45
Finland	1.50	3.05	−3.58	7.49	−1.06	−2.91	−5.79	3.18	0.71	3.71	−3.73	3.89	1.68	0.68	−0.85	3.56	0.17	0.26	0.11	0.25
Morocco	1.26	0.99	−0.54	3.73	−0.50	−1.89	−1.68	1.06	0.67	2.19	−1.77	2.40	0.62	2.62	−2.47	3.03	0.47	0.05	0.42	0.50
Austria	1.13	1.65	−1.37	5.34	−1.27	−1.12	−3.77	0.46	1.13	1.91	−1.67	5.01	1.11	0.67	0.00	2.30	0.16	0.91	0.00	0.49
Portugal	0.98	3.41	−5.41	5.72	−1.48	−1.13	−4.84	0.77	1.29	1.09	−1.25	2.90	0.92	1.30	−1.00	2.41	0.25	0.53	0.05	0.44
Trinidad and Tobago	0.97	2.39	−4.16	4.28	−0.77	−2.35	−3.87	2.09	0.40	3.94	−2.66	3.00	1.22	0.90	−0.43	3.91	0.11	0.15	0.09	0.15
Peru	0.92	1.93	−0.93	4.70	−0.27	−5.07	−1.92	2.95	0.13	11.67	−2.04	2.70	0.70	1.20	−0.54	2.38	0.37	0.07	0.32	0.41
Ireland	0.91	1.33	−1.28	2.56	−1.03	−0.75	−2.16	0.43	−0.72	−1.94	−3.07	1.48	2.20	0.44	0.73	3.64	0.45	0.52	0.07	0.76
France	0.74	25.68	−29.68	31.15	−10.66	−1.04	−24.86	15.75	4.49	2.62	−13.92	23.26	5.23	0.95	−4.67	12.09	1.69	0.43	1.08	3.44
Dominican Republic	0.70	1.69	−1.62	3.41	−0.22	−4.95	−1.41	2.57	0.09	6.73	−0.88	1.28	0.53	1.08	−0.74	1.21	0.30	0.14	0.22	0.34
Tunisia	0.66	1.23	−0.55	2.00	−0.27	−2.75	−1.00	1.40	0.12	3.04	−0.26	0.86	0.58	0.65	0.03	1.06	0.23	0.20	0.12	0.31
New Zealand	0.60	2.44	−0.96	3.76	−0.37	−2.95	−2.17	1.85	−0.09	−9.30	−1.77	0.94	0.70	0.66	−0.14	1.40	0.36	0.44	0.16	0.65
Ecuador	0.59	8.92	−10.91	9.15	−0.64	−8.12	−12.17	7.13	0.61	1.83	−0.72	2.91	0.28	2.97	−1.70	1.78	0.34	0.18	0.28	0.49
Singapore	0.58	13.84	−17.42	10.96	−2.41	−1.49	−10.66	3.55	−0.33	−17.28	−11.04	6.69	2.15	1.18	−2.88	4.64	1.17	0.72	−0.76	2.04
Yemen, Rep.	0.56	4.05	−4.41	3.76	−0.58	−3.32	−4.39	3.23	0.40	2.53	−1.89	1.63	0.23	1.41	−0.26	0.83	0.51	0.11	0.41	0.60
Bahrain	0.56	3.81	−4.73	4.60	−0.38	−5.36	−5.69	3.47	0.17	3.81	−1.03	1.32	0.38	1.02	−0.48	1.11	0.40	0.09	0.33	0.46
Sri Lanka	0.54	1.15	−0.49	1.67	0.04	13.71	−1.56	0.84	0.14	2.29	−0.36	0.65	0.29	0.36	0.17	0.48	0.07	1.97	−0.34	0.15
United Kingdom	0.53	30.27	−28.88	25.58	−13.79	−0.69	−36.10	1.50	−2.44	−4.63	−22.94	21.35	14.88	0.26	9.61	22.67	1.88	0.26	1.37	3.04
Guatemala	0.52	1.36	−0.51	1.57	0.05	12.77	−0.89	0.85	0.18	1.16	−0.15	0.64	0.08	1.04	−0.06	0.20	0.20	0.26	0.14	0.29
Croatia	0.51	1.54	−0.95	1.65	−0.35	−1.47	−1.45	0.53	0.17	4.76	−0.68	2.34	0.70	1.47	−2.12	1.81	−0.02	−20.67	−0.74	0.66
Sudan	0.49	2.17	−1.89	1.75	0.15	6.38	−1.87	1.31	0.04	7.51	−0.55	0.52	0.18	0.60	−0.06	0.33	0.12	0.24	0.09	0.19
Hong Kong, China	0.48	7.62	−5.03	8.44	−1.07	−2.42	−4.63	2.76	0.20	18.65	−8.47	7.41	0.93	1.57	−2.01	3.59	0.42	0.78	0.13	1.27
Kenya	0.43	2.61	−1.40	1.77	0.06	18.09	−1.56	1.52	0.15	1.67	−0.24	0.50	−0.01	−8.48	−0.18	0.16	0.23	0.12	0.18	0.27
Ethiopia	0.42	2.60	−2.17	2.19	0.19	6.09	−2.52	2.16	0.00	−69.72	−0.54	0.59	0.09	3.33	−0.43	0.75	0.14	0.26	0.08	0.19
Lebanon	0.41	3.14	−2.35	2.51	−0.53	−1.58	−2.62	0.36	0.32	4.03	−2.51	2.10	0.36	0.94	−0.40	1.03	0.27	0.33	0.20	0.42
Honduras	0.38	0.90	−0.23	1.12	0.13	2.03	−0.23	0.63	0.10	2.47	−0.45	0.38	0.05	2.23	−0.19	0.20	0.10	0.18	0.08	0.14
Mexico	0.36	41.68	−27.04	20.00	−15.70	−0.70	−37.47	−2.12	4.64	2.31	−15.88	21.90	5.58	2.67	−33.56	21.37	5.84	0.21	4.30	7.64
Jordan	0.35	1.71	−0.63	1.53	−0.56	−1.97	−3.86	0.37	0.24	2.73	−0.67	1.94	0.25	1.14	−0.67	0.88	0.42	0.17	0.26	0.55
Slovenia	0.32	3.74	−1.77	3.08	−0.37	−2.77	−2.56	1.97	0.14	3.59	−0.75	0.70	0.55	0.23	0.36	0.81	0.00	273.77	−0.19	0.13
Angola	0.29	8.89	−3.68	7.11	−0.08	−31.63	−4.02	6.94	0.01	68.75	−0.67	1.76	0.17	3.91	−1.62	0.85	0.20	0.22	0.14	0.28
Ghana	0.27	1.37	−0.55	0.65	−0.03	−11.69	−0.62	0.36	0.03	4.30	−0.34	0.15	0.12	0.50	0.03	0.24	0.15	0.10	0.12	0.17
El Salvador	0.23	1.74	−0.39	0.86	−0.06	−4.65	−0.41	0.47	0.11	1.53	−0.23	0.39	0.08	0.95	−0.01	0.21	0.10	0.12	0.07	0.11
Costa Rica	0.22	2.00	−0.37	1.29	−0.08	−8.06	−1.45	1.01	0.07	6.00	−0.81	0.91	0.11	1.15	−0.08	0.30	0.12	0.09	0.09	0.13

Table 8 continued

Country	ΔCO_2				C_{eff}				E_{eff}				Y_{eff}				P_{eff}			
	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max
Jamaica	0.21	2.39	−0.90	1.07	−0.20	−2.17	−1.40	0.32	0.26	1.26	−0.53	0.66	0.08	3.04	−0.22	0.69	0.07	0.31	0.05	0.12
Namibia	0.20	2.33	−0.21	1.66	0.11	4.36	−0.16	1.62	0.03	2.20	−0.12	0.20	0.03	1.24	0.00	0.11	0.03	0.58	0.00	0.05
Congo, Rep.	0.19	2.25	−0.56	0.82	0.12	4.84	−0.68	1.43	0.02	12.15	−0.51	0.36	−0.01	−9.91	−0.14	0.12	0.06	0.21	0.04	0.07
United Republic of Tanzania: Zanzibar	0.17	2.72	−0.58	1.14	−0.05	−7.84	−0.66	0.94	0.08	0.81	−0.05	0.18	0.06	1.21	−0.05	0.18	0.08	0.17	0.06	0.11
Cyprus	0.15	2.18	−0.54	0.75	−0.11	−2.58	−0.70	0.27	0.04	9.41	−0.71	0.58	0.12	0.90	−0.08	0.24	0.09	0.32	0.07	0.16
Nepal	0.14	3.09	−0.74	0.97	0.02	22.96	−0.81	0.79	0.02	1.73	−0.04	0.09	0.05	1.21	−0.09	0.12	0.06	0.20	0.04	0.07
Panama	0.14	6.32	−1.31	1.41	−0.03	−21.90	−1.43	1.06	0.00	−74.53	−0.66	0.77	0.08	1.39	−0.07	0.30	0.09	0.35	0.00	0.12
Senegal	0.13	2.26	−0.47	0.61	−0.02	−19.78	−0.72	0.94	0.01	30.44	−0.73	0.29	0.04	2.28	−0.17	0.17	0.10	0.10	0.09	0.12
Sweden	0.13	31.36	−6.10	7.22	−1.34	−2.76	−5.65	5.15	0.25	8.37	−3.36	3.36	1.07	0.86	−1.32	2.03	0.15	0.75	0.01	0.35
Paraguay	0.13	2.83	−0.81	0.55	−0.02	−11.86	−0.63	0.32	0.08	1.39	−0.04	0.28	−0.01	−17.56	−0.23	0.11	0.08	0.33	0.00	0.09
Nicaragua	0.13	1.25	−0.18	0.29	−0.05	−4.31	−0.47	0.27	0.05	1.89	−0.10	0.26	0.06	1.09	−0.08	0.18	0.06	0.06	0.05	0.06
Togo	0.12	1.83	−0.17	0.71	0.07	2.76	−0.18	0.51	0.02	5.41	−0.16	0.15	0.00	−14.67	−0.15	0.10	0.04	0.34	0.02	0.06
Benin	0.12	1.09	−0.06	0.35	0.04	3.53	−0.28	0.27	0.01	10.27	−0.29	0.15	0.02	0.79	−0.01	0.04	0.05	0.27	0.04	0.08
Albania	0.11	3.11	−0.41	0.64	−0.01	−28.25	−0.59	0.63	−0.02	−10.70	−0.24	0.43	0.14	0.75	−0.16	0.25	−0.01	−2.88	−0.03	0.02
Netherlands	0.10	75.12	−10.17	15.41	−4.25	−1.66	−16.71	6.87	0.97	4.43	−6.48	6.53	2.54	0.89	−0.95	5.51	0.85	0.23	0.50	1.09
Mozambique	0.10	1.75	−0.07	0.60	0.03	5.02	−0.11	0.49	−0.03	−2.33	−0.13	0.13	0.06	0.71	−0.01	0.13	0.03	0.14	0.03	0.04
Bolivia	0.09	17.02	−2.98	3.08	−0.42	−3.82	−4.13	2.64	0.23	2.13	−0.87	0.82	0.11	1.19	−0.17	0.28	0.18	0.12	0.14	0.21
Botswana	0.09	4.13	−0.40	0.75	−0.05	−5.98	−0.43	0.52	−0.09	−1.16	−0.26	0.12	0.16	0.60	−0.02	0.28	0.07	0.23	0.05	0.09
Haiti	0.07	3.79	−0.36	0.64	0.02	12.04	−0.33	0.53	0.05	1.50	−0.05	0.22	−0.02	−1.38	−0.09	0.02	0.02	0.30	0.01	0.03
Cote d'Ivoire	0.07	33.35	−4.95	4.18	−0.22	−9.53	−5.00	3.29	0.16	2.01	−0.30	0.80	−0.02	−9.09	−0.37	0.34	0.14	0.31	0.09	0.22
Iceland	0.03	3.06	−0.11	0.26	−0.09	−1.30	−0.35	0.09	0.05	1.48	−0.03	0.23	0.05	0.99	−0.05	0.15	0.02	0.29	0.01	0.03
Uruguay	0.03	20.48	−1.26	1.02	−0.09	−4.33	−1.10	0.38	0.06	5.84	−0.40	0.74	0.05	5.85	−0.53	0.54	0.02	0.77	−0.01	0.03
Cameroon	0.02	36.87	−1.38	1.20	−0.14	−4.65	−1.58	0.98	0.06	2.11	−0.07	0.32	0.01	7.65	−0.22	0.10	0.08	0.34	0.00	0.11
Armenia	0.00	−195.67	−0.90	0.67	0.11	5.88	−1.11	1.32	−0.31	−2.05	−1.69	0.35	0.23	0.77	−0.23	0.43	−0.03	−0.67	−0.07	−0.01
Hungary	−0.01	−349.08	−4.12	3.48	−1.41	−1.12	−3.96	0.25	−0.57	−3.64	−3.21	3.04	2.09	0.50	−0.24	3.05	−0.12	−0.28	−0.17	−0.07
Zambia	−0.01	−18.62	−0.51	0.52	−0.09	−2.63	−0.53	0.40	0.03	3.46	−0.12	0.30	−0.01	−19.75	−0.29	0.11	0.05	0.21	0.04	0.06
Malta	−0.02	−26.43	−1.23	0.36	−0.11	−3.37	−0.66	0.42	0.01	30.51	−0.66	0.67	0.06	1.19	−0.07	0.14	0.02	0.33	0.01	0.03
Denmark	−0.04	−165.25	−9.86	11.71	−1.40	−2.26	−6.40	3.19	0.15	22.06	−5.59	6.79	1.02	0.88	−0.20	2.99	0.20	0.37	0.12	0.39
Luxembourg	−0.04	−21.07	−1.89	1.36	−0.38	−1.18	−1.38	0.23	−0.03	−15.75	−1.08	0.90	0.27	0.67	−0.01	0.54	0.11	0.33	0.03	0.16
Gabon	−0.12	−6.38	−2.08	1.06	−0.22	−3.42	−2.27	0.83	0.04	3.64	−0.31	0.15	0.01	11.99	−0.17	0.12	0.06	0.55	0.02	0.10
Switzerland	−0.19	−9.43	−2.30	3.92	−1.18	−0.76	−2.44	0.62	0.50	1.95	−0.98	2.80	0.24	2.24	−0.57	1.24	0.25	0.36	0.08	0.38
Belgium	−0.27	−18.34	−7.16	11.14	−3.22	−1.21	−9.36	4.87	0.90	3.60	−3.27	8.30	1.73	0.86	−1.46	3.83	0.31	0.27	0.21	0.44
Kyrgyzstan	−0.44	−2.85	−2.69	1.17	−0.14	−2.73	−0.85	0.47	−0.21	−2.48	−0.87	0.63	−0.14	−5.03	−1.62	0.45	0.05	0.63	−0.01	0.09

Table 8 continued

Country	ΔCO$_2$				C$_{eff}$				E$_{eff}$				Y$_{eff}$				P$_{eff}$			
	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max	Mean	C.V.	Min	Max
Latvia	−0.47	−1.50	−1.48	0.59	−0.36	−1.45	−1.50	0.27	−0.41	−1.02	−1.09	0.20	0.40	0.78	−0.41	0.83	−0.10	−0.63	−0.21	−0.03
Estonia	−0.49	−3.67	−4.82	2.41	−0.48	−1.20	−1.34	0.59	−0.77	−1.93	−3.42	1.61	0.96	0.81	−0.78	2.23	−0.21	−0.82	−0.58	−0.06
Slovakia	−0.67	−3.80	−6.30	3.86	−1.45	−1.67	−6.49	2.27	−0.57	−2.52	−2.40	1.79	1.30	0.97	−1.74	3.12	0.05	1.49	−0.07	0.16
Lithuania	−0.67	−2.07	−3.89	0.78	−0.62	−1.80	−2.98	1.44	−0.24	−4.44	−1.91	1.16	0.28	5.05	−3.32	1.34	−0.09	−0.30	−0.12	−0.04
Bulgaria	−0.70	−9.63	−13.63	15.22	−1.30	−3.90	−12.54	9.94	−0.02	−154.28	−4.76	6.20	0.99	2.52	−4.92	3.14	−0.37	−0.58	−0.82	−0.22
Colombia	−0.72	−6.32	−9.41	4.01	−2.17	−1.78	−11.30	4.69	−0.03	−61.55	−2.80	3.17	0.47	3.42	−3.67	2.54	1.02	0.14	0.81	1.21
Tajikistan	−1.30	−2.36	−8.48	0.61	−1.04	−2.16	−6.53	0.54	0.09	7.89	−0.93	1.41	−0.43	−2.81	−3.30	0.44	0.09	0.71	0.05	0.27
Azerbaijan	−1.54	−2.10	−9.13	2.25	−1.35	−1.85	−6.30	3.54	0.20	26.64	−3.61	12.65	−0.74	−7.70	−13.28	3.03	0.34	0.47	0.21	0.73
Czech Republic	−1.79	−2.98	−9.34	10.01	−4.62	−0.75	−11.67	1.93	0.10	38.82	−7.38	5.30	2.84	0.88	−0.78	7.39	−0.11	−1.81	−0.57	0.17
Belarus	−2.48	−2.22	−16.22	2.71	−1.37	−0.97	−3.63	1.56	−2.15	−1.67	−9.37	4.44	1.23	4.58	−9.19	7.16	−0.20	−0.71	−0.32	0.19
Romania	−2.65	−2.85	−14.09	11.49	−2.86	−0.90	−6.86	0.92	−2.20	−1.85	−9.12	3.60	2.81	1.74	−7.08	8.34	−0.40	−1.07	−1.35	−0.06
Poland	−2.68	−4.61	−25.03	14.74	−7.41	−0.37	−13.75	−3.60	−9.93	−1.41	−34.34	9.48	14.76	0.42	5.11	24.22	−0.09	−8.39	−1.63	0.85
Saudi Arabia	−4.20	−12.36	−155.35	39.88	−22.07	−2.18	−161.69	23.83	11.69	1.11	−14.67	32.83	−0.88	−9.19	−12.10	15.03	7.05	0.36	3.24	12.10
Germany	−4.78	−4.13	−32.78	30.31	−22.17	−0.38	−39.70	−13.47	6.36	2.97	−23.74	34.01	9.41	1.19	−16.03	24.35	1.62	1.06	−0.24	5.64
Kazakhstan	−4.93	−4.20	−39.52	21.62	−0.26	−34.72	−15.00	15.69	−5.92	−1.79	−20.27	8.74	2.49	6.03	−26.20	19.24	−1.24	−1.20	−3.31	1.31
Russian Federation	−38.36	−2.25	−245.26	64.12	−41.11	−1.03	−147.17	21.96	2.33	28.89	−83.60	144.65	4.57	26.14	−224.74	141.38	−4.15	−0.57	−7.92	−0.06
World	497.64	0.83	−263.22	1278.28	−425.55	−0.39	−679.34	−176.96	60.18	4.59	−397.15	561.85	654.83	0.41	244.39	1187.69	208.18	0.02	200.08	214.90

Table 9 Countrywise Offsetting rate

Countries	dCo_2	Increasing	Offsetting	% Offsetting	Countries	dCo_2	Increasing	Offsetting	% Offsetting
Russian Federation	−38.36	0.42	−38.78	9327.30	Albania	0.11	0.14	−0.03	20.40
Kazakhstan	−4.93	1.25	−6.18	493.44	Angola	0.29	0.36	−0.07	20.05
Lithuania	−0.67	0.18	−0.86	465.93	Panama	0.14	0.17	−0.03	19.93
Belarus	−2.48	1.03	−3.51	340.68	Finland	1.50	1.85	−0.36	19.29
Gabon	−0.12	0.06	−0.18	283.92	Tunisia	0.66	0.81	−0.15	18.73
Latvia	−0.47	0.30	−0.77	256.27	South Africa	9.47	11.53	−2.07	17.92
Bulgaria	−0.70	0.62	−1.32	212.45	Argentina	1.90	2.30	−0.40	17.48
Romania	−2.65	2.41	−5.06	210.29	Portugal	0.98	1.17	−0.19	16.05
Saudi Arabia	−4.20	6.17	−10.38	168.11	Dominican Republic	0.70	0.83	−0.13	15.38
Czech Republic	−1.79	2.73	−4.52	165.40	Peru	0.92	1.07	−0.14	13.56
Estonia	−0.49	0.76	−1.25	165.13	Austria	1.13	1.27	−0.14	10.88
Slovakia	−0.67	1.35	−2.02	149.81	Senegal	0.13	0.14	−0.01	8.77
Colombia	−0.72	1.49	−2.20	148.10	Philippines	2.52	2.74	−0.22	7.89
Germany	−4.78	11.03	−15.81	143.32	Chile	2.24	2.40	−0.17	6.91
Switzerland	−0.19	0.49	−0.68	139.48	Costa Rica	0.22	0.23	−0.01	4.93
Zambia	−0.01	0.04	−0.06	132.49	Ecuador	0.59	0.61	−0.03	4.18
Malta	−0.02	0.08	−0.10	119.39	Turkey	6.63	6.82	−0.19	2.78
Poland	−2.68	14.66	−17.34	118.26	Japan	12.67	12.53	0.13	−1.07
Belgium	−0.27	2.04	−2.32	113.37	Ghana	0.27	0.27	0.00	−1.83
Luxembourg	−0.04	0.37	−0.42	111.34	Canada	18.30	17.74	0.56	−3.15
Denmark	−0.04	1.22	−1.25	102.96	Mozambique	0.10	0.09	0.00	−4.14
Armenia	0.00	0.20	−0.20	101.41	Nicaragua	0.13	0.12	0.01	−4.67
Hungary	−0.01	1.97	−1.97	100.39	Spain	8.62	8.08	0.54	−6.67
Netherlands	0.10	3.39	−3.28	96.93	Brazil	9.08	8.17	0.91	−11.09
Mexico	0.36	11.42	−11.06	96.87	United Arab Emirates	7.35	6.58	0.77	−11.70
United Kingdom	0.53	16.76	−16.23	96.85	Morocco	1.26	1.09	0.17	−15.32
Sweden	0.13	1.22	−1.09	89.36	United Republic of Tanzania: Zanzibar	0.17	0.14	0.03	−22.92
France	0.74	6.91	−6.17	89.31	Pakistan	4.41	3.53	0.89	−25.11
Singapore	0.58	3.33	−2.74	82.46	Syrian Arab Republic	2.16	1.72	0.44	−25.46
Cameroon	0.02	0.10	−0.08	82.24	Israel	2.62	2.05	0.57	−27.93
Australia	3.31	12.07	−8.75	72.53	Iran, Islamic Rep.	16.30	12.58	3.72	−29.53
Bolivia	0.09	0.28	−0.19	68.44	Malaysia	8.60	6.63	1.97	−29.78
Ireland	0.91	2.66	−1.75	65.78	El Salvador	0.23	0.18	0.05	−30.14
Hong Kong, China	0.48	1.35	−0.87	64.66	Egypt,	6.44	4.93	1.51	−30.64
Botswana	0.09	0.22	−0.14	61.84	Bangladesh	1.75	1.31	0.44	−33.80
Iceland	0.03	0.07	−0.04	53.03	Nepal	0.14	0.10	0.04	−37.76
Uruguay	0.03	0.07	−0.03	51.15	Jamaica	0.21	0.15	0.06	−42.48
Uzbekistan	1.65	3.17	−1.53	48.17	Nigeria	4.10	2.74	1.36	−49.60
Jordan	0.35	0.66	−0.31	47.28	Sri Lanka	0.54	0.36	0.18	−50.89
New Zealand	0.60	1.05	−0.45	43.03	Thailand	11.77	7.49	4.28	−57.15
Cote d'Ivoire	0.07	0.12	−0.05	42.89	Sudan	0.49	0.30	0.19	−62.89
United States	103.51	179.00	−75.49	42.17	Ethiopia	0.42	0.24	0.18	−77.52
Slovenia	0.32	0.56	−0.23	41.62	Guatemala	0.52	0.28	0.23	−81.66
China	197.13	312.94	−115.81	37.01	Benin	0.12	0.07	0.06	−82.05
Lebanon	0.41	0.62	−0.21	34.38	Paraguay	0.13	0.07	0.06	−85.92
Italy	3.78	5.67	−1.89	33.31	Vietnam	6.36	3.41	2.95	−86.53
Indonesia	8.59	12.53	−3.93	31.40	Kenya	0.43	0.21	0.21	−98.71

Table 9 continued

Countries	dCo$_2$	Increasing	Offsetting	% Offsetting	Countries	dCo$_2$	Increasing	Offsetting	% Offsetting
Greece	1.89	2.74	−0.85	31.00	Algeria	9.45	4.68	4.77	−102.00
Cyprus	0.15	0.21	−0.06	29.56	Oman	1.57	0.70	0.87	−123.65
Korea, Rep.	14.61	20.31	−5.71	28.09	Honduras	0.38	0.15	0.23	−155.01
Bahrain	0.56	0.77	−0.21	27.84	Namibia	0.20	0.06	0.14	−236.86
Trinidad and Tobago	0.97	1.34	−0.37	27.76	Norway	4.76	1.40	3.35	−238.90
Croatia	0.51	0.69	−0.18	26.32	Venezuela, RB	4.39	1.27	3.12	−245.32
India	47.21	64.01	−16.80	26.24	Togo	0.12	0.03	0.09	−258.06
Yemen, Rep.	0.56	0.74	−0.18	24.06	Congo, Rep.	0.19	0.05	0.14	−268.39

Fig. 1 Relationship between share of total emissions in 2004 and share of change in emissions from 1992 to 2004
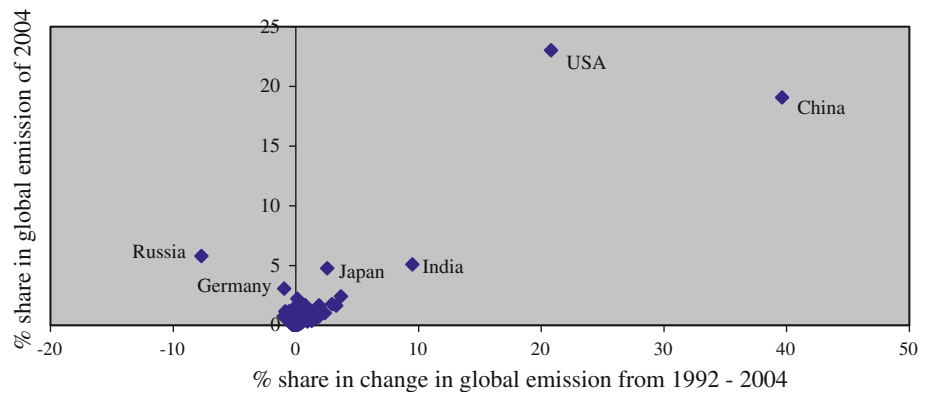
Fig. 2 Top 20 countries with highest per capita CO$_2$ emissions
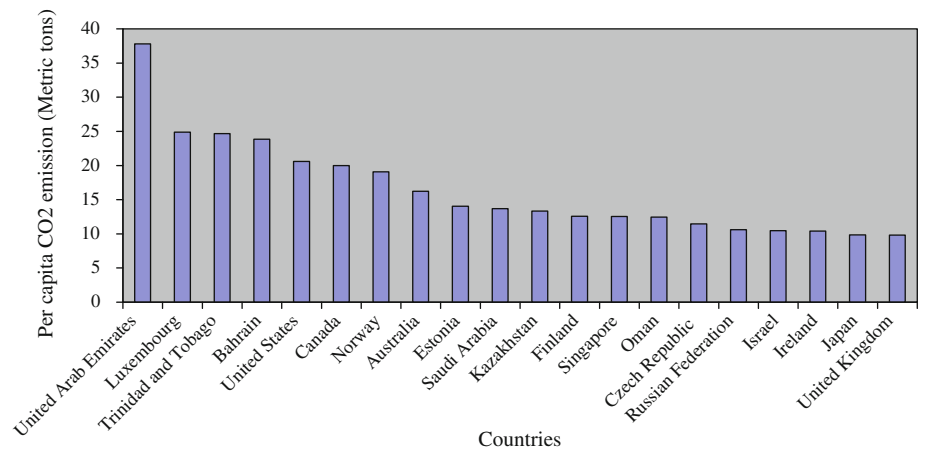
Fig. 3 Top 20 countries in highest CO$_2$ emissions with respect to GDP
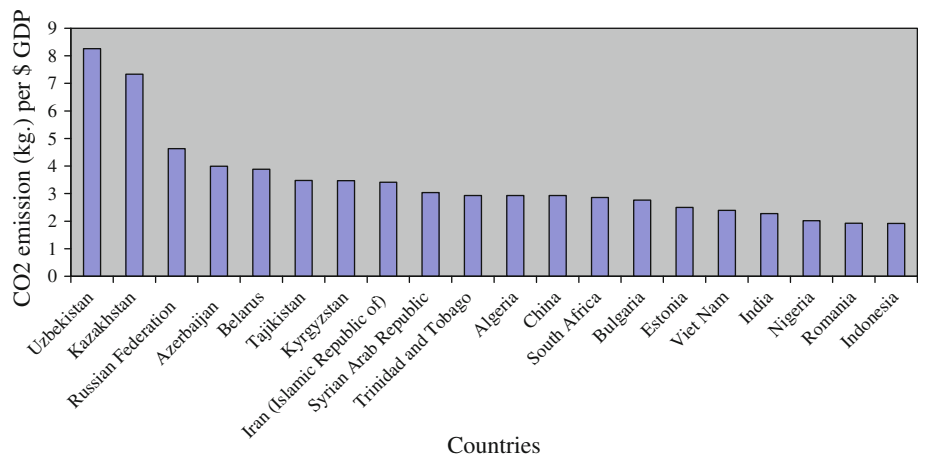
Fig. 4 Top 20 countries in highest CO_2 emissions with respect to energy consumption
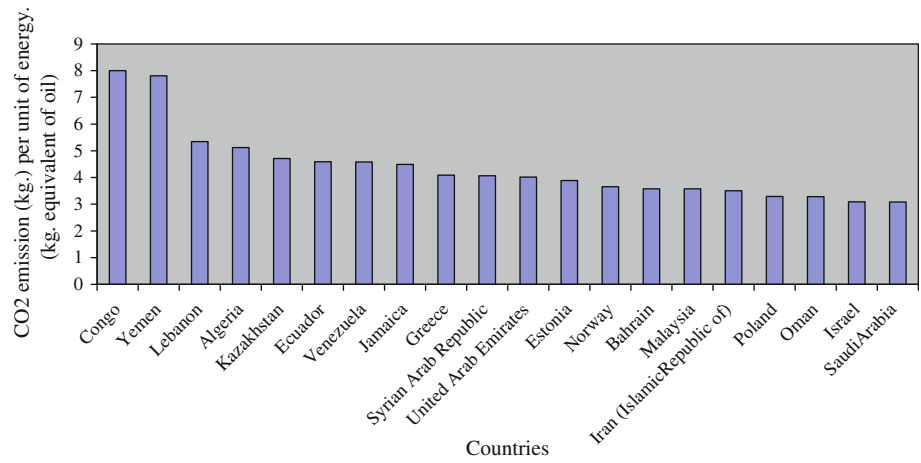
Fig. 5 Change in global CO_2 and the contributing factors
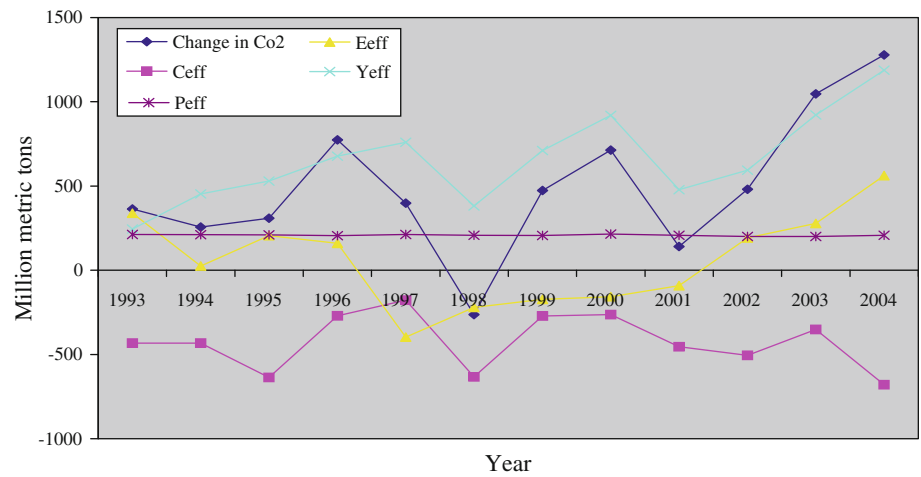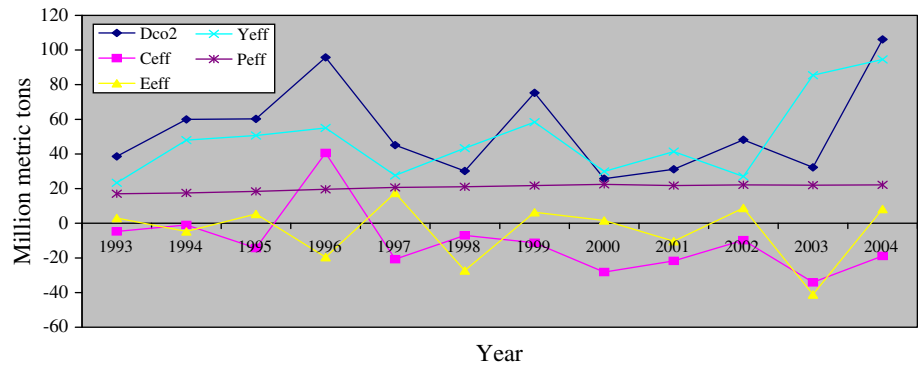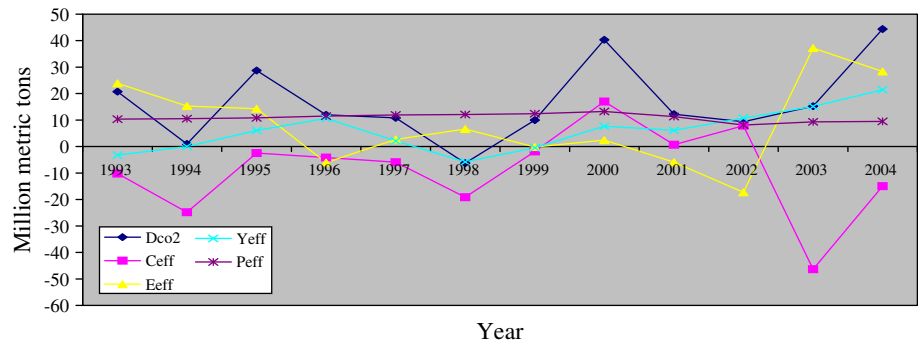

Fig. 6 Change in CO_2 and the contributing factors in HINO countries
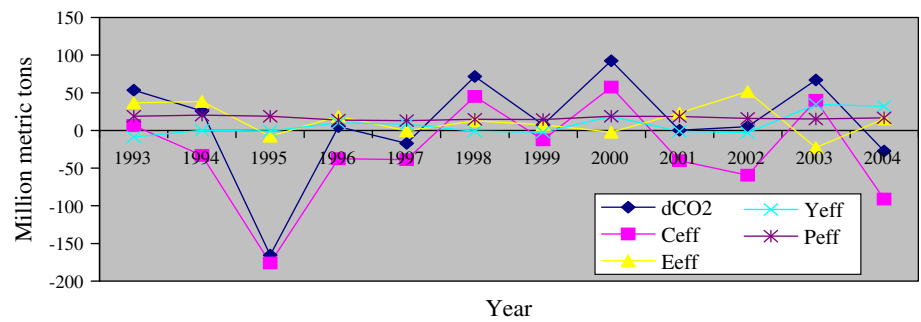
Fig. 7 Change in CO_2 and the contributing factors in HIO countries
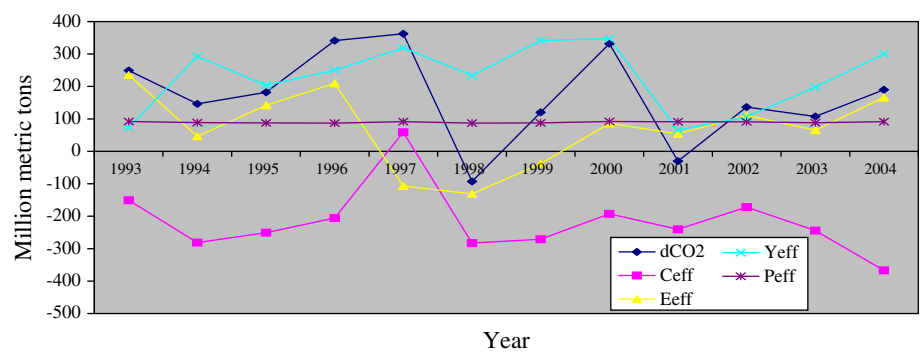
Fig. 8 Change in CO_2 and the contributing factors in UMI countries
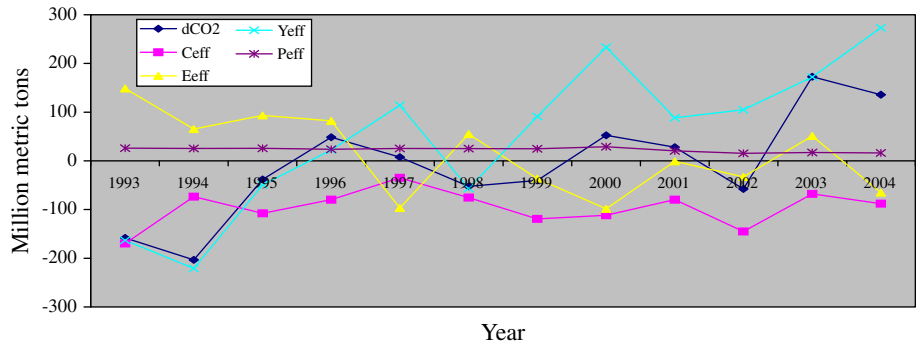
Fig. 9 Change in CO_2 and the contributing factors in LMI countries
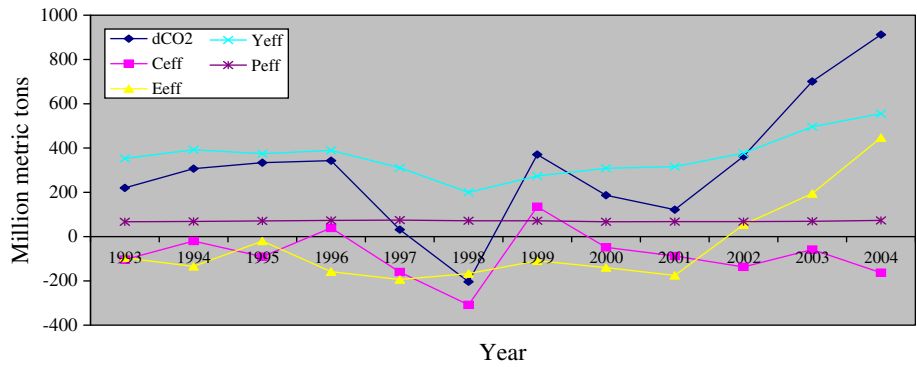
Fig. 10 Change in CO_2 and the contributing factors in LI countries
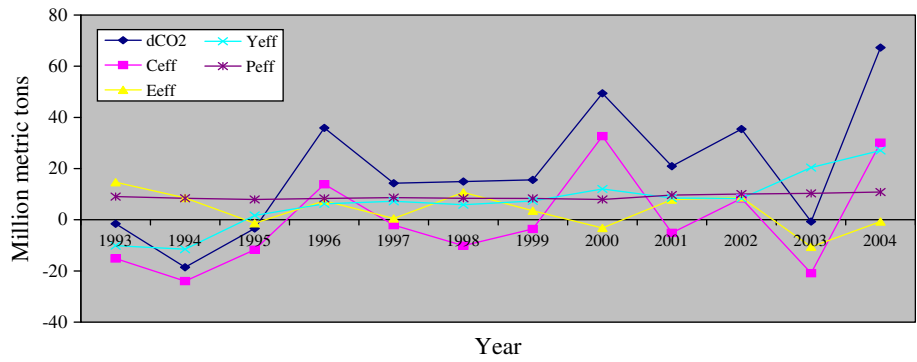
Fig. 11 Change in CO_2 and the contributing factors in East Asia and Pacific
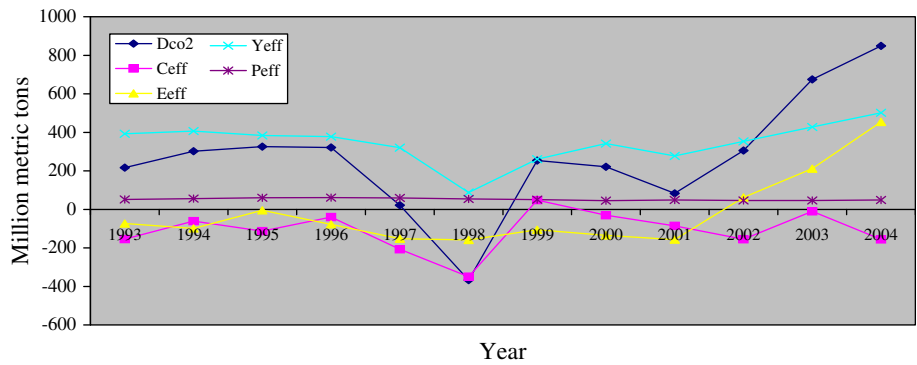
Fig. 12 Change in CO_2 and the contributing factors in Europe and Central Asia
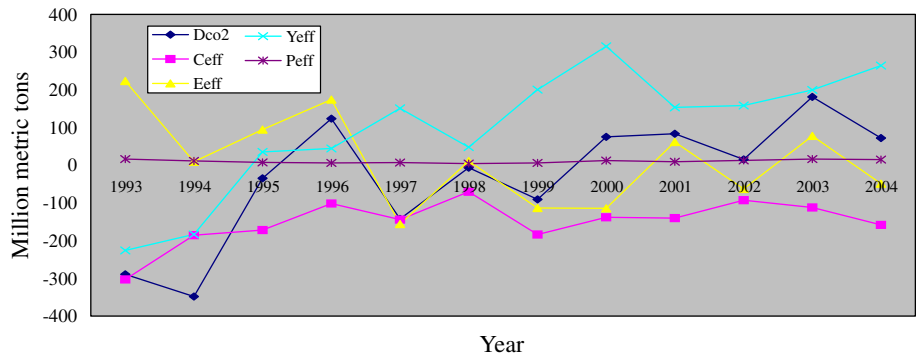
Fig. 13 Change in CO_2 and the contributing factors in Latin America and Carribean
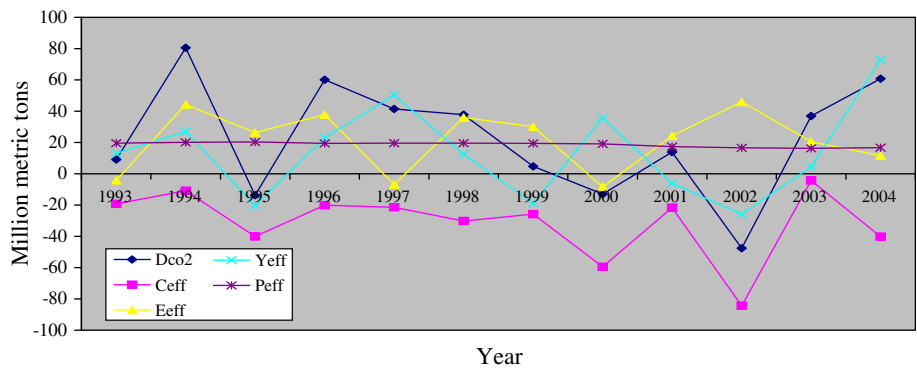
Fig. 14 Change in CO_2 and the contributing factors in Middle East and North Africa
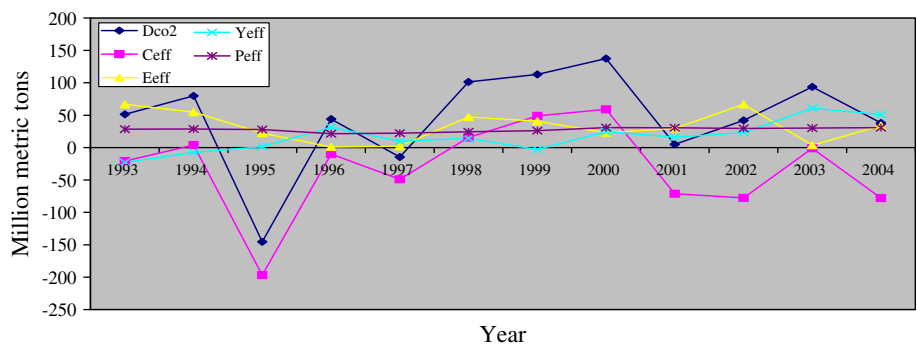
Fig. 15 Change in CO_2 and the contributing factors in North America
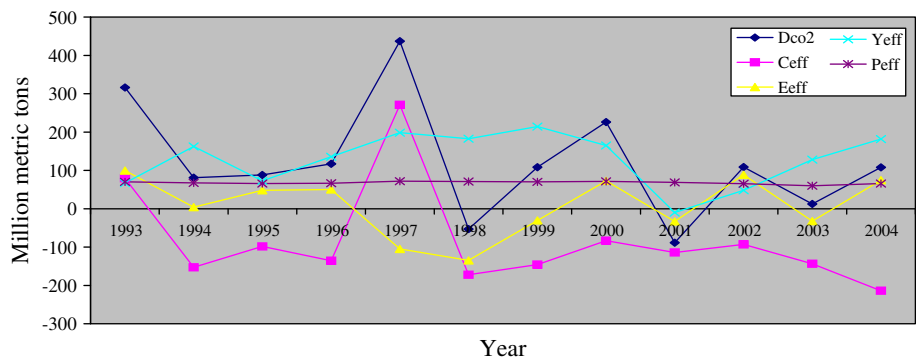
Fig. 16 Change in CO_2 and the contributing factors in South Asia

Fig. 17 Change in CO_2 and the contributing factors in Sub-Saharan Africa

Fig. 18 Change in CO_2 and the contributing factors in China
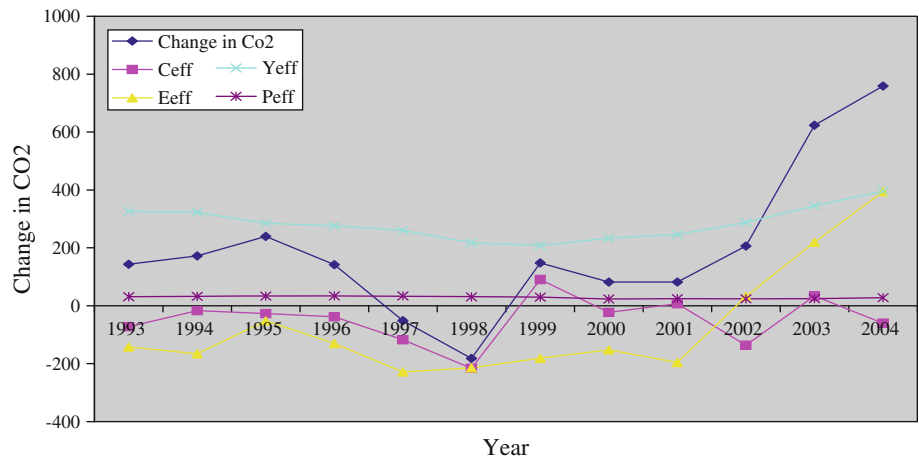
Fig. 19 Change in CO_2 and the contributing factors in USA
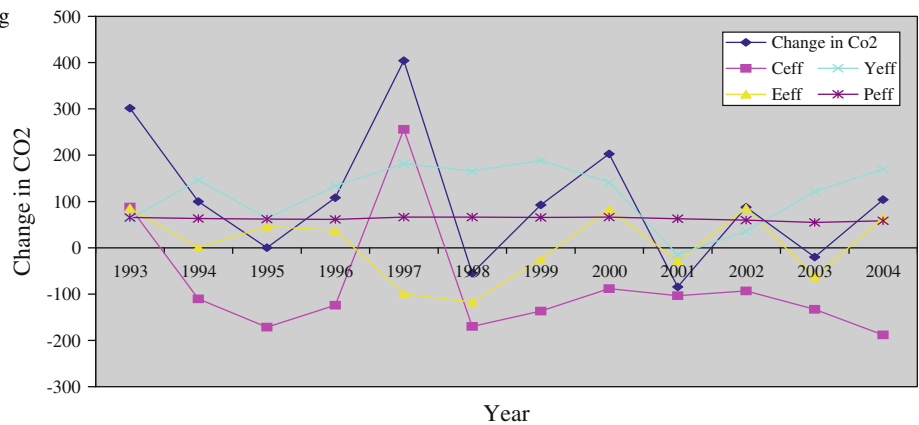
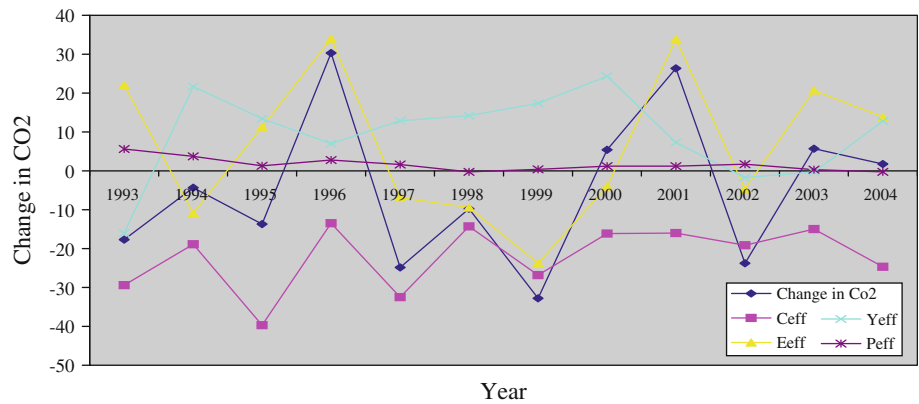**Fig. 20** Change in CO$_2$ and the contributing factors in India
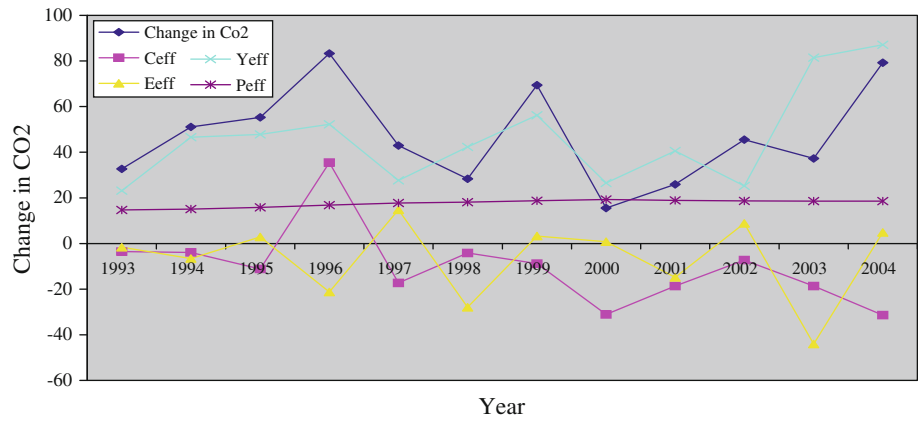
Fig. 21 Change in CO$_2$ and the contributing factors in Japan
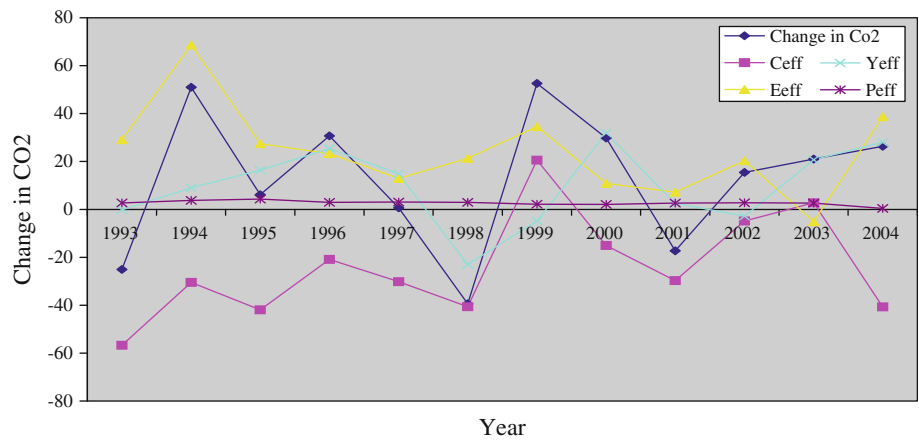
Fig. 22 Change in CO$_2$ and the contributing factors in Russian Federation
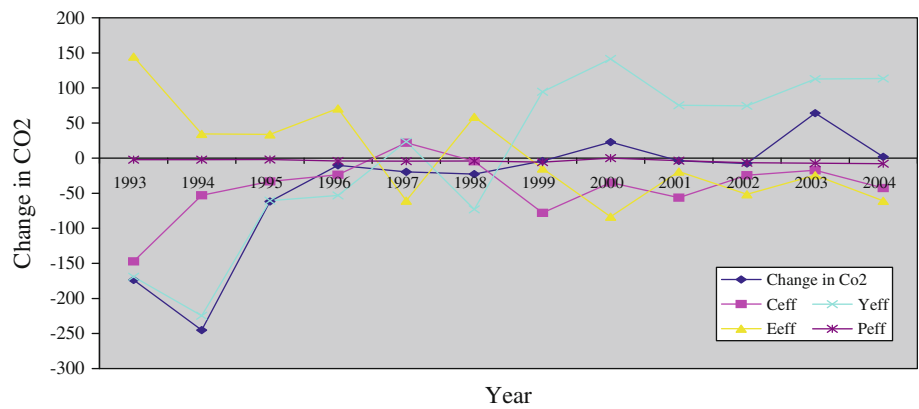
Fig. 23 Change in CO$_2$ and the contributing factors in Germany

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