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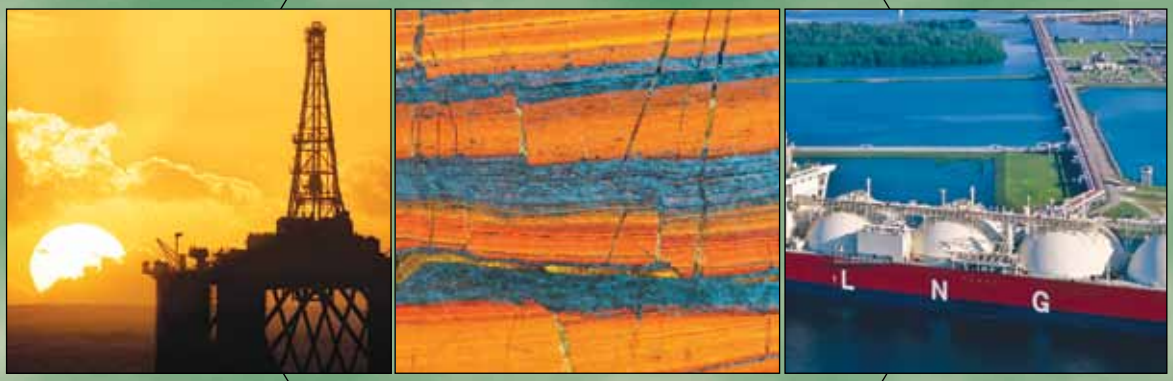
Changes in CO_2 Emissions from Energy Use



A Multicountry Decomposition Analysis

Robert Bacon
Masami Kojima

THE WORLD BANK

World Bank Group's Oil, Gas, and Mining Policy Division
Oil, Gas, Mining, and Chemicals Department

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Cover photos: Oil rig, hematite-banded ironstone, LNG tanker

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World Bank | Oil, Gas, and Mining Policy Division Working Paper

Contents

Tables

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Abbreviations

CO_2	carbon dioxide
IEA	International Energy Agency
OECD	Organisation for Economic Co-operation and Development
U.S. EIA	U.S. Energy Information Administration

All tonnes are metric tonnes.

All monetary amounts are current U.S. dollars, unless otherwise specified.

Executive Summary

The continued growth of global emissions of carbon dioxide (CO_2) and their likely adverse effects on global warming are focusing debate on the contribution of various countries to total emissions and the comparability of efforts across countries in mitigating these emissions. This paper examines recent trends in CO_2 emissions across countries at different levels of development and asks what has been contributing to the growth of emissions as well as to their moderation.

The paper compares countries on their absolute levels of CO_2 emissions from energy use—more specifically, from the combustion of fossil fuels—as well as the levels of emissions per capita and per unit of gross domestic product (GDP). Countries' performance ranges widely depending on the metric used, with significant differences even within each income group, underscoring multiple and complex drivers of CO_2 emissions. In absolute terms, the top 20 emitters accounted for nearly 80 percent of global emissions in 2006. Measured on a per capita basis, the top per capita emitter released ten times the global average. Half of the top 20 per capita emitters were major hydrocarbon producers. Some countries have seen their emissions intensity (CO_2 emissions per unit of GDP) fall during the most recent decade for which data are available (1996–2006); others, including a few high-income countries, have seen intensity gradually increase. Globally, with the exception of 2003 and 2004, emissions intensity declined every year during the decade.

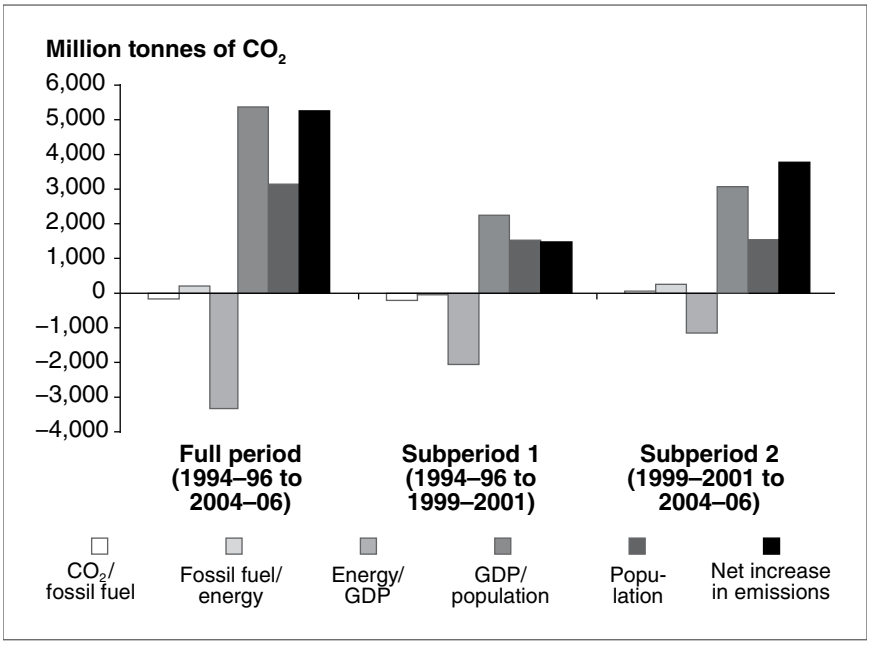
The paper applies a decomposition analysis, an accounting methodology based on a log mean Divisia index, to analyze the change in CO_2 emissions over a decade. The methodology allows the change in emissions to be separated into changes in five factors:

- The carbon intensity of fossil fuels consumed
- The share of fossil fuels in total energy used (fossil fuel intensity of energy)
- The energy required to produce a unit of GDP (energy intensity)
- GDP per capita
- Population

Because they are additive, the relative effects of these factors can be readily expressed and compared. To reduce fluctuations due to temporary jumps in annual data, the initial value was taken as the average for the period 1994–96, and the final value was taken as the average for 2004–06. The decade was split into two five-year subperiods to better capture changes within the decade. Data from the International Energy Agency (IEA) for CO_2 emissions and energy supply and consumption were used to obtain the main findings. An alternative source of information on emissions and energy use, drawn from the U.S. Energy Information Administration (U.S. EIA), was used to provide supplementary information on a wider range of countries.

The findings from applying decomposition to global emissions are illustrated in figure E.1. The net increase in CO_2 emissions over the full period is 5,300 million metric tonnes. The growth of GDP per capita and population contributed the most to this net increase: 5,400 million and 3,100 million tonnes, respectively. Without other mitigating factors, CO_2 emissions would have increased by 8,500 million tonnes in the study decade. During the same period, the carbon intensity of fossil fuels (CO_2/fossil fuel) declined slightly, and the fossil fuel intensity of total energy

Figure E.1 Decomposition Analysis of Global CO_2 Emissions



Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

(fossil fuel/energy) increased slightly, contributing to a net increase of about 50 million tonnes between the two factors. Offsetting these was a marked reduction in energy intensity (energy/GDP), reducing emissions by 3,300 million tonnes. Analysis of the two subperiods shows that the increase in emissions due to growth in per capita GDP was almost entirely offset by the increase in energy intensity during the first subperiod (1994–96 to 1999–2001), while only a third was offset during the second subperiod (1999–2001 to 2004–06). The net increase in emissions in subperiod 2 was more than double that in subperiod 1.

The foregoing discussion suggests the concept of offsetting. Because most economies grow over time, everything else being equal, CO_2 emissions would increase with economic growth. Where GDP growth (the sum of GDP/population and population in figure E.1) is positive, this study defines an offsetting coefficient: the ratio of the negative value of the sum of the changes in emissions of the three factors sensitive to energy policies—fossil fuel mix, fossil fuel share in total energy, and energy intensity—to the change in emissions related to GDP growth. The offsetting coefficient is positive if the three factors sensitive to energy policies move in a way that lowers the potential increase in emissions. Emissions and GDP are then said to be "decoupled" in accord with a framework developed by the Organisation for Economic Co-operation and Development (OECD). Under the OECD concept, *relative decoupling* occurs if the offsetting coefficient is positive but less than 100 percent, and *absolute decoupling* occurs if the coefficient is greater than 100 percent and the total emissions of the economy fall. A negative offsetting coefficient means that the combined effect of the three factors sensitive to energy policies is to *amplify* rather than *mitigate* the growth of CO_2 emissions—for example, if energy intensity increases rather than declines.

Globally, the offsetting coefficient was much higher in subperiod 1 than in subperiod 2 (table E.1). The first subperiod, however, had features peculiar to the 1990s: the transition economies were being restructured and were disposing of unproductive capital, and their aggregate GDP increased at about half the global rate while their energy consumption fell. In fact, for several transition economies, including the Russian Federation, four of the five decomposition factors led to a fall in emissions in both subperiods; and only in subperiod 2 did total emissions increase. The table shows that the transition economies were able to offset double the emissions increase from GDP growth during subperiod 1 but less than 100 percent during subperiod 2. If the transition economies are excluded from the data—on the reasoning that their performance in

Table E.1 Performance of Groups of Countries

Region	Offsetting coefficient (%)			2006 emissions (million tonnes)
	Full period	Sub-period 1	Sub-period 2	
World	38	61	18	27,899
Transition economies	113	199	83	3,110
World excluding transition economies	26	47	7	24,789
World excluding transition economies and China	36	33	40	19,182
Annex 1 countries	76	78	73	14,064
Annex I countries excluding transition economies	61	56	68	11,389
Top 10 emitters in 2006	41	71	12	17,665

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

the 1990s was largely due to unusual circumstances and not representative—global performance deteriorates further, essentially having no offset during subperiod 2.

Subperiod 2 witnessed another development having a large impact on global CO_2 emissions: after exhibiting a steady and dramatic decline up to 2002, energy intensity in China—with one-fifth of both the world population and global CO_2 emissions—increased markedly for the next few years before resuming the declining trend in 2006. According to data provided by the Chinese National Bureau of Statistics, the country's energy intensity in 2005 was 10.7 percent higher than in 2002 (NBS 2007). If both the transition economies and China are excluded from the data, global offsetting performance improves from the first subperiod to the second.

Annex I countries—that is, signatories to the United Nations Framework Convention on Climate Change that have largely adopted emission reduction targets for the 2008–12 period under the Kyoto Protocol—fared about the same between the two subperiods, and did better in subperiod 2 if the 14 transition economies are excluded. That said, they should be exhibiting absolute decoupling, and fell short by a third even during subperiod 2 (an offsetting coefficient of 68 versus the target of at least 100 percent).

The top 10 emitters in 2006, which accounted for 65 percent of global CO_2 emissions, performed considerably worse during subperiod 2. There

were marked differences in individual country performance, stages of development, and emissions per capita. Five out of 10 offset emissions from GDP growth more in the second subperiod than in the first, including three of the top five emitters. Among the five countries with per capita GDP at purchasing power parity within 11 percent of each other in 2006—Canada, Germany, Italy, Japan, and the United Kingdom—the offsetting coefficient for the full period ranged from 25 percent for Italy to 145 percent for Germany and averaged 74 percent. The United States—whose per capita GDP was one-third higher than the average of the next five richest countries (Canada, Germany, Italy, Japan, and the United Kingdom) and whose per capita emissions were twice that of the five-country average—fared worse, with an offsetting coefficient of 66 percent during the same period.

The distribution of offsetting coefficients for the study decade is given in table E.2. By definition, only those countries in which GDP grew are included. Two-thirds of the countries had positive offsetting coefficients. Half of the countries analyzed had positive offsetting coefficients in both the full period and the two subperiods. Nearly 40 percent of countries offset half or more of the emissions increase due to GDP growth in the decade examined by decreasing the carbon intensity of fossil fuels, the fossil fuel intensity of energy, or the energy intensity of the economy. Almost one-fifth of the countries managed to achieve absolute decoupling of CO_2 emissions from economic growth in the study decade.

Table E.2 Distribution of Offsetting Coefficients for the Full Period, by Country Category
number of countries

Offset	Low income (18)	Lower middle income (33)	Upper middle income (31)	High income (40)	Annex I[a] (38)	Total (122)
Negative	12	18	7	5	2	42
Positive	6	15	24	35	36	80
0% – 50%	1	7	13	12	7	34
50% – 100%	3	4	3	15	13	25
≥ 100%	2	4	8	8	16	22

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.
Note: Numbers in parentheses are the total number of countries in that group. For the total column, that is the sum of the low-, lower-middle-, upper-middle-, and high-income countries.
a. Annex I signatories are a mix of developed and developing countries.

By income, the percentage of countries with varying degrees of offsetting tended to increase with rising income. The exceptionally strong performance of Annex I countries relative to high-income countries is due in part to the fact that 14 of 38 Annex I countries are transition economies: 12 of the 14 transition economies that are Annex I countries showed absolute decoupling. Although not shown in the table, a much higher percentage of countries across all categories showed absolute decoupling in subperiod 1 than in subperiod 2. For example, the share of Annex I countries with offsetting coefficients greater than 100 percent fell from 46 percent in subperiod 1 to 13 percent during subperiod 2.

Countries in the early stages of development tended to show less offsetting. In table E.2, the highest percentage of countries with a negative offsetting coefficient were low income, and virtually none showed absolute decoupling. However, this finding must be taken in the context of their very low per capita emissions today. Many countries where per capita emissions are markedly below even the most stringent stabilization target levels considered by international bodies are extremely poor and would not be expected to follow a development path in which total emissions from energy use would decline or even stabilize in the near term. Different metrics of emissions in each country—absolute levels, emissions per capita, and emissions per unit of economic output—enter into discussions of the efforts each country should make as its contribution to slowing global warming. Spence (2009) proposes an approach to global emissions mitigation that takes into account a country's current level of per capita emissions as well as its level of economic development. The recently proposed Greenhouse Rights Development framework details a similar approach and suggests a development threshold of welfare below which people should not be expected to share the costs of climate change mitigation (Baer and others 2008).

Several studies have used longer time periods to assess CO_2 emissions trajectories, such as the recently released E3G publication on the Group of 20 countries (Vivid Economics 2009). The present study points to unique circumstances resulting in a marked shift in trends around the beginning of this decade, with a slowdown of the decline in global emissions growth in the decade's second half as compared to its first. Consequently, projecting emissions trends observed predominantly in the 1990s could be misleading, and the findings of such studies should be interpreted with caution.

The IEA database permits disaggregation of economywide emissions and energy consumption data by three sectors: (1) agriculture, fisheries,

and forestry (referred to as agriculture hereafter); (2) manufacturing and energy production (industry); and (3) the rest of the economy (service sector). Decomposition analysis by sector means that energy intensity can be separated into two factors, the first related to the effects of changes in sector levels of energy intensity (the energy required to produce a unit of sector GDP), and the second related to changes in sector share of total GDP.

Extended decomposition that includes the sector structure of GDP shows that, for the full period, the service sector's share of global GDP increased at the expense of agriculture and industry. Because the service sector had a lower energy intensity than industry, although higher than that of agriculture, there was a small overall reduction in total use of energy for a given amount of GDP. At the same time, the service sector registered a significant reduction in energy intensity, contributing significantly to the offsetting effect, while the carbon intensity of fossil fuels and the fossil fuel share of energy analyzed at the sector level made minor contributions. Without the decrease in the energy intensity of the global service sector, the increase in total emissions would have been almost 50 percent higher. The industrial sector showed a drop in the carbon intensity of fossil fuels and the fossil fuel intensity of energy during subperiod 1, but this trend was reversed in subperiod 2.

The interpretation of findings here should be tempered by the fact that the IEA and U.S. EIA databases were not in agreement regarding the effects of the carbon intensity of fossil fuels; further, in developing countries, moving households to modern forms of energy may entail increasing, rather than decreasing, the fossil fuel intensity of energy. This paper nonetheless suggests that these two factors make minor contributions, and that understanding the role of changing energy intensity is key to understanding changes in CO_2 emissions. The study points to the need for further work on end-use energy intensity as well as energy supply intensity and drivers of changes at the sectoral level.

Chapter 1

Background

Increasing evidence on the extent and effects of global warming, coupled with ongoing negotiations on policies to mitigate its effects, is focusing attention on the major contribution made by CO_2 emissions. Most industrialized countries have committed to reducing their CO_2 emissions below 1990 levels by 2012 and are expected to reduce absolute levels of emissions significantly further by 2020. Many developing countries are expected to moderate their growth of emissions compared to country-specific business-as-usual trajectories.

It is generally accepted that emissions tend to grow with an economy's level of income unless policies are undertaken to decouple the two. Analysis of the extent to which different countries have or have not managed to curb the growth of CO_2 emissions relative to their economic growth in the recent past can provide insights on future potential changes. It can also identify countries from which successful lessons might be gleaned.

Decomposition analysis enables detailed accounting for changes in emissions. Factors relating to the mix of fossil fuels, the share of fossil fuels in total energy consumption, the energy required to produce a unit of GDP, GDP per capita, and population can be brought together in a framework that allows the contribution of changes in each factor to be related to changes in total emissions.

Many studies have used decomposition analysis of emissions for selected groups of countries. Bacon and Bhattacharya (2007) briefly reviewed a number of these studies and provided a decomposition of CO_2 emissions from the energy sector for the 70 countries with the greatest level of emissions. Their analysis was based on the change in emissions between 1994 and 2004. Bosch (2009) analyzed the decomposition of CO_2 emissions from the world's top emitting countries for the period 1971 to 2005.

The present study extends the 2007 publication in a number of directions. It updates the earlier study by adding data for 2005 and 2006, and provides results based on emissions and energy data from the International Energy Agency for 123 countries. For a limited group of countries,

the study extends the decomposition analysis further by adding a factor relating to changes in the sectoral composition of GDP based on a division of the economy into agriculture, fisheries, and forestry; industry including energy production; and the rest of the economy.

Bacon and Bhattacharya (2007) used data provided by the U.S. Energy Information Administration because of its wider coverage. However, the U.S. EIA database does not allow disaggregation into the three sectors. Aside from differences in the numerical values of the data themselves, an important difference between the U.S. EIA and IEA databases is that the former excludes biomass from the primary energy supply except where biomass is used in power generation, while the latter includes biomass consumed outside the power sector. The IEA approach provides more comprehensive coverage of energy consumption in developing countries where biomass use, particularly by low-income households, can be widespread. Decomposition results based on U.S. EIA data are provided in the second half of appendix B.

The results of the current and 2007 studies are not strictly comparable for several reasons:

1. The beginning and end data points for the change in emissions are based on three-year averages in the present study (as opposed to single years in the previous report) in order to moderate the effect of temporary and unrepresentative jumps in the data series.
2. As noted, the data source used here is primarily the IEA, rather than the U.S. EIA as used in the earlier study. Although supplementary calculations based on the U.S. EIA are included in appendix B, these cannot be directly compared to the 2007 study because of revisions to earlier years' data that have subsequently been made by the U.S. EIA. Further—and again, as noted above—the IEA, but not the U.S. EIA, includes biomass utilization outside the power sector, which is important in lower-income developing countries.
3. The IEA data format makes it possible to extend the analysis to shifts among three major sectors. Sectoral differences in the relative importance of the decomposition factors enable a more focused understanding of where changes in the pattern of emissions have been occurring.

Chapter 2

Levels and Intensities of Emissions

Different metrics of emissions in each country—the absolute level, emissions per capita, and emissions per unit of economic output—enter into discussions of the efforts each country should make as its contribution to slowing global warming. These metrics are briefly discussed here.

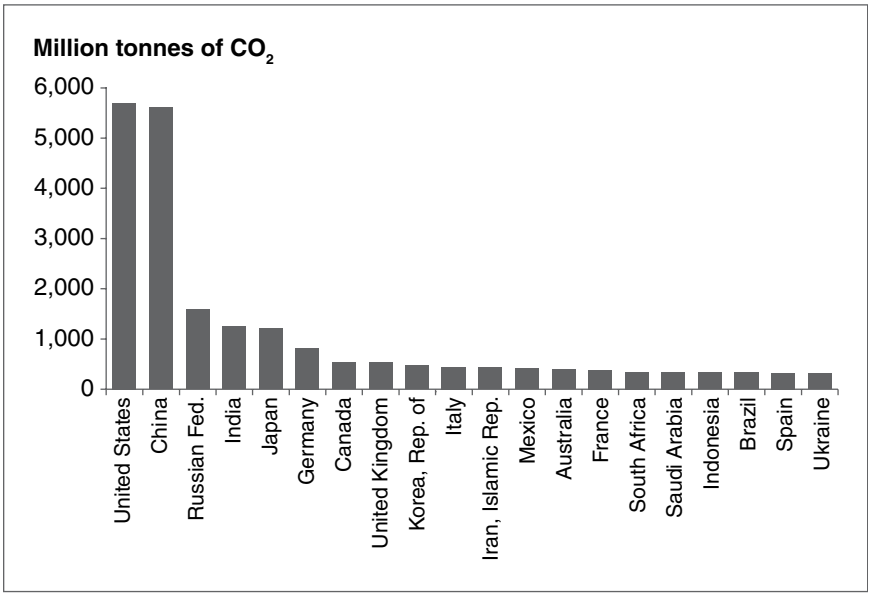
The top 20 countries in terms of CO_2 emissions from fossil fuel combustion accounted for 78 percent of global emissions in 2006 (figure 2.1).[1] The United States and China alone accounted for two-fifths of these emissions. Averaged across the world, CO_2 emissions amounted to 4.3 tonnes per person, an increase from 3.8 tonnes in 1994. The 2006 per capita level of CO_2 emissions is about twice as high as the level currently estimated by experts (approximately 2 tonnes) for stabilizing atmospheric concentrations of CO_2 at 400 parts per million and greenhouse gas concentrations at 490 parts per million (IPCC 2007). The top per capita emitter released 10 times the global average (figure 2.2); half of the top 20 emitters on a per capita basis are major hydrocarbon producers.

Figure 2.3 shows 20 economies that are most CO_2-intensive for a unit of GPD. GDP is measured at purchasing power parity. Among the countries are low-income net importers of fossil fuels, suggesting that reducing the CO_2 intensity of such economies could result in both global and local benefits in terms of improved energy security and balance of payments (Bacon and Kojima 2008).

Declines in emissions intensities as measured by GDP have followed a variety of trends in recent years. A few examples are shown in figure 2.4. Kazakhstan is typical of former Soviet Union republics, where the intensity of emissions fell rapidly in the 1990s. China's intensity fell until the early part of this decade and then rose somewhat, resulting in essentially no net reduction in the country's energy intensity between 2000 and

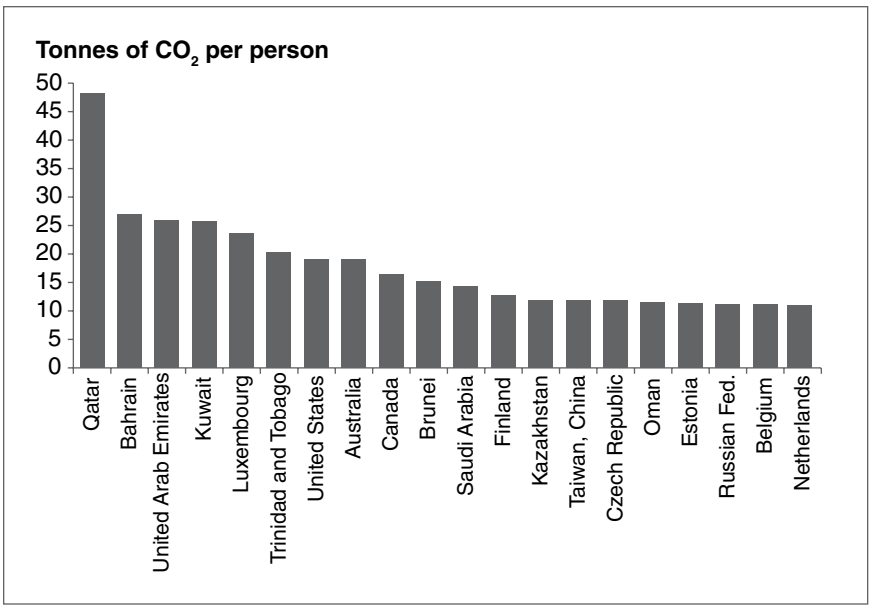
[1]As discussed here, CO_2 emissions exclude those from land use changes.

Figure 2.1 Top 20 Countries Ranked by Total CO_2 Emissions in 2006



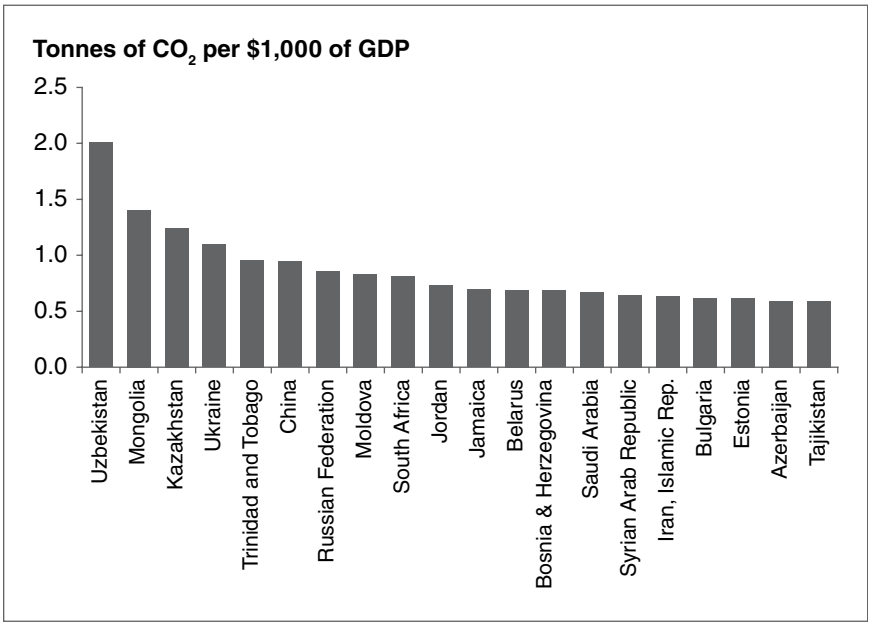
Source: IEA 2009a.

Figure 2.2 Top 20 CO_2 Emitters Per Capita in 2006



Sources: IEA 2009a, World Bank 2009, and authors' calculations.

Figure 2.3 Top 20 CO_2 Emitters Per Unit of GDP in 2006

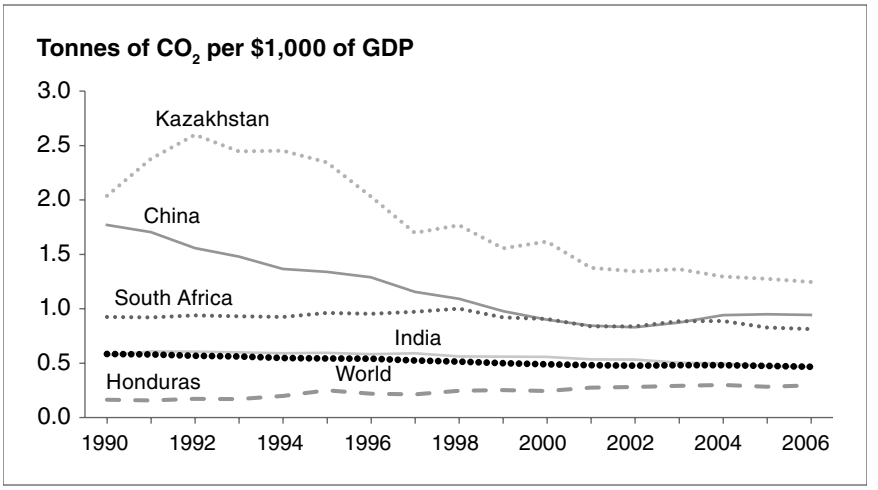


Sources: IEA 2009a, World Bank 2009, and authors' calculations.
Note: GDP is valued at purchasing power parity in 2005 U.S. dollars. GDPs for Bahrain and Qatar, the top two per capita emitters in figure 2.2, are not available for 2006.

2006. This pattern of decline in emissions intensity during the 1990s followed by an increase is also observed in Austria, Albania, the Republic of Congo, the Arab Republic of Egypt, Luxembourg, Oman, and Sudan. India and South Africa are two of the many countries where emissions intensity has been declining in the last decade. In contrast, Honduras has seen its emissions intensity gradually increase, although from a low base. Other countries with gradually increasing emissions intensities since 1990 include Bangladesh, Benin, Bolivia, Brunei Darussalam, Ecuador, Ethiopia, Gabon, Ghana, Guatemala, Haiti, the Islamic Republic of Iran, Malaysia, Morocco, Namibia, Saudi Arabia, Tanzania, Thailand, Vietnam, and the Republic of Yemen. Globally, emissions intensity declined every year between 1990 and 2006 except in 2003 and 2004.

The inverse of emissions intensity is carbon productivity. A recent E3G study on the Group of 20 economies suggests that there is a weak positive relationship between carbon productivity and GDP per capita. Further, change in carbon productivity shows a variable relationship to change in GDP: between 1990 and 2005, among non-Annex I countries, China, Mexico, and South Africa increased their carbon productivity;

Figure 2.4 CO_2 Emissions Per Unit of GDP



Sources: IEA 2009a, World Bank 2009, and authors' calculations.
Note: GDP is valued at purchasing power parity in 2005 U.S. dollars.

Indonesia and Turkey were less successful; and Saudi Arabia saw declining carbon productivity (Vivid Economics 2009). Among high-income countries, carbon productivity declined (and carbon intensity increased) in Kuwait, New Zealand, Oman, Saudi Arabia, and Spain in the decade studied here, 1994–1996 to 2004–2006, based on IEA data.

Looking at changes in CO_2 emissions intensity, only 20 countries of the 125 for which GDP and IEA CO_2 emissions data are available showed declining intensity in the two successive five-year intervals in this study (1994–96 to 1999–2001 and 1999–2001 to 2004–06), with the decline in subperiod 2 exceeding that in subperiod 1. These countries, which include those with high emissions intensities, transition economies, and lower-middle-income developing countries, are Armenia, Australia, Bahrain, Belgium, Colombia, Croatia, the Czech Republic, Greece, India, Japan, Jordan, the Republic of Korea, Peru, the Philippines, Russia, Tajikistan, Tunisia, Ukraine, the United Arab Emirates, and Uzbekistan.

This first-order assessment shows that the ranking of country performance varies widely depending on the metric selected. To gain a better understanding of the nature of changes in emissions during the last decade, decomposition analysis is employed to highlight those factors that are strongly or weakly linked to these changes.

Chapter 3

Methodology

CO_2 emissions can be broken down into several contributing factors using a Kaya-type identity (Kaya 1990).

Five-Factor Decomposition

Following Bacon and Bhattacharya (2007), this study expresses emissions as follows:

$$\begin{aligned} E_i &\equiv (E_i/FF_i) \times (FF_i/TE_i) \times (TE_i/GDP_i) \times (GDP_i/POP_i) \times (POP_i) \\ &\equiv C_i \times S_i \times I_i \times G_i \times P_i \end{aligned} \quad (1)$$

where

E_i is the amount of CO_2 emitted from fossil fuels in a year in country i,
FF_i is the amount of fossil fuel consumed,
TE_i is the total primary energy supply for domestic consumption,
GDP_i is gross domestic product,
POP_i is population.

The change in a country's emissions (ΔE_i) between two time periods, 0 and 1, can be written according to identity 1. The identity at time 0 can be written in the compact form

$$E(0) \equiv C(0) \times S(0) \times I(0) \times G(0) \times P(0)$$

and similarly for time 1. The change in the emissions between the two periods can be related to the sum of effects linked to changes in each of the factors: the carbon intensity of fossil fuels (C_{eff}), the fossil fuel share in energy (S_{eff}), the energy intensity of the economy (I_{eff}), GDP per capita (G_{eff}), and total population (P_{eff}):

$$\Delta E_i \equiv E(1) - E(0) \equiv C_{eff} + S_{eff} + I_{eff} + G_{eff} + P_{eff}. \quad (2)$$

These changes can be precisely linked in an additive form using decomposition analysis (Ang 2004; Bacon and Bhattacharya 2007). More

specifically, the effects can be calculated using the logarithmic mean Divisia index:

$$C_{eff} = \{[E(1) - E(0)]/\log[E(1)/E(0)]\} \times \log[C(1)/C(0)].$$

Using the decomposition method, the carbon intensity effect (C_{eff}) identifies what would have been the change in CO_2 emissions if the fossil fuel mix had changed but all other factors had remained constant. Other effects are calculated similarly, allowing a one-at-a-time identification of the impact of changes in each factor in identity 1. The particular form of decomposition used allows the effects to be added so as to equal the total change in CO_2 emissions. In the absence of an additive decomposition, the relative importance of the different changes that contribute to the total change in emissions would be difficult to evaluate.

The years selected for decomposition for times 0, 1, and 2 in this study are 1994–96, 1999–2001, and 2004–06. The full period is between 1994–96 and 2004–06, the first subperiod is between 1994–96 and 1999–2001, and the second subperiod is between 1999–2001 and 2004–06.

The set of variables from which identity 2 is constructed contains two factors that increase over time for most countries—income per capita and total population—and three others that can be decreased: the carbon intensity of fossil fuels (highest for coal and lowest for natural gas), the fossil fuel intensity of total energy consumption (which can be decreased by shifting to renewable and nuclear energy), and the energy intensity of an economy (which can be decreased through energy conservation, energy efficiency improvement, and structural changes in the economy). Following Bacon and Bhattacharya (2007), the extent to which net decreases in C_{eff}, S_{eff}, and I_{eff} offset net increases in G_{eff} and P_{eff} is termed the offsetting coefficient:

$$\text{Offsetting coefficient} \equiv X = -(C_{eff} + S_{eff} + I_{eff})/(G_{eff} + P_{eff}).$$

In this study, X is defined only if $G_{eff} + P_{eff}$ is positive. Combining terms to correspond to the offsetting definition, a shortened version of identity 1 can be written as

$$E_i \equiv (E_i/GDP_i) \times (GDP_i). \quad (3)$$

Offsetting is then equal to

$$X = -\log\{[E(1)/GDP(1)]/[E(0)/GDP(0)]\}/\log[GDP(1)/GDP(0)] \quad (4)$$

For small changes in emissions and GDP, equation 3 can be simplified to

$$X = 1 - g_E/g_G$$

where g_E represents the rate of growth of emissions and g_G the rate of growth of GDP. The right-hand side of equation 4 in turn is equal to 1 minus the elasticity of emissions with respect to GDP.

The offsetting coefficient has also been termed the decoupling index (Diakoulaki and Mandaraka 2007). By this concept, strong decoupling exists if total emissions fall while GDP increases (that is, offsetting is more than 100 percent); if emissions rise less than GDP (offsetting is positive but less than 100 percent), decoupling is termed weak. This classification is consistent with that of the OECD (2002), focusing on movements in the ratio of emissions to GDP; the OECD termed the two cases absolute and relative decoupling, respectively.

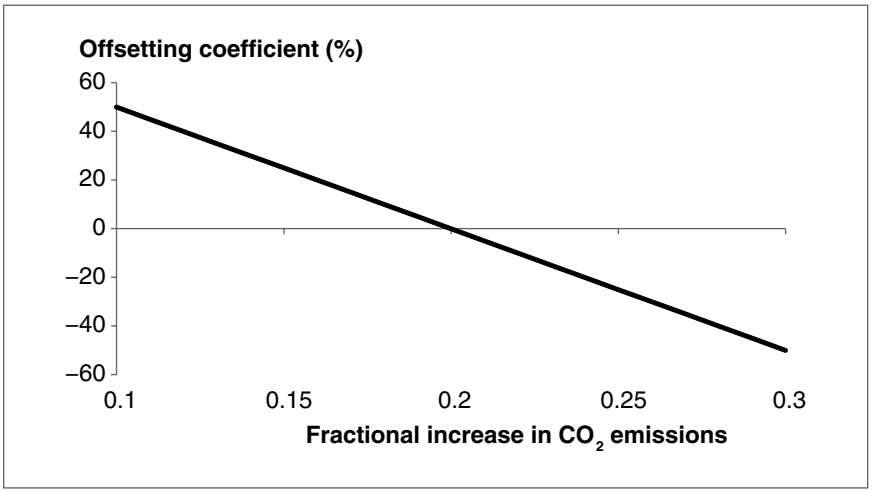
Equation 4 can be used to illustrate the sensitivity of the offsetting coefficient to relative changes in emissions and GDP between two time periods. CO_2 emissions data are not based on measurements but calculated and can vary for a given year and country depending on the methodology and data source; for example, CO_2 emissions from the IEA and the U.S. EIA can differ markedly for some countries. Even a small difference in estimated CO_2 emissions can lead to a significant difference in the offsetting coefficient. If g_E and g_G are close, a small difference in the change in CO_2 emissions can even result in a sign reversal. This can be seen in figure 3.1, which computes the offsetting coefficient using the simplified expression given by equation 4, setting g_G equal to 0.2. When g_E is close to 0.2, merely changing it from 0.18 to 0.22 changes the offsetting coefficient from +10 percent to –10 percent. This result suggests that offsetting coefficients should be interpreted with caution.

Six-Factor Decomposition

An extension of identity 1 was used by Turton and Hamilton (1999) and Karakaya and Özçağ (2005) by distinguishing between total primary energy supply and total final energy consumption. The ratio of the two reflects both conversion efficiency and fuel mix. The identity becomes

$$\begin{aligned} E_i &\equiv (E_i/FF_i) \times (FF_i/TE_i) \times (TE_i/TFEC_i) \times (TFEC_i/GDP_i) \\ &\quad \times (GDP_i/POP_i) \times (POP_i) \\ &\equiv C_i \times S_i \times V_i \times I^*_i \times G_i \times P_i \end{aligned} \tag{5}$$

Figure 3.1 Sensitivity of Offsetting Coefficient to g_E/g_G



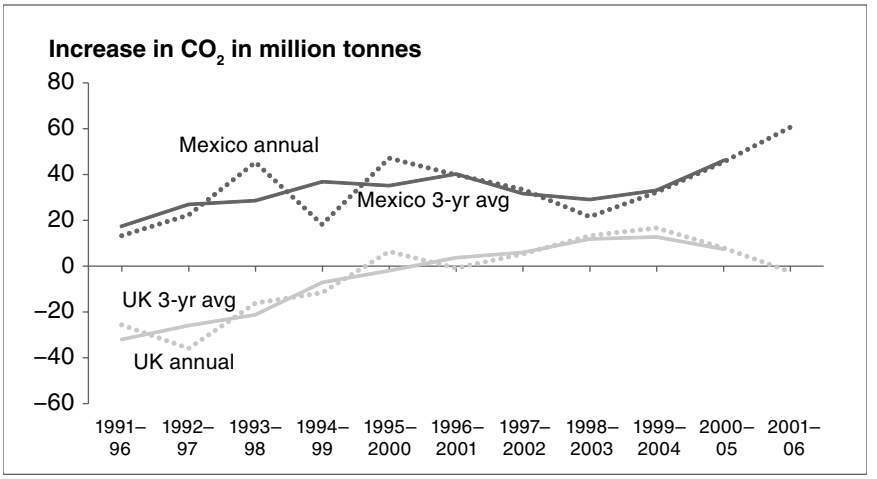
Sources: Authors' calculations using equation 4.
Note: The fractional increase in GDP is set at 0.2.

where $TFEC_i$ is the amount of total final energy consumption. Energy intensity in identity 5 is defined with respect to total final energy consumed rather than total primary energy. The equivalent for identity 2 becomes

$$\Delta E \equiv C_{eff} + S_{eff} + V_{eff} + I^*_{eff} + H_{eff} + G_{eff} + P_{eff}. \quad (6)$$

As in Bacon and Bhattacharya (2007), this study examines changes in emissions 10 years apart, further subdivided into two subperiods of 5 years each. The 2007 publication applied decomposition analysis to annual data. However, annual emissions show considerable scatter from year to year in some countries. To protect against the possibility of basing analysis on an "odd" year, this study takes the average of three years to compute changes in the emissions and contributing factors. The difference in using annual emissions data versus emissions averaged over three years is shown in figure 3.2 for changes in emissions over five years in Mexico and the United Kingdom. Selecting years when the increase in CO_2 emissions is particularly high (between 1993 and 1998 in Mexico and between 1995 and 2000 in Mexico and the United Kingdom) or low (between 1992 and 1997 in the United Kingdom and between 1994 and 1999 in Mexico) might yield misleading conclusions.

Figure 3.2 Comparison of Annual and Three-Year Average Data



Sources: IEA 2009a and authors' calculations.
Note: When averaging emissions over three years, "1996" is the average of annual data between 1995 and 1997, and so on; 1991–96 gives the increase in CO_2 emissions between 1991 and 1996.

Sectoral Decomposition

This study also applies decomposition analysis to sectoral data in selected countries. For this purpose, GDP is disaggregated into three sectors:

- Agriculture comprising agriculture, forestry, and fisheries
- Industry comprising energy production and manufacturing industry
- Service comprising the rest of the economy, mostly transport, residential, and commercial

Decomposition is carried out similarly to identity 2, but C_{eff}, S_{eff}, and I_{eff} are defined differently, and there is an extra term H_{eff}:

$$\Delta E_j \equiv C_{eff,j} + S_{eff,j} + I_{eff,j} + H_{eff,j} + G_{eff} + P_{eff}. \quad (7)$$

In identity 7, j is one of the three sectors, E_j is the CO_2 emissions of sector j, $C_{eff,j}$ takes fossil fuel consumption in sector j (and similarly for $S_{eff,j}$ and $I_{eff,j}$), and $H_{eff,j}$ is sector j's share of GDP; G_{eff} and P_{eff} are identical to those in identity 2. The calculation of the sector-specific terms is given by

$$C_{eff,j} = \{[E_j(1) - E_j(0)]/\log[E_j(1)/E_j(0)]\} \times \log[C_j(1)/C_j(0)]$$

and so on.

This form of the identity adds more detail by analyzing, sector by sector, changes in emissions due to changes in fossil fuel mix and changes in share of fossil fuels in total energy. In addition, changes in aggregate energy intensity of GDP are replaced by changes in energy intensity for each sector and by changes in the sector shares in aggregated GDP. For example, if services as a whole are less energy intensive than industry—as is the case globally—then a shift in the composition of GDP toward services and away from industry would tend to decrease total emissions, even if the energy intensity of each sector remained unchanged.

See appendix A for more information on the data used and their handling.

Chapter 4

Results

The results of various types of decomposition analysis show widely ranging performance by income, sector, and time period.

Five-Factor Decomposition

Decomposition based on identity 2 was carried out for each country and each study period, and for groups of countries with common characteristics: countries in different income groups, economies in transition, Annex I signatories to the United Nations Framework Convention on Climate Change, and top 10 CO_2 emitters in 2006. There were broad similarities in each group with the exception of the top 10 emitters.

Positive factors indicate that they contributed to rising emissions. For example, positive G_{eff} and P_{eff} signal increasing per capita GDP and increasing population, respectively. These factors are expected to be positive, ideally offset markedly by negative C_{eff}, S_{eff}, and I_{eff}. Table 4.1 shows the percentage of countries for which the coefficients in identity 2 are positive. G_{eff} and P_{eff} are positive for at least 80 percent of the countries studied, which is as expected. The factor with the lowest percentage of countries with positive coefficients is energy intensity, indicating falling

Table 4.1 Percentage of Countries with Positive Coefficients in Five-Factor Decomposition

# of countries	Period	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE
			IEA data				
123	Full	40	60	25	93	86	82
125	Subperiod 1	42	57	35	82	85	74
123	Subperiod 2	49	53	22	96	86	90
			U.S. EIA data				
165	Full	38	51	36	90	90	85
167	Subperiod 1	34	50	42	80	88	78
167	Subperiod 2	45	55	34	90	90	89

Sources: IEA 2009a and 2009b, U.S. EIA 2009, World Bank 2009, and authors' calculations.

energy intensity in two-thirds or more of the countries studied. Fossil fuel intensity, in contrast, increased for more than half the countries. A contributing factor to this increase in developing countries is declining traditional use of biomass, which is, nonetheless, a positive move for a variety of reasons: traditional biomass typically causes health-harming indoor air pollution, all too often requires hours of manual collection, and can lead to declining forest cover. The carbon intensity of fossil fuels declined in more than 50 percent of the countries in each of the study periods.

About two-thirds of the countries for which offsetting coefficients were calculated (that is, whose GDP rose) show positive offsetting coefficients in the full period. More countries registered positive offsetting coefficients in the second subperiod than in the first; half have positive offsetting coefficients in both the full period and the two subperiods. Based on IEA data,[1] about 40 percent of countries offset half or more of their emissions increase due to GDP growth in each study period by decreasing the carbon intensity of fossil fuels, the fossil fuel intensity of energy, or the energy intensity of their economy. Nearly one-fifth of countries were able to achieve absolute decoupling of CO_2 emissions from economic growth in the study decade (table 4.2).

The percentage of countries with varying degrees of offsetting tended to increase with increasing income. The exceptionally strong performance of Annex I countries relative to high-income countries in table 4.2 is partly due to the fact that 14 of the 38 Annex I countries are transition economies, all of which had positive offsetting coefficients during the decade examined. In fact, most of these 14 transition economies showed absolute decoupling: of 16 Annex I countries with offsetting coefficients equal to or greater than 100 percent in the full period, 12 are transition economies.

The percentage of Annex I countries with absolute decoupling period fell sharply in subperiod 2, however. Of the 24 nontransition economies, the number achieving absolute decoupling fell from 8 to 5. Annex I countries are expected to achieve absolute decoupling during 2012–20, but several were far from achieving this goal at the end of the decade studied. During subperiod 2, Austria, Italy, Luxembourg, and Spain had negative offsetting coefficients, amplifying the increase in emissions from GDP growth. Although Australia, Croatia, Finland, the Netherlands, New Zealand, and Turkey had positive offsetting coefficients, they were smaller than 50 percent.

[1]Corresponding results using U.S. EIA data are given in table B.8.

Table 4.2 Distribution of Offsetting Coefficients by Country Category

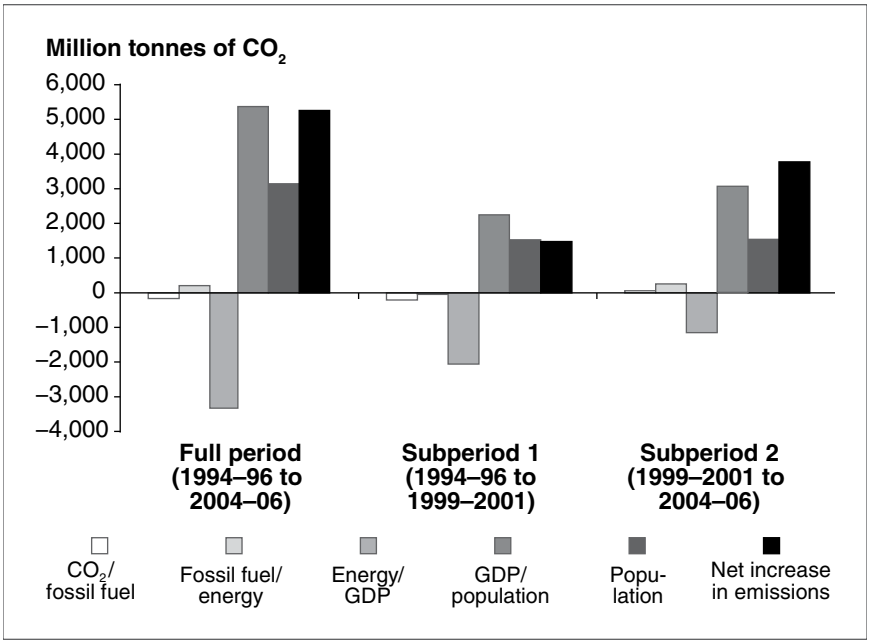
Period and offset	Low income	Lower middle income	Upper middle income	High income	Annex I	Total[a]
			Number of countries			
Full period	18	33	31	40	38	122
Subperiod 1	19	31	29	41	35	120
Subperiod 2	19	32	32	40	38	123
All three periods	17	30	29	40	35	116
			Percentage of countries			
Positive offset						
Full period	33	45	77	88	95	66
Subperiod 1	42	45	59	83	89	61
Subperiod 2	58	69	91	80	89	76
All three periods	29	33	52	70	80	50
Offset ≥ 50%						
Full period	28	24	35	58	76	39
Subperiod 1	37	23	38	56	71	40
Subperiod 2	32	31	47	55	74	43
All three periods	12	13	21	43	60	25
Offset ≥ 100%						
Full period	11	12	26	20	42	18
Subperiod 1	21	10	28	32	46	23
Subperiod 2	16	3	9	13	13	10
All three periods	6	3	3	8	9	5

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.
a. Total is the sum of low-, lower-middle-, upper-middle-, and high-income countries.

Table B.7 shows the ratios of offsetting coefficients obtained using the two different data sets. As equation 3 shows, X is a function only of CO_2 emissions and GDP. Because the same database was used for GDP, ratios that differ from 1 in table B.7 are due entirely to differences in CO_2 emissions between the IEA and U.S. EIA databases.

Decomposition analysis of global CO_2 emissions for the three study periods is shown in figure 4.1. By far the greatest offsetting factor is the decrease in the world economy's energy intensity. The figure shows that the reduction in energy intensity was smaller while the fossil fuel intensity of energy increased during subperiod 2.

Figure 4.1 Decomposition Analysis of Global CO_2 Emissions

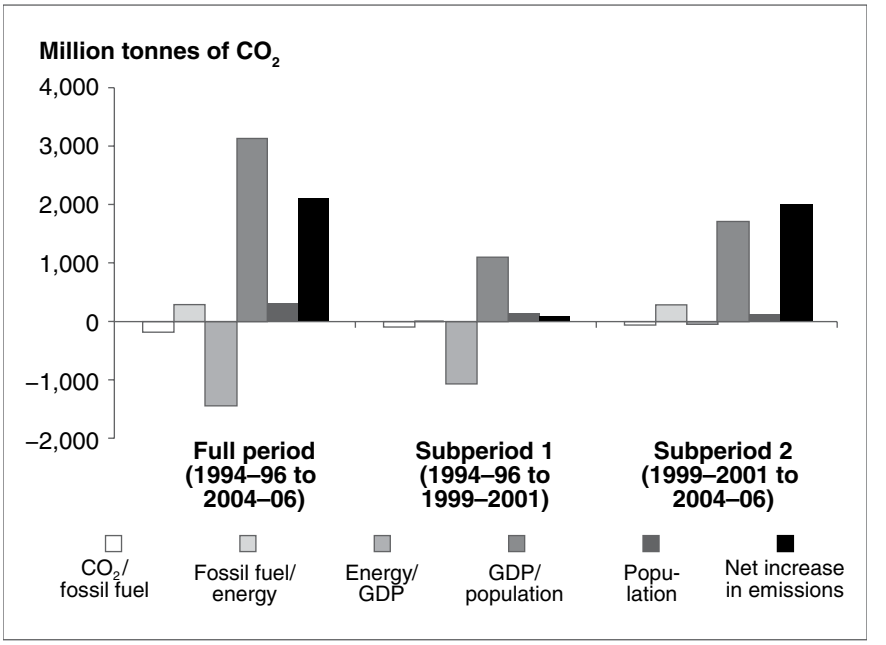


Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

Energy intensity in China decreased significantly in subperiod 1, nearly achieving absolute decoupling—which is remarkable given its level of per capita GDP—but decreased little during subperiod 2 (figure 4.2). Energy intensity fell steadily and sharply up to 2002 (figure 2.4), after which it increased by 10.7 percent in the next three years (NBS 2007). The government has set ambitious targets and associated policies for reducing the country's energy intensity, and China's energy intensity has again been declining since 2006 (NBS 2008 and 2009). The fall and rise of China's energy intensity up to 2006 has been the subject of much investigation. A paper by the Chinese Academy of Sciences cites the rapid expansion of energy-intensive subsectors (such as iron, steel, aluminum, and cement manufacture) and rise in the investment-to-consumption ratio as the primary drivers for increasing energy intensity in 2003–05 (Liao, Fan, and Wei 2007). Although China did not offset emissions growth due to increasing GDP during subperiod 2, its exceptionally large reduction in energy intensity during subperiod 1 enabled it to deliver good overall performance for the full period.

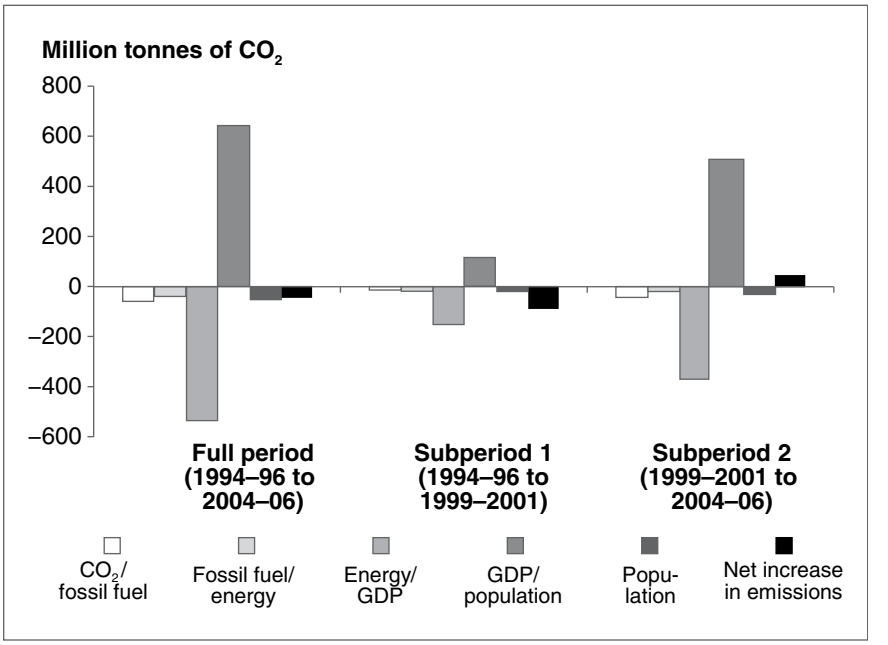
For Russia, four out of five effects in identity 2 are negative in each of the study periods (figure 4.3). Only in subperiod 2 did the country's CO_2 emissions increase. Several other transition economies exhibited similar trends.

Figure 4.2 Decomposition Analysis of CO_2 Emissions in China



Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

Figure 4.3 Decomposition Analysis of CO_2 Emissions in Russia



Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

Table 4.3 shows aggregated offset statistics for select groups of countries, together with their CO_2 emissions in 2006 to give an idea of their relative contributions to global emissions. The transition economies, which accounted for one-ninth of global emissions in 2006, offset twice the potential emissions from GDP growth during subperiod 1. The 1990s were a unique period in the history of these countries, when they were restructured and disposed of unproductive capital; their combined GDP increased 10 percent, while their energy consumption fell 8 percent between 1994 and 2000. During the current decade, the transition economies returned to more normal economic growth patterns, resulting in a lower offsetting coefficient—although still 83 percent.

If the transition economies are excluded from the calculations, the global offsetting coefficient declines by 14 and 11 percentage points in

Table 4.3 Performance of Countries by Category

Category/country	Offsetting coefficient (%)			2006 emissions (million tonnes)	2006 per capita emissions (tonnes)	2006 per capita GDP (US$)
	Full period	Sub-period 1	Sub-period 2			
World	38	61	18	27,899	4.3	9,093
Transition economies	113	199	83	3,110	7.9	10,649
World excluding transition economies	26	47	7	24,789	4.0	8,993
World exc. transition economies and China	36	33	40	19,182	4.0	10,206
Annex I countries	76	78	73	14,064	11.1	28,336
Annex I countries exc. transition economies	61	56	68	11,389	11.9	33,442
Top 10 emitters in 2006	41	71	12	17,665	5.4	10,913
United States	66	56	80	5,697	19.0	42,616
China	39	93	-9	5,607	4.3	4,524
Russian Federation	107	187	91	1,587	11.0	12,797
India	34	23	43	1,250	1.1	2,416
Japan	54	45	58	1,213	9.5	31,041
Germany	145	158	115	823	9.9	32,334
Canada	51	41	65	539	16.5	35,660
United Kingdom	96	102	89	536	8.8	32,941
Korea, Rep. of	42	25	56	476	9.7	22,364
Italy	25	43	–7	448	7.5	28,478

Sources: IEA 2009a and 2009b, World Bank 2009, authors' calculations.
Note: For detailed information on the countries included, see appendix B. Per capita GDP is valued at purchasing power parity in 2005 U.S. dollars.

the subperiods 1 and 2, respectively, resulting in essentially no offsetting during subperiod 2. If both the transition economies and China are excluded—leaving two-thirds of global emissions in 2006—the degree of offsetting actually improves from the first subperiod to the second.

Annex I countries fared reasonably well on the whole. When the transition economies are excluded, leaving mostly Annex II countries,[2] the offsetting coefficient increased in subperiod 2, although falling far short of the minimum target of 100 percent needed to decrease CO_2 emissions.

The top 10 emitters in 2006 performed poorly in subperiod 2, but there was wide variation in the performance of individual countries and their income levels. Three of the top five emitters—which accounted for 55 percent of global CO_2 emissions in 2006—improved their offsetting between the two subperiods; and the offsetting coefficient decreased by about 100 percentage points for the remaining two, although both started from positions of significant offsetting. Germany is the only country that maintained absolute decoupling in both subperiods. For the full period, Germany and Russia achieved absolute decoupling, and the United Kingdom came close.

The top 10 emitters are at very different stages of economic development, and the per capita GDP of the United States, the richest country among them in 2006, was 18 and 9 times that of India and China, respectively. Similarly, the United States as the highest per capita emitter generated 17 and 4 times the per capita emissions of India and China. Among the five countries with per capita GDP within 11 percent of each other in 2006—Japan, Germany, Canada, United Kingdom, and Italy, which are the five richest countries after the United States—the offsetting coefficient for the full period ranged from 25 percent for Italy to 145 percent for Germany and averaged 74 percent. By contrast, the United States, whose per capita GDP was one-third higher than the average of the above five countries and whose per capita emissions were twice their average, had an offsetting coefficient of 66 percent during the same period.

Results based on identity 2 for each country and each study period are tabulated in appendix B. The first three tables in the appendix show results using energy and emissions data from the IEA; the next three show results using data from the U.S. EIA. As mentioned earlier, aside from data differences, the greatest difference between the two data sets is that the IEA includes biomass consumed outside the power sector in its

[2]Annex II countries are Annex I countries excluding Turkey and those countries that were economies in transition in 1992.

definition of primary energy, leading to significantly different shares of fossil fuels in energy (S_{eff}) and energy intensity (I_{eff}) in those developing countries where there is considerable traditional use of biomass.

Six-Factor Decomposition

While the efficiency of conversion from primary energy to end-use energy might be expected to improve over time, this trend did not emerge in the results of decomposition based on an alternative formulation expressed by identity 6 and using IEA data. In each study period, 50 percent or more of the countries studied had positive V_{eff}, indicating that the conversion efficiency of energy deteriorated (table 4.4). Globally, this deterioration was significant, accounting for an additional 720 million tonnes of CO_2 for the decade. Among the top five emitters, there was marked improvement in conversion efficiency in the United States but deterioration in China, India, and Russia; the effect was essentially zero in Japan. Further work is needed to confirm this trend and to explore possible explanations. The detailed results are given in appendix C.

Table 4.4 Percentage of Countries with Positive Coefficients in Six-Factor Decomposition, Based on IEA Data

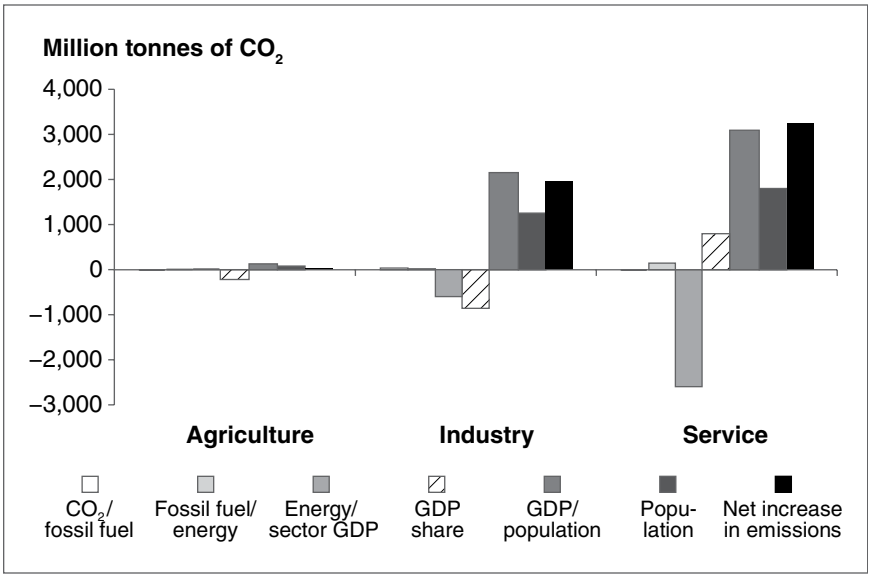
# of countries	Period	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}
123	Full	40	60	50	23	93	86
125	Subperiod 1	42	57	58	26	82	85
123	Subperiod 2	49	53	52	24	96	86

S*ources:* IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

Sectoral Decomposition

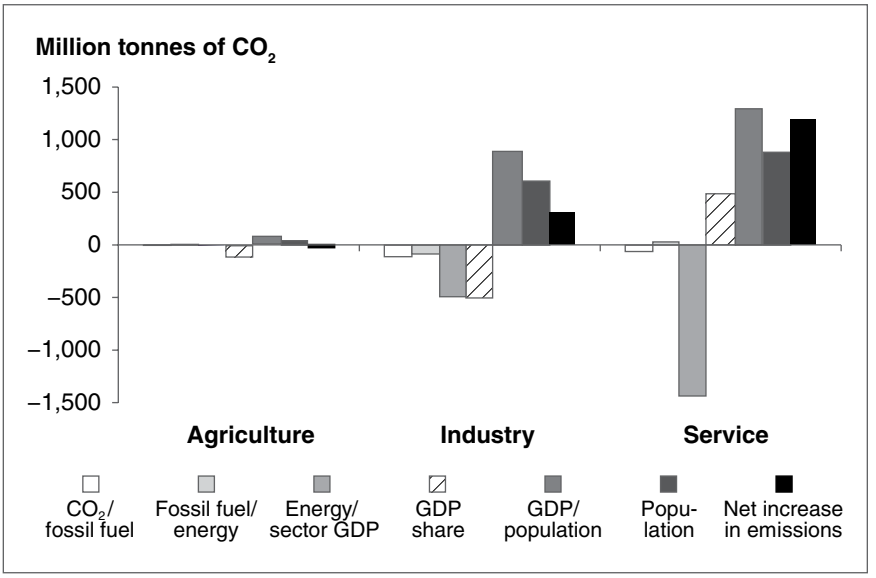
Sectoral decomposition analysis can be used to indicate whether shifts in the productive structure of the economy are, by themselves, slowing or accelerating changes in emissions. Sectoral decomposition analysis for the world is shown in figures 4.4, 4.5, and 4.6. For the full period, the service sector's share of global GDP increased at the expense of agriculture and industry. Because the service sector had a lower energy intensity than industry, although higher than that of agriculture, there was a small overall reduction in total use of energy for a given amount of GDP. At the same time, the service sector registered a significant reduction in energy intensity, contributing significantly to the offsetting effect, while the carbon intensity of fossil fuels and the fossil fuel share of energy analyzed at

Figure 4.4 Sectoral Decomposition Analysis of Global CO_2 Emissions, 1994–96 to 2004–06



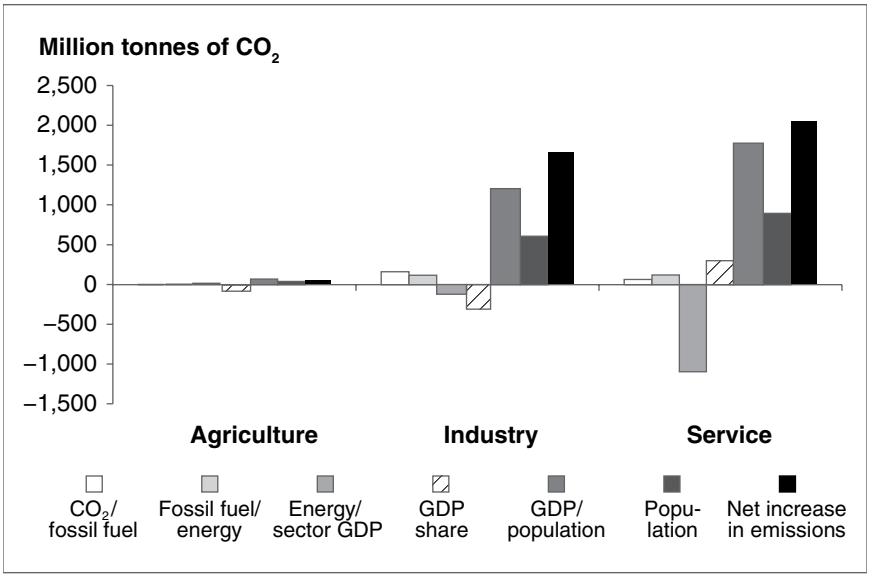
Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

Figure 4.5 Sectoral Decomposition Analysis of Global CO_2 Emissions, 1994–96 to 1991–2001



Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

Figure 4.6 Sectoral Decomposition Analysis of Global CO_2 Emissions, 1999–2001 to 2004–06



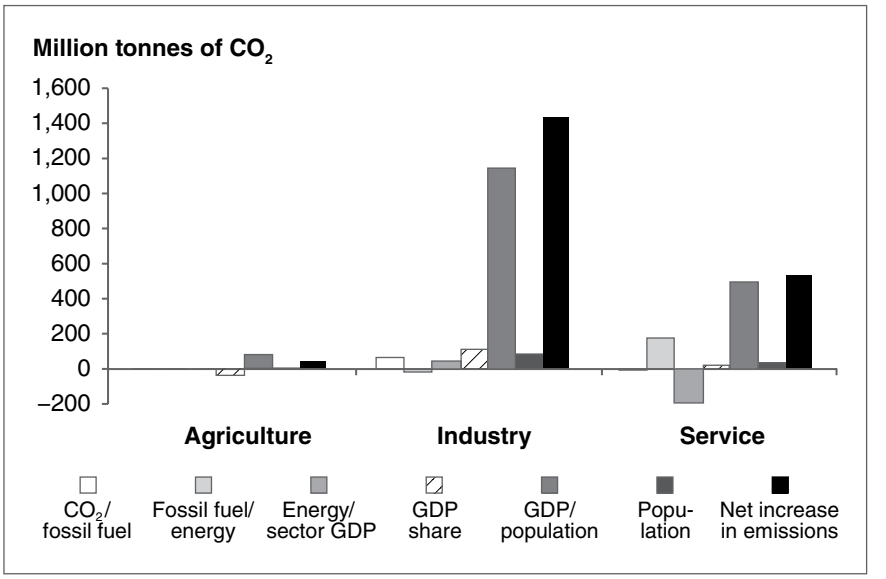
Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

the sector level made minor contributions. Without the decrease in the energy intensity of the global service sector, the increase in total emissions would have been almost 50 percent higher. Comparison of the two subperiods shows that the increase in CO_2 emissions was much larger during subperiod 2, particularly in industry. In the industrial sector, the carbon intensity of fossil fuels and the fossil fuel intensity of energy fell during subperiod 1; this trend was reversed in subperiod 2.

China had a negative offsetting coefficient in subperiod 2 because of the temporary rise in energy intensity. Sectoral decomposition analysis of China for subperiod 2 is shown in figure 4.7. The fossil fuel intensity of the service sector increased markedly, reflecting, in part, increasing use of modern commercial forms of energy by households that had previously relied more on biomass. Industry's share of GDP increased, as did its energy intensity and the carbon intensity of fossil fuels.

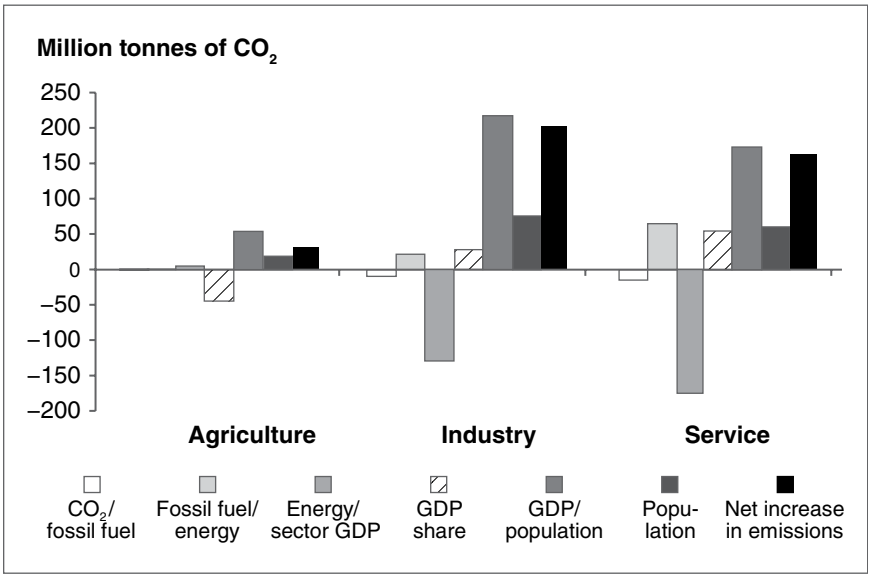
India is one of the 20 countries in which CO_2 emissions intensity (per unit of GDP) declined in both subperiods and declined more in the second than in the first. Figure 4.8 shows sectoral decomposition analysis for India for the full period. Both industry and service increased their shares of GDP at the expense of agriculture and reduced their respective energy intensities significantly. Although the carbon intensity of fossil

Figure 4.7 Sectoral Decomposition Analysis of CO_2 Emissions in China, 1999–2001 to 2004–06



Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

Figure 4.8 Sectoral Decomposition Analysis of CO_2 Emissions in India, 1994–96 to 2004–06



Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.

fuels fell in both sectors, their fossil fuel intensities increased. As with China, the amount of traditional biomass consumed did not increase much during this period, but consumption of modern commercial forms of energy—most of which is based on fossil fuels—did, particularly in the service sector.

Plots of sectoral decomposition analysis for the three study periods for 21 countries—Brazil, Chile, China, Egypt, India, Indonesia, the Islamic Republic of Iran, Italy, Japan, Kazakhstan, Korea, Mexico, Russia, Saudi Arabia, South Africa, Thailand, Turkey, Ukraine, the United Kingdom, the United States, and Vietnam—are given in a supplementary file available at http://siteresources.worldbank.org/EXTOGMC/Resources/Supplementary_decomposition_analysis_plots.pdf. The plots show that, in many of these countries, the decrease in the service sector's energy intensity was the dominant factor in offsetting some of the growth in total emissions related to GDP growth. Notable exceptions include Brazil and Turkey in subperiod 1; Italy and Mexico in subperiod 2; Indonesia for the full period and subperiod 1; the Islamic Republic of Iran in the full period and subperiod 2; and Egypt, Saudi Arabia, and Thailand for all three study periods.

The service sector's energy intensity may have declined for one of two reasons:

1. Certain subsectors of services with low energy intensity grew particularly rapidly.
2. Large areas of the service sector improved their energy efficiency, including households that, while not contributing to sector GDP, may have moved to more efficient use of energy through better insulation, higher-efficiency electric appliances, more efficient lighting, and higher-fuel-economy vehicles.

Further research and more disaggregated data will be needed to provide a better understanding of the role in the last decade of the service sector's declining energy intensity.

The industry sector is the most energy-intensive of the three. Its energy intensity declined in most countries, but, as with services, there were exceptions. Increases in energy intensity were experienced by Brazil, Chile, China, Indonesia, the Islamic Republic of Iran, Italy, Japan, Korea, Saudi Arabia, South Africa, Thailand, Ukraine, and the United Kingdom during the first subperiod; Turkey, the United Kingdom, and Vietnam during subperiod 2; and Brazil, Italy, Thailand, the United Kingdom, and Vietnam over the full period.

Chapter 5

Conclusions

This study finds that, at the global level, the increase in CO_2 emissions was greater in the second half of the decade examined than in the first half, even though more countries had positive offsetting coefficients during the latter subperiod. More rapid growth of GDP accounts for some of this increase. Although a reduction in energy intensity offset some of this growth in each subperiod, its effect was weaker in the second subperiod—a finding of some concern. Also of concern is the fact that the carbon emissions intensity of fossil fuels and fossil fuel mix declined in the subperiod 1 but rose in subperiod 2.

Several studies have used longer time periods to assess CO_2 emissions trajectories, such as the recently released E3G publication on the Group of 20 countries (Vivid Economics 2009). The present study points to unique circumstances resulting in a marked shift in trends around the beginning of this decade, with a slowdown of the decline in global emissions growth in the decade's second half as compared to its first. Consequently, projecting emissions trends observed predominantly in the 1990s into the future could be misleading.

When the decomposition analysis was carried out using sectoral data, the fall in energy intensity in the service sector in both subperiods was significant, while the effect was considerably smaller in the industrial sector.

Examination of the top five emitters confirms the importance of the decrease in the service sector's energy intensity, apart from Japan in the subperiod 1 and China in subperiod 2 where the energy intensity increased. In China (all three study periods), India (all three study periods), and Japan (subperiod 2), fossil fuel intensity rose, partly negating the effects of reduced energy intensity.

Analyzing the results by income shows that absolute decoupling tended to occur more in upper-middle and high-income countries. A notable feature of this trend is high representation of transition economies, which decoupled so strongly in subperiod 1 as to compensate for their weaker performance during subperiod 2 to deliver good overall

performance for the full period. Because many transition economies are Annex I signatories, the latter as a whole did much better than high-income countries on average in subperiod 1.

Countries in the early stages of development tended to show less offsetting, and virtually none showed absolute decoupling. However, this finding must be taken in the context of their very low per capita emissions today. Many countries—where per capita emissions are markedly below even the most stringent stabilization target levels considered by international bodies—are extremely poor and would not be expected to follow a development path in which total emissions from energy use would decline or even stabilize in the near term. As suggested by Spence (2009), emissions from these countries will, and should be permitted to, increase for the foreseeable future, mitigated by their own planning and policy efforts toward energy efficiency and low-carbon energy sources. The recently proposed Greenhouse Rights Development framework details a similar approach and suggests a development threshold of welfare below which people should not expected to share the costs of climate change mitigation (Baer and others 2008).

Even though decoupling was not as strong globally in the second subperiod as in the first, the good performance of several countries across the entire income spectrum indicates the potential for wider improvements as governments engage with the task of increasing energy efficiency and energy conservation, thereby slowing the growth of CO_2 emissions. As low-income countries develop, they will be better able to take advantage of a menu of options and achieve stronger decoupling by following these examples.

Appendix A

Data Treatment

IEA energy data are from extended energy balances of OECD and non-OECD countries. For five-factor decomposition analysis, energy in the analysis is total primary energy supply in the database. Individual fossil fuel contributions are summed. The IEA presents CO_2 emissions calculated using both the Intergovernmental Panel on Climate Change's Reference Approach and its Tier 1 Sectoral Approach. This study takes the latter and sums all CO_2 emissions except those from industrial and municipal wastes.

Turton and Hamilton (1999) point out that the assumptions used by the IEA for determining the notional thermal efficiency of nuclear and hydroelectric power can have a large influence on energy use data for those countries deriving a large proportion of energy from these fuels.

For sectoral decomposition, energy consumption is based on final energy consumed in each sector except electricity and heat, for which fuel sources for power and heat production are apportioned to each sector according to its final consumption. Losses in the transmission and distribution of energy, heat, and fuels are apportioned similarly. CO_2 emissions are based on the distribution of different fossil fuels consumed. This approach differs from that for the five-factor decomposition analysis, which is based only on primary energy. The differences are generally small except in countries with significant charcoal consumption (where charcoal rather than biomass consumption is taken for sectoral decomposition); blast furnace gas, gas works gas, coke oven coke (Egypt); and coal- or gas-to-liquids (South Africa). These differences can produce results for C_{eff} that differ appreciably from those obtained in the five-factor analysis.

The U.S. EIA data are updated regularly, and historical data are frequently revised. CO_2 emissions data used in the 2007 publication are generally higher in the most recent update than in the previous publication. The U.S. EIA CO_2 emissions data should be closer to the IEA's CO_2 emissions data using the Intergovernmental Panel on Climate Change's Reference Approach, but using the latter did not narrow the gap in the

results based on the U.S. EIA and IEA databases (for example, the results in table B.7) markedly.

Population and GDP data are taken from the World Bank's *World Development Indicators*. Bahrain, Cambodia, and Myanmar had all the requisite data except for GDP in 2006, enabling decomposition analysis only for the first subperiod. GDP data were missing for Chad, Cuba, Iraq, the Democratic Republic of Korea, Monaco, Palau, Qatar, Somalia, Turkmenistan, and Zimbabwe.

Appendix B

Results for Five-Factor Decomposition

This appendix presents the results of decomposition analysis according to identity 2 based on emissions and energy consumption data from the IEA and U.S. EIA for the full period and the two subperiods. In all cases, data are first averaged over three consecutive years, with the midyear representing the year of interest. The results of calculations using IEA data are provided first (tables B.1 through B.3, followed by the results using U.S. EIA data (tables B.4 through B.6). From IEA, the required data were available for 123 countries for the full period. In addition, Bahrain, Cambodia, Libya, and Myanmar had GDP data to enable decomposition for one subperiod. From U.S. EIA, the required data were available for 165 countries. In addition, Bahrain, Libya, Maldives, and Myanmar had data to enable decomposition for one subperiod. The U.S. EIA tables also show the results for Taiwan, China. For all six tables, calculations were also carried out for the world.

Using IEA data, calculations were carried out for Annex I countries (except Liechtenstein and Monaco, for which data were not available), Annex I countries excluding the 14 transition economies (Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Slovak Republic, Slovenia, and Ukraine), all transition economies for which data were available (Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, the Former Yugoslavia Republic of Macedonia, Moldova, Poland, Romania, Russia, Serbia, Slovak Republic, Slovenia, Tajikistan, Ukraine, and Uzbekistan), the world excluding the transition economies, the world excluding the transition economies and China, and for the top 10 CO_2 emitters in 2006 (the United States, China, Russia, India, Japan, Germany, Canada, the United Kingdom, Korea, and Italy).

To give an indication of the degree of discrepancies between the two data sets, table B.7 tabulates the ratio of the offsetting coefficients calculated from IEA and U.S. EIA data.

Distribution of offsetting coefficients among different categories of countries using U.S. EIA data are given in table B.8. The IEA equivalent of this table is provided in the main text in table 4.2.

Offsetting coefficients are not given where GDP declined over the time interval in question:

- Bulgaria subperiod 1
- Burundi subperiod 1
- Central African Republic subperiod 2
- Democratic Republic of Congo full period and subperiod 1
- Djibouti subperiod 1
- Guinea-Bissau all three periods
- Haiti subperiod 2
- Liberia subperiod 2
- Moldova subperiod 1
- Papua New Guinea subperiod 1
- Romania subperiod 1
- Seychelles subperiod 2
- Sierra Leone subperiod 1
- Solomon Islands full period and subperiod 1
- Ukraine subperiod 1

Table B.1 Decomposition Analysis between 1994–96 and 2004–06 Based on IEA Data

million tonnes of CO_2

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Albania	–0.2	0.9	–0.1	1.5	0.0	2.1	–37
Algeria	2	0	–5	16	11	24	11
Angola	0.8	0.9	–2.6	3.1	1.6	3.7	20
Argentina	–2	2	–3	12	14	22	13
Armenia	–0.1	–0.2	–1.5	3.0	–0.2	1.0	64
Australia	21	2	–46	82	40	99	19
Austria	1	–2	0	12	2	13	6
Azerbaijan	–1	0	–30	27	3	–1	105
Bangladesh	0.2	5.0	–2.3	8.8	5.2	17	–21
Belarus	–4	–1	–34	41	–3	–1	102
Belgium	–10	–4	–17	21	4	–5	121
Benin	0.1	1.8	–0.2	0.2	0.4	2.2	–297
Bolivia	0.1	0.7	0.1	1.1	2.0	3.9	–27
Bosnia & Herzegovina	0	2	–1	10	1	12	–19
Botswana	–0.1	0.3	–1.5	1.9	0.6	1.1	55
Brazil	7	–2	13	28	41	88	–27
Brunei Darussalam	–0.2	0.0	0.0	–0.3	1.2	0.7	24
Bulgaria	3	–4	–19	17	–4	–7	157
Cameroon	–0.06	–0.06	–0.50	0.48	0.65	0.51	55
Canada	–11	16	–91	119	48	82	51
Chile	–3	1	1	14	6	19	7
China	–182	291	–1,444	3,132	310	2,107	39
Colombia	–2	4	–16	5	9	2	87
Congo, Dem. Rep. of	0.9	–1.2	0.6	–0.6	0.6	0.2	n.a.
Congo, Rep. of	–0.1	0.3	0.1	0.1	0.2	0.5	–99
Costa Rica	–0.2	–1.0	0.2	1.2	1.1	1.3	45
Côte d'Ivoire	0.1	1.2	0.7	–0.3	1.0	2.7	–295
Croatia	1.3	–0.1	–3.3	7.9	–0.6	5.1	30
Cyprus	0.6	0.0	–1.1	1.4	0.8	1.6	27
Czech Republic	–2	–13	–20	33	–1	–3	108
Denmark	–3	–7	–14	10	2	–12	205
Dominican Republic	2.0	0.7	–3.9	5.4	2.4	6.6	16
Ecuador	–1.9	1.3	1.6	3.3	2.7	6.9	–16
Egypt, Arab Rep. of	2	2	10	28	21	63	–29
El Salvador	0.0	–0.1	0.2	0.6	0.9	1.5	–6

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Eritrea	–0.08	0.12	–0.30	–0.14	0.23	–0.17	277
Estonia	–1	0	–11	12	–1	–1	109
Ethiopia	0.3	1.3	–0.8	0.8	1.0	2.6	–43
Finland	–3	–5	–12	21	2	3	87
France	–8	–10	–37	63	19	26	68
Gabon	0.20	0.09	0.20	–0.17	0.32	0.65	–314
Georgia	–1.2	–1.0	–4.9	4.1	–0.7	–3.7	208
Germany	–17	–38	–113	109	8	–52	145
Ghana	0.3	2.0	–0.7	1.1	1.2	3.9	–69
Greece	–3	0	–9	29	4	19	40
Guatemala	0.7	1.3	0.3	0.9	1.9	5.1	–81
Haiti	0.02	0.54	0.32	–0.12	0.19	0.95	–1,169
Honduras	0.2	1.3	–0.2	0.9	1.0	3.2	–72
Hungary	–5	0	–21	25	–1	–2	110
Iceland	–0.25	–0.64	0.12	0.68	0.22	0.13	85
India	–28	98	–272	445	155	397	34
Indonesia	34	24	7	34	34	133	–96
Iran, Islamic Rep. of	–17	0	23	97	51	154	–4
Ireland	–3	1	–16	22	5	10	63
Israel	2	0	–5	7	12	16	15
Italy	–11	–9	5	50	13	47	25
Jamaica	–0.11	0.30	1.12	0.26	0.62	2.18	–149
Japan	4	–6	–70	111	22	61	54
Jordan	0	0	–1	3	4	6	19
Kazakhstan	–16	3	–85	107	–7	1	99
Kenya	–1.0	0.9	0.2	0.2	2.3	2.6	–4
Korea, Rep. of	–14	–31	–32	156	28	107	42
Kuwait	4	0	–1	9	18	30	–11
Kyrgyz Republic	0.05	–0.36	–2.14	1.73	0.62	–0.10	104
Latvia	–0.7	–0.5	–5.8	6.3	–0.8	–1.5	127
Lebanon	0.2	0.0	–2.1	2.4	1.9	2.4	45
Lithuania	–0.5	–0.8	–8.0	8.9	–0.9	–1.3	116
Luxembourg	–2.5	2.3	–2.3	3.6	1.2	2.2	54
Macedonia, FYR	0.1	–0.7	–2.2	1.5	0.3	–1.0	157
Malaysia	5	3	5	27	24	64	–26
Malta	–0.14	0.00	–0.33	0.49	0.17	0.19	71
Mexico	–18	6	–22	71	44	81	29
Moldova	–0.8	–0.6	–5.0	3.3	–1.1	–4.2	293

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Mongolia	–0.2	0.0	–4.2	3.4	1.1	0.1	98
Morocco	1	0	0	8	4	13	–9
Mozambique	–0.10	0.24	–0.59	0.66	0.33	0.55	45
Namibia	0.0	0.0	0.1	0.5	0.5	1.0	–10
Nepal	0.1	0.5	–0.2	0.4	0.5	1.2	–36
Netherlands	–4	–5	–29	36	10	7	84
New Zealand	9	1	–7	6	4	11	–19
Nicaragua	0.0	0.4	–0.1	0.8	0.5	1.6	–22
Nigeria	6	3	–8	8	11	20	–10
Norway	–7.9	3.9	–2.7	7.8	2.0	3.2	68
Oman	–1.6	0.0	7.3	5.1	2.9	13.6	–72
Pakistan	0	6	–6	16	24	40	–1
Panama	0.2	0.3	–0.9	1.2	0.9	1.7	21
Paraguay	0.02	0.14	–0.36	–0.24	0.71	0.27	42
Peru	0.0	0.1	–4.2	5.6	3.5	4.9	46
Philippines	–1.2	–4.2	–9.7	12.9	13.5	11.3	57
Poland	–24	6	–153	137	–3	–37	127
Portugal	–2	1	1	10	3	13	3
Romania	4	–11	–41	29	–5	–24	199
Russian Federation	–59	–39	–535	643	–52	–43	107
Saudi Arabia	1	0	35	19	58	113	–46
Senegal	0.1	0.6	–0.1	0.6	0.9	2.1	–42
Serbia	–2	0	–4	16	–2	9	38
Singapore	–6	0	–11	13	8	3	85
Slovak Republic	–1	–3	–15	16	0	–2	114
Slovenia	0.0	–0.7	–2.8	5.6	0.1	2.2	60
South Africa	–5	2	–34	44	55	63	36
Spain	–7	16	–3	73	27	106	–6
Sri Lanka	–0.2	2.2	–0.3	3.3	0.8	5.7	–42
Sudan	–0.1	3.6	–1.9	2.9	1.6	6.1	–36
Sweden	–7	–4	–15	15	1	–10	161
Switzerland	–0.1	–2.1	–2.9	4.4	2.2	1.6	75
Syrian Arab Rep.	–1	0	–2	3	11	12	18
Tajikistan	0.3	–0.2	–2.4	1.8	0.7	0.3	88
Tanzania	0.3	–0.1	0.1	0.9	0.8	2.0	–18
Thailand	–14	11	28	33	16	74	–50
Togo	0.05	–0.09	0.05	0.00	0.27	0.28	–4
Trinidad and Tobago	–1	0	1	11	1	11	3

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Tunisia	–0.8	0.1	–2.3	6.2	1.9	5.1	37
Turkey	–6	12	–15	49	29	68	13
Ukraine	–13	–16	–136	124	–31	–71	176
United Arab Emirates	3	0	–18	6	46	36	30
United Kingdom	–2	4	–147	131	20	5	96
United States	–7	14	–1,123	1,124	574	582	66
Uruguay	–0.02	0.27	0.03	0.52	0.14	0.94	–42
Uzbekistan	–2	0	–40	34	15	7	85
Venezuela, R.B. de	11	–3	–10	–1	24	21	11
Vietnam	–3	30	–8	28	6	53	–56
Yemen, Rep. of	0	0	3	2	4	10	–53
Zambia	–0.07	–0.12	–0.28	0.26	0.44	0.22	69
World	–160	209	–3,324	5,390	3,147	5,263	38
Transition economies	–121	–80	–1,182	1,290	–72	–164	113
World exc. transition economies	–94	380	–2,233	4,404	2,969	5,426	26
World exc. transition economies and China	–153	96	–1,841	2,500	2,716	3,319	36
Annex I countries	–167	–128	–2,467	3,088	568	895	76
Annex I countries exc. transition economies	–76	–22	–1,625	2,042	762	1,081	61
Top 10 emitters in 2006	38	142	–2,448	4,025	1,490	3,247	41

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations
Note: n.a. = not applicable (GDP growth is negative).

Table B.2 Decomposition Analysis between 1994–96 and 1999–2001 Based on IEA Data

million tonnes of CO_2

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Albania	0.0	0.5	0.0	0.7	–0.1	1.2	–75
Algeria	–0.6	0.1	–1.1	4.8	4.8	8.0	18
Angola	0.2	0.2	–0.8	0.8	0.6	1.1	25
Argentina	–3.8	0.8	1.7	3.7	7.1	9.4	13
Armenia	–0.10	–0.15	–0.19	0.96	–0.15	0.37	54
Australia	16	–1	–23	46	18	56	13
Austria	–0.2	–1.0	–3.2	7.5	0.5	3.7	54
Azerbaijan	1	0	–14	7	1	–5	154
Bahrain	0.3	0.0	–0.6	1.2	1.5	2.4	11
Bangladesh	0.1	2.3	–1.2	3.4	2.2	6.8	–20
Belarus	–2	–1	–18	16	–1	–6	141
Belgium	–4	–3	–7	13	1	1	95
Benin	0.0	1.0	–0.1	0.1	0.1	1.0	–375
Bolivia	–1.4	0.4	0.0	0.5	0.8	0.4	71
Bosnia & Herzegovina	0.9	1.5	–0.7	6.6	0.5	8.9	–25
Botswana	–0.1	0.2	–0.6	1.0	0.4	0.8	43
Brazil	4	17	16	6	20	64	–143
Brunei Darussalam	–0.50	0.00	0.05	–0.24	0.56	–0.12	137
Bulgaria	2	–4	–9	2	–2	–10	n.a.
Cameroon	–0.03	–0.16	–0.27	0.27	0.31	0.13	78
Canada	2	21	–63	73	23	57	41
Chile	–4	3	5	7	3	14	–40
China	–92	7	–1,070	1,106	142	92	93
Colombia	1.6	4.4	–7.1	–2.0	5.1	2.1	31
Congo, Dem. Rep. of	0.74	–0.92	0.61	–0.60	0.24	0.06	n.a.
Congo, Rep. of	0.03	–0.03	–0.02	–0.02	0.08	0.04	32
Costa Rica	–0.41	–0.48	0.07	0.57	0.55	0.29	74
Côte d'Ivoire	0.5	1.3	0.4	0.2	0.6	2.9	–282
Croatia	1.0	0.0	–1.2	3.4	–0.5	2.7	8
Cyprus	0.2	0.0	–0.5	0.7	0.4	0.8	29
Czech Republic	0	–2	–13	10	–1	–6	163
Denmark	–4	–4	–11	6	1	–11	253
Dominican Republic	1.1	0.9	–1.4	3.8	1.2	5.6	–13
Ecuador	–0.7	0.3	1.2	–0.4	1.3	1.7	–85
Egypt, Arab Rep. of	0	1	2	15	9	25	–7

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
El Salvador	–0.10	0.07	0.19	0.33	0.45	0.94	–20
Eritrea	–0.01	0.08	–0.29	–0.03	0.09	–0.15	321
Estonia	–0.2	–0.4	–6.1	5.3	–0.8	–2.2	149
Ethiopia	0.3	0.3	–0.2	0.2	0.4	1.0	–69
Finland	–2	–6	–9	12	1	–4	132
France	0	–2	–25	43	7	22	55
Gabon	0.02	0.00	0.11	–0.12	0.16	0.17	–305
Georgia	–0.2	–1.2	–3.6	1.8	–0.4	–3.6	344
Germany	–22	–27	–80	76	5	–47	158
Ghana	0.1	1.3	0.0	0.4	0.5	2.3	–147
Greece	–3	0	0	11	2	11	20
Guatemala	0.1	1.0	0.6	0.6	0.8	3.1	–121
Haiti	0.00	0.53	0.11	0.00	0.09	0.73	–706
Honduras	0.0	0.8	–0.3	0.1	0.4	1.1	–102
Hungary	–2	0	–12	12	–1	–3	124
Iceland	–0.14	–0.48	0.18	0.36	0.10	0.02	95
India	–11	49	–96	174	75	191	23
Indonesia	27	11	28	–8	16	73	–906
Iran, Islamic Rep. of	–9	1	13	27	22	54	–10
Ireland	–3	2	–7	15	2	8	51
Israel	0.8	–0.1	–2.9	4.4	6.3	8.4	21
Italy	–11	–5	–1	38	1	22	43
Jamaica	–0.20	0.22	1.24	–0.29	0.38	1.34	–1,446
Japan	1	–22	1	30	14	24	45
Jordan	0.5	0.0	–0.8	0.5	1.8	2.0	13
Kazakhstan	–6	1	–54	24	–9	–44	386
Kenya	–1.2	1.2	0.3	–0.1	1.1	1.3	–37
Korea, Rep. of	–15	–16	11	63	17	60	25
Kuwait	1	0	5	–4	9	10	–143
Kyrgyz Republic	0.0	–0.5	–1.8	0.8	0.3	–1.2	204
Latvia	–0.2	–0.6	–3.5	2.6	–0.5	–2.1	196
Lebanon	0.2	0.0	0.6	0.8	1.1	2.6	–43
Lithuania	–0.3	–0.6	–4.4	3.2	–0.5	–2.6	194
Luxembourg	–2.0	1.2	–2.4	1.8	0.5	–0.9	140
Macedonia, FYR	0.4	–0.4	–1.5	0.8	0.2	–0.6	158
Malaysia	5	1	6	8	12	32	–62
Malta	–0.05	0.00	–0.42	0.40	0.08	0.01	99
Mexico	–5	1	–30	45	24	35	49

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Moldova	–0.8	–0.3	–2.8	–0.4	–0.5	–4.8	n.a.
Mongolia	0.0	0.0	–2.3	0.9	0.5	–0.9	162
Morocco	0	0	1	2	2	5	–29
Mozambique	–0.16	0.20	–0.28	0.29	0.15	0.20	54
Myanmar	0.0	0.9	–2.3	2.3	0.4	1.3	51
Namibia	–0.02	–0.12	–0.04	0.09	0.24	0.16	52
Nepal	0.1	0.9	–0.1	0.2	0.3	1.4	–165
Netherlands	–2	–4	–28	27	5	–1	102
New Zealand	3.7	1.3	–1.3	2.5	1.4	7.7	–95
Nicaragua	0.0	0.6	–0.3	0.4	0.3	1.0	–45
Nigeria	6.0	–0.5	–1.1	0.1	4.9	9.3	–86
Norway	–3.0	1.1	–1.9	4.9	1.0	2.0	66
Oman	–0.5	0.0	3.9	1.3	1.7	6.3	–112
Pakistan	0	4	1	3	11	18	–35
Panama	–0.5	0.3	0.3	0.5	0.5	1.1	–10
Paraguay	0.04	0.10	0.01	–0.29	0.37	0.24	–181
Peru	–0.5	0.4	–0.7	1.5	1.8	2.5	25
Philippines	0.7	–4.3	2.4	4.5	6.7	10.0	11
Poland	–11	2	–110	81	–1	–39	149
Portugal	–1.7	2.0	2.1	9.2	1.1	12.6	–23
Romania	2	–9	–18	–3	–1	–30	n.a.
Russian Federation	–14	–19	–152	118	–20	–86	187
Saudi Arabia	4	0	13	–2	25	41	–74
Senegal	0.1	0.3	0.2	0.3	0.4	1.2	–89
Serbia	0.6	–1.5	–2.9	2.8	–1.2	–2.2	241
Singapore	0	0	–11	5	5	–1	105
Slovak Republic	–1.2	–1.8	–6.7	7.0	0.2	–2.5	134
Slovenia	0.0	–0.1	–1.4	2.9	0.0	1.3	54
South Africa	6	–4	–21	4	33	18	52
Spain	–5	7	1	44	6	53	–8
Sri Lanka	0.0	1.8	0.1	1.6	0.3	3.8	–106
Sudan	–1.4	1.8	–0.8	0.9	0.6	1.1	31
Sweden	–1	–4	–10	9	0	–6	166
Switzerland	–0.4	–0.7	–1.7	2.8	0.8	0.8	77
Syrian Arab Rep.	–1.7	0.0	4.1	0.1	5.1	7.6	–46
Tajikistan	0.15	–0.23	–0.51	–0.25	0.34	–0.50	617
Tanzania	0.36	–0.74	0.03	0.19	0.31	0.13	73
Thailand	–8	6	20	–5	8	21	–507

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Togo	0.12	–0.07	0.04	0.03	0.14	0.26	–50
Trinidad and Tobago	–0.6	0.0	2.3	3.3	0.4	5.4	–49
Tunisia	–0.1	0.1	–0.6	3.1	1.1	3.5	16
Turkey	0	6	1	12	15	33	–25
Ukraine	–17	–9	–25	–18	–16	–84	n.a.
United Arab Emirates	1	0	–7	–3	22	14	29
United Kingdom	–12	1	–72	73	8	–2	102
United States	8	22	–599	704	310	445	56
Uruguay	–0.14	0.32	0.35	0.25	0.13	0.91	–139
Uzbekistan	–3	0	–5	12	9	12	40
Venezuela, R.B. de	4	–1	0	–6	12	9	–41
Vietnam	–1	11	–4	9	2	17	–45
Yemen, Rep. of	0.1	0.1	1.1	1.4	1.8	4.4	–39
Zambia	–0.03	–0.31	–0.06	–0.02	0.22	–0.20	197
World	–205	–41	–2,050	2,247	1,532	1,483	61
Transition economies	–57	–46	–517	345	–34	–308	199
World exc. transition economies	–177	69	–1,455	1,917	1,437	1,792	47
World exc. transition economies and China	–61	61	–848	1,203	1,344	1,699	33
Annex I countries	–75	–77	–1,341	1,633	277	417	78
Annex I countries exc. transition economies	–42	–5	–844	1,209	369	687	56
Top 10 emitters in 2006	–137	–34	–1,607	1,751	760	734	71

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.
Note: n.a. = not applicable (GDP growth is negative).

Table B.3 Decomposition Analysis between 1999–2001 and 2004–06 Based on IEA Data

million tonnes of CO_2

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Albania	–0.33	0.48	–0.17	0.86	0.08	0.92	2
Algeria	2	0	–3	11	6	16	6
Angola	0.6	0.7	–1.9	2.3	0.9	2.7	17
Argentina	2	1	–5	8	7	13	13
Armenia	0.02	–0.09	–1.33	2.10	–0.08	0.64	68
Australia	5	3	–23	36	23	43	26
Austria	1	–1	4	4	2	10	–71
Azerbaijan	–1	0	–14	18	1	3	83
Bangladesh	0	3	–1	5	3	10	–21
Belarus	–2	1	–15	23	–1	5	74
Belgium	–6	–1	–10	8	2	–6	156
Benin	0.1	0.6	0.0	0.1	0.3	1.2	–196
Bolivia	1.7	0.2	0.1	0.6	1.0	3.6	–131
Bosnia & Herzegovina	–1.1	1.1	0.0	3.1	0.4	3.5	1
Botswana	0.05	0.13	–0.99	0.89	0.25	0.33	71
Brazil	3	–22	–4	25	22	24	49
Brunei Darussalam	0.36	0.00	–0.11	0.01	0.56	0.83	–45
Bulgaria	1	0	–9	13	–2	3	75
Cambodia	–0.1	0.9	–0.8	1.1	0.3	1.3	5
Cameroon	–0.02	0.11	–0.22	0.19	0.32	0.39	25
Canada	–14	–6	–28	47	26	25	65
Chile	0.6	–2.2	–4.7	8.5	3.1	5.3	54
China	–62	286	–50	1,714	127	2,015	–9
Colombia	–3.3	0.0	–8.8	7.5	4.5	–0.2	102
Congo, Dem. Rep. of	0.15	–0.28	–0.08	0.06	0.32	0.17	55
Congo, Rep. of	–0.13	0.31	0.09	0.08	0.09	0.45	–163
Costa Rica	0.2	–0.5	0.2	0.6	0.5	1.0	12
Côte d'Ivoire	–0.55	–0.10	0.52	–0.63	0.54	–0.22	–142
Croatia	0.3	–0.1	–2.2	4.6	–0.1	2.4	46
Cyprus	0.36	–0.02	–0.60	0.66	0.40	0.80	25
Czech Republic	–1	–11	–7	23	0	3	86
Denmark	0.4	–2.5	–2.7	3.1	0.8	–0.9	123
Dominican Republic	1.0	–0.3	–3.0	1.9	1.4	0.9	72
Ecuador	–1.1	1.0	0.2	3.9	1.2	5.2	–1
Egypt, Arab Rep. of	3	2	9	12	12	38	–59

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
El Salvador	0.06	–0.17	0.01	0.24	0.41	0.56	14
Eritrea	–0.07	0.04	–0.02	–0.10	0.13	–0.02	169
Estonia	–0.3	0.2	–4.6	6.2	–0.3	1.2	80
Ethiopia	–0.1	1.1	–0.7	0.7	0.5	1.6	–26
Finland	–0.5	1.6	–2.2	7.4	0.8	7.0	14
France	–9	–8	–12	21	13	4	88
Gabon	0.19	0.09	0.09	–0.04	0.15	0.48	–318
Georgia	–0.7	0.2	–0.9	1.6	–0.2	0.0	103
Germany	4	–12	–32	32	2	–5	115
Ghana	0.2	0.6	–0.8	0.9	0.7	1.6	–2
Greece	0	–1	–9	18	2	8	56
Guatemala	0.7	0.3	–0.5	0.4	1.2	2.0	–32
Haiti	0.03	–0.05	0.27	–0.16	0.13	0.22	n.a.
Honduras	0.1	0.4	0.2	0.8	0.5	2.0	–54
Hungary	–3	0	–8	13	–1	0	98
Iceland	–0.11	–0.14	–0.07	0.31	0.12	0.11	75
India	–17	48	–184	279	80	207	43
Indonesia	5	14	–28	50	20	61	13
Iran, Islamic Rep. of	–6	–1	8	72	27	99	0
Ireland	0	0	–10	8	4	2	83
Israel	1.7	–0.2	–2.0	2.2	5.7	7.5	6
Italy	0	–5	6	11	12	25	–7
Jamaica	0.11	0.07	–0.18	0.61	0.24	0.84	0
Japan	3	16	–72	82	8	37	58
Jordan	–1.1	–0.1	0.2	2.7	1.9	3.6	22
Kazakhstan	–8	2	–19	68	3	45	35
Kenya	0.4	–0.5	–0.2	0.4	1.2	1.3	19
Korea, Rep. of	3	–15	–48	96	11	47	56
Kuwait	3	0	–7	15	9	19	19
Kyrgyz Republic	0.1	0.2	–0.2	0.7	0.2	1.1	–13
Latvia	–0.5	0.0	–1.9	3.2	–0.2	0.5	81
Lebanon	0.0	0.0	–3.0	1.9	0.9	–0.3	110
Libya	0.8	0.0	–3.0	1.8	4.2	3.7	37
Lithuania	–0.1	–0.1	–3.1	5.0	–0.3	1.3	72
Luxembourg	–0.1	0.8	0.5	1.4	0.5	3.1	–63
Macedonia, FYR	–0.28	–0.31	–0.71	0.74	0.10	–0.46	155
Malaysia	0	2	–3	21	12	32	3
Malta	–0.09	0.00	0.11	0.08	0.08	0.18	–11

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Mexico	–13	5	11	25	20	46	–4
Moldova	0.0	–0.2	–1.5	2.8	–0.5	0.6	74
Mongolia	–0.1	0.0	–1.8	2.3	0.6	1.0	66
Morocco	1	0	–1	6	2	8	3
Mozambique	0.09	0.01	–0.29	0.37	0.17	0.35	36
Namibia	0.02	0.15	0.14	0.38	0.18	0.87	–56
Nepal	–0.06	–0.48	–0.14	0.20	0.31	–0.18	135
Netherlands	–2.2	–1.4	–0.9	8.3	4.2	8	36
New Zealand	5.4	–1.0	–6.9	3.7	2.4	4	39
Nicaragua	0.05	–0.31	0.19	0.34	0.26	1	13
Nigeria	–1	4	–7	8	6	11	25
Norway	–5.0	2.9	–0.7	2.9	1.1	1.2	71
Oman	–1.2	0.0	3.2	4.2	1.1	7.3	–39
Pakistan	0	2	–7	14	13	22	20
Panama	0.8	–0.1	–1.3	0.7	0.5	0.6	50
Paraguay	–0.01	0.04	–0.39	0.05	0.35	0.0	91
Peru	0.5	–0.4	–3.6	4.3	1.7	2.5	58
Philippines	–2.0	0.2	–13.1	9.1	7.2	1.4	92
Poland	–11	4	–41	53	–2	2	95
Portugal	–0.8	–1.6	–0.7	1.2	1.8	0.0	101
Romania	2	–1	–19	28	–3	6	77
Russian Federation	–44	–20	–370	508	–32	43	91
Saudi Arabia	–4	0	21	23	32	72	–32
Senegal	0.00	0.26	–0.32	0.34	0.53	0.82	6
Serbia	–2	2	–1	13	–1	11	9
Singapore	–6.5	0.0	0.2	7.8	2.3	3.7	63
Slovak Republic	0.28	–1.30	–7.73	8.98	0.00	0.23	97
Slovenia	0.0	–0.5	–1.4	2.7	0.1	0.9	67
South Africa	–11	6	–11	41	20	45	26
Spain	–2	9	–4	28	23	52	–4
Sri Lanka	–0.2	0.2	–0.6	1.9	0.6	1.9	22
Sudan	2.1	1.2	–0.8	1.7	0.8	5.0	–101
Sweden	–5	–1	–5	6	1	–4	156
Switzerland	0.3	–1.3	–1.2	1.6	1.4	0.8	73
Syrian Arab Republic	1.3	–0.1	–6.7	3.2	6.4	4.0	58
Tajikistan	0.1	0.1	–1.7	2.0	0.3	0.8	66
Tanzania	–0.2	0.9	0.1	0.6	0.4	1.9	–76
Thailand	–5	5	5	41	7	53	–10

Category/country	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Togo	–0.08	–0.02	0.01	–0.03	0.14	0.02	82
Trinidad and Tobago	–0.2	0.0	–2.6	8.3	0.4	5.9	32
Tunisia	–0.8	0.0	–1.9	3.3	0.9	1.5	63
Turkey	–7	6	–18	39	14	34	35
Ukraine	4	–6	–97	126	–13	13	88
United Arab Emirates	1	0	–11	10	22	23	31
United Kingdom	10	3	–74	57	12	7	89
United States	–16	–8	–539	429	271	137	80
Uruguay	0.13	–0.06	–0.35	0.29	0.01	0.03	90
Uzbekistan	1	0	–36	24	7	–5	117
Venezuela, R.B. de	7	–2	–10	5	12	12	31
Vietnam	–2	19	–3	18	4	36	–66
Yemen, Rep. of	0.4	0.1	1.9	0.8	2.4	5.5	–74
Zambia	–0.04	0.21	–0.21	0.27	0.18	0.41	8
World	63	262	–1,145	3,059	1,542	3,780	18
Transition economies	–59	–31	–620	890	–35	145	83
World exc. transition economies	103	319	–680	2,423	1,469	3,635	7
World exc. transition economies and China	–94	34	–1,002	1,305	1,377	1,620	40
Annex I countries	–92	–50	–1,120	1,449	291	477	73
Annex I countries exc. transition economies	–34	–18	–790	837	399	394	68
Top 10 emitters in 2006	191	183	–723	2,180	683	2,514	12

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations.
Note: n.a. = not applicable (GDP growth is negative).

Table B.4 Decomposition Analysis between 1994–95 and 2004–06 Based on U.S. EIA Data

million tonnes of CO_2

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Albania	–0.1	1.0	–0.3	1.7	0.0	2.4	–39
Algeria	–8	0	–24	20	13	2	95
Angola	1	–1	–3	8	4	10	17
Antigua and Barbuda	0.01	0.00	–0.07	0.12	0.11	0.16	29
Argentina	–5	1	7	12	15	29	–9
Armenia	0.3	0.0	–4.6	7.7	–0.6	2.7	61
Australia	9	2	–24	86	42	115	10
Austria	2	3	–3	13	2	17	–10
Azerbaijan	–2	–1	–42	36	4	–5	113
Bangladesh	0	0	3	10	6	19	–20
Belarus	–5	1	–37	42	–3	–2	104
Belgium	–4	–2	–15	27	5	11	64
Belize	–0.01	0.00	0.36	0.14	0.17	0.66	–114
Benin	0.0	0.0	0.8	0.2	0.5	1.6	–115
Bhutan	0.01	–0.03	–0.09	0.13	0.06	0.08	57
Bolivia	–1.5	0.3	2.3	1.1	2.0	4.2	–35
Bosnia & Herzegovina	2	2	–7	12	1	11	19
Botswana	–0.2	–0.2	–1.1	1.9	0.6	0.9	62
Brazil	–13	–1	12	33	47	79	1
Brunei Darussalam	–0.1	0.0	3.3	–0.3	1.2	4.1	–334
Bulgaria	–2	0	–13	17	–4	–1	111
Burkina Faso	–0.13	0.04	–0.04	0.26	0.27	0.40	24
Burundi	0.00	0.01	–0.02	–0.07	0.09	0.01	37
Cambodia	0.00	0.01	–0.38	0.33	0.11	0.07	84
Cameroon	–0.8	–0.7	–1.9	1.2	1.7	–0.5	117
Canada	0	35	–112	133	54	110	41
Cape Verde	0.01	0.00	0.05	0.05	0.04	0.16	–60
Central African Republic	–0.003	0.005	–0.006	–0.027	0.060	0.029	13
Chad	0.00	0.00	–0.12	0.08	0.06	0.03	79
Chile	–3	3	4	15	6	25	–16
China	–53	–42	–910	3,220	318	2,533	28
Colombia	–1.5	–0.7	–7.9	5.2	9.2	4.4	70
Comoros	0.005	0.000	0.005	0.000	0.020	0.031	–54
Congo, Dem. Rep. of	0.1	–1.1	–0.3	–0.8	0.8	–1.3	–39,012

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Congo, Rep. of	–0.6	0.4	0.6	0.3	1.0	1.6	–25
Costa Rica	–0.4	–0.7	0.0	1.2	1.1	1.2	47
Côte d'Ivoire	–0.7	0.6	0.8	–0.4	1.2	1.5	–74
Croatia	–0.2	0.1	–4.2	8.6	–0.7	3.6	54
Cyprus	–0.1	0.0	–0.8	1.7	1.0	2.0	29
Czech Republic	0	–14	–30	33	–1	–12	138
Denmark	–3	–6	–17	11	2	–13	202
Djibouti	0.00	0.00	–0.10	–0.23	0.47	0.14	44
Dominica	–0.001	–0.003	0.013	0.013	–0.001	0.021	–77
Dominican Republic	–0.5	0.0	–0.2	5.2	2.3	6.8	10
Ecuador	0.1	0.2	–1.3	3.6	3.0	5.5	15
Egypt, Arab Rep. of	–10	3	6	32	23	53	3
El Salvador	0.0	–0.1	0.7	0.6	0.9	1.9	–35
Equatorial Guinea	–4.2	0.0	1.1	5.7	0.6	3.3	48
Eritrea	–0.01	0.00	–0.43	–0.18	0.30	–0.32	362
Estonia	–1	0	–9	13	–1	2	84
Ethiopia	0.0	0.1	0.8	0.7	0.9	2.6	–57
Fiji	0.00	–0.02	0.18	0.16	0.08	0.39	–62
Finland	0	–3	–13	19	1	4	83
France	–5	–3	–41	69	20	41	54
Gabon	–0.20	–0.24	–0.93	–0.54	1.04	–0.88	275
Gambia	0.00	0.00	–0.04	0.03	0.09	0.08	32
Georgia	–0.1	–0.2	–3.5	3.6	–0.6	–0.8	126
Germany	–23	–24	–98	112	8	–24	120
Ghana	–0.1	1.6	–1.1	1.2	1.2	2.8	–16
Greece	–2	–2	–12	32	4	20	45
Grenada	0.00	0.00	0.02	0.06	0.01	0.09	–31
Guatemala	0.2	0.3	1.7	1.0	2.0	5.1	–74
Guinea	0.00	–0.13	–0.21	0.20	0.27	0.13	72
Guinea-Bissau	0.00	0.00	0.09	–0.13	0.10	0.07	n.a.
Guyana	–0.02	0.01	0.37	0.20	0.00	0.57	–177
Haiti	0.00	0.12	0.70	–0.13	0.22	0.90	–973
Honduras	0.1	0.7	1.1	0.9	1.0	3.8	–95
Hungary	–4	0	–19	25	–1	0	100
Iceland	0.07	–0.94	0.37	0.95	0.31	0.76	40
India	–23	–7	–199	463	161	395	37
Indonesia	26	–28	20	35	35	88	–26
Iran, Islamic Rep. of	–29	0	54	103	54	183	–16

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Ireland	–1	–1	–11	22	5	14	47
Israel	0	0	–2	7	13	18	10
Italy	–15	0	0	52	13	50	23
Jamaica	0.0	0.0	1.0	0.3	0.7	2.0	–103
Japan	16	8	–34	111	22	123	8
Jordan	–0.9	0.0	–0.9	3.4	4.1	5.8	24
Kazakhstan	–7	4	–50	111	–8	51	51
Kenya	0.0	0.3	0.0	0.2	2.3	2.8	–15
Kiribati	0.000	0.000	0.003	0.006	0.005	0.014	–27
Korea, Rep. of	–19	–23	–32	165	29	120	38
Kuwait	0	0	3	9	19	31	–10
Kyrgyz Republic	0.1	–1.3	–3.0	2.0	0.7	–1.6	160
Lao PDR	0.03	–0.02	–0.04	0.18	0.08	0.24	8
Latvia	–1.4	0.0	–5.2	6.7	–0.8	–0.7	112
Lebanon	0.0	0.0	–1.9	2.5	1.9	2.5	43
Lesotho	0.00	–0.06	0.04	0.03	0.03	0.04	32
Liberia	0.00	0.00	–0.43	0.36	0.21	0.15	74
Lithuania	–1	0	–10	10	–1	–2	126
Luxembourg	–1.3	0.6	–1.9	4.0	1.3	2.8	48
Macedonia, FYR	–0.7	–0.9	–1.8	1.5	0.3	–1.6	189
Madagascar	0.0	0.1	0.7	0.0	0.5	1.3	–134
Malawi	–0.01	–0.04	0.03	0.01	0.22	0.22	5
Malaysia	13	–9	10	31	27	71	–22
Mali	0.00	0.02	–0.19	0.17	0.17	0.18	48
Malta	–0.02	0.00	–0.31	0.57	0.19	0.43	43
Mauritania	–0.2	0.0	–1.2	0.2	0.9	–0.4	135
Mauritius	0.1	0.0	0.0	1.1	0.3	1.6	–15
Mexico	–8	1	–34	73	46	79	34
Moldova	–1.6	–0.4	–2.6	2.9	–1.0	–2.7	242
Mongolia	0.0	0.0	–4.4	3.0	1.0	–0.4	111
Morocco	–0.4	0.0	–2.3	8.0	4.2	9.4	22
Mozambique	0.3	–2.4	2.6	1.0	0.5	2.0	–34
Namibia	–0.1	0.0	0.6	0.4	0.4	1.3	–73
Nepal	–0.2	0.0	0.8	0.4	0.5	1.5	–80
Netherlands	12	–4	–30	51	13	43	34
New Zealand	0.1	3.3	–8.4	6.9	4.1	6.0	46
Nicaragua	0.1	0.3	0.0	0.9	0.6	1.8	–29
Niger	–0.01	0.00	–0.29	–0.02	0.43	0.11	74

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Nigeria	–23	–1	–20	19	26	1	97
Norway	–0.1	2.7	–7.3	9.4	2.5	7.2	39
Oman	0	0	7	6	3	15	–77
Pakistan	–6	4	–8	17	25	31	25
Panama	–0.2	–0.5	–4.8	3.4	2.6	0.7	89
Papua New Guinea	0.0	0.2	1.5	–0.8	0.9	1.8	–1,719
Paraguay	0.0	0.1	0.2	–0.2	0.7	0.8	–64
Peru	–0.1	–0.8	–3.5	5.9	3.6	5.1	46
Philippines	0	–2	–7	13	14	18	33
Poland	–21	1	–144	136	–3	–32	124
Portugal	–2	2	1	11	3	15	–9
Romania	1	–7	–43	31	–5	–23	190
Russian Federation	–36	–19	–552	693	–56	29	95
Rwanda	0.0	0.0	–0.5	0.3	0.4	0.1	84
Samoa	0.00	0.00	–0.03	0.05	0.01	0.03	50
Saudi Arabia	3	0	68	23	70	164	–76
Senegal	0.0	–0.1	–0.1	0.8	1.2	1.8	10
Seychelles	0.01	0.00	0.22	0.07	0.07	0.38	–159
Sierra Leone	0.02	0.00	–0.04	0.11	0.29	0.38	4
Singapore	–8	0	–3	36	21	46	19
Slovak Republic	–3	–2	–16	17	0	–4	120
Slovenia	0.1	–0.3	–4.1	6.3	0.1	2.1	68
Solomon Islands	0.00	0.00	0.04	–0.06	0.05	0.03	n.a.
South Africa	–2	2	–39	57	72	90	30
Spain	–5	13	7	82	30	128	–14
Sri Lanka	–0.1	1.5	–0.5	3.5	0.8	5.2	–20
St. Kitts and Nevis	0.00	0.00	–0.01	0.03	0.02	0.04	19
St. Lucia	0.00	0.00	0.11	0.04	0.03	0.18	–149
St. Vincent and the Grenadines	0.00	0.00	0.00	0.06	0.01	0.08	–12
Sudan	0.0	0.7	2.2	2.8	1.6	7.4	–66
Suriname	0.01	0.16	–0.31	0.47	0.14	0.46	24
Swaziland	0.03	0.07	–0.14	0.12	0.23	0.29	15
Sweden	–1	–6	–19	17	1	–7	137
Switzerland	–0.4	0.3	–5.8	4.9	2.5	1.6	78
Syrian Arab Republic	–1	0	–4	3	12	10	35
Taiwan, China	–6	13	1	87	16	111	–8
Tajikistan	0.3	1.5	–1.6	1.9	0.7	2.8	–7

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Tanzania	–0.1	0.5	–0.1	0.9	0.9	2.0	–12
Thailand	–10	1	46	36	17	90	–69
Togo	0.0	0.3	1.0	0.0	0.4	1.7	–309
Tonga	0.001	0.000	–0.002	0.017	0.005	0.022	4
Trinidad and Tobago	–6	0	3	19	1	17	15
Tunisia	–1.2	–0.1	–1.3	6.7	2.1	6.2	29
Turkey	–13	10	–3	49	29	72	8
Uganda	0.02	0.04	–0.25	0.43	0.41	0.65	23
Ukraine	–11	–15	–136	134	–33	–60	160
United Arab Emirates	–4	0	–24	8	62	41	41
United Kingdom	–14	11	–153	143	22	8	95
United States	55	19	–1,255	1,171	598	588	67
Uruguay	0.0	0.9	–0.2	0.6	0.2	1.5	–107
Uzbekistan	–3	1	–30	34	15	18	64
Vanuatu	0.001	0.000	0.022	–0.006	0.018	0.035	–182
Venezuela, R.B. de	–1	–5	4	–1	26	23	8
Vietnam	–4	5	14	31	7	53	–37
Yemen, Rep. of	–0.8	0.0	1.1	2.4	4.2	6.9	–4
Zambia	0.01	0.00	–0.33	0.29	0.48	0.44	43
World	82	180	–3,080	5,591	3,265	6,037	32

Sources: U.S. EIA 2009, World Bank 2009, and authors' calculations.
Note: n.a. = not applicable (GDP growth is negative).

Table B.5 Decomposition Analysis between 1994–96 and 1999–2001 Based on U.S. EIA Data

million tonnes of CO_2

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Albania	–0.02	0.52	–0.17	0.77	–0.06	1.05	–47
Algeria	–2	0	–14	6	6	–3	125
Angola	0.9	0.2	–1.5	2.2	1.5	3.3	11
Antigua and Barbuda	0.00	0.00	–0.06	0.03	0.06	0.03	62
Argentina	–4	1	5	4	7	13	–20
Armenia	0.4	0.1	–1.3	2.4	–0.4	1.2	41
Australia	8	2	–6	48	19	71	–6
Austria	0.8	–1.1	–2.9	8.0	0.6	5.4	37
Azerbaijan	10	0	–25	10	2	–2	117
Bahrain	0.0	0.0	0.8	1.6	2.1	4.6	–21
Bangladesh	0.0	0.0	1.6	3.9	2.5	8.0	–25
Belarus	–4	0	–17	17	–1	–6	136
Belgium	–4	–2	–6	17	2	7	64
Belize	0.0	0.0	0.2	0.1	0.1	0.4	–207
Benin	0.0	0.0	0.3	0.1	0.2	0.6	–86
Bhutan	0.01	0.03	–0.06	0.06	0.02	0.06	28
Bolivia	–0.8	–0.1	0.6	0.5	0.9	1.0	28
Bosnia & Herzegovina	1.6	1.4	–5.2	8.5	0.7	7.0	24
Botswana	–0.1	–0.1	–0.5	1.0	0.4	0.7	49
Brazil	–9	7	26	7	24	55	–79
Brunei Darussalam	0.0	0.0	0.3	–0.2	0.4	0.6	–134
Bulgaria	0.3	–1.2	–2.3	1.9	–2.1	–3.4	n.a.
Burkina Faso	–0.04	0.03	0.11	0.15	0.13	0.37	–34
Burundi	0.00	0.01	0.03	–0.05	0.03	0.02	n.a.
Cambodia	0.00	0.03	–0.19	0.13	0.06	0.03	85
Cameroon	–0.3	–0.7	–1.2	0.7	0.8	–0.6	135
Canada	–1	26	–78	80	25	52	51
Cape Verde	–0.01	0.00	0.00	0.03	0.02	0.03	31
Central African Republic	0.00	0.00	–0.02	0.01	0.03	0.03	33
Chad	0.00	0.00	–0.01	0.00	0.03	0.02	46
Chile	–2	4	4	7	3	16	–56
China	–94	–35	–975	1,088	139	123	90
Colombia	–1.4	1.6	–0.8	–1.9	4.9	2.4	20
Comoros	0.005	0.000	0.002	–0.001	0.009	0.015	–80

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Congo, Dem. Rep. of	0.1	–0.6	0.0	–0.9	0.4	–1.1	n.a.
Congo, Rep. of	0.3	0.0	–0.6	–0.1	0.4	0.0	93
Costa Rica	–0.2	–0.6	0.3	0.6	0.6	0.7	39
Côte d'Ivoire	–0.7	0.5	1.1	0.2	0.7	1.8	–91
Croatia	0.4	0.1	–1.5	3.9	–0.5	2.3	31
Cyprus	0.0	0.0	–0.4	0.9	0.5	1.1	26
Czech Republic	2	–7	–18	10	–1	–14	259
Denmark	–7	–4	–10	7	1	–13	256
Djibouti	0.00	0.00	0.07	–0.31	0.28	0.04	n.a.
Dominica	–0.001	–0.005	0.010	0.009	–0.001	0.011	–48
Dominican Republic	–0.3	0.1	0.3	3.5	1.1	4.7	–3
Ecuador	0.2	–0.5	0.7	–0.5	1.5	1.4	–32
Egypt, Arab Rep. of	–6	0	–2	17	10	20	27
El Salvador	0.0	0.0	0.6	0.3	0.5	1.3	–69
Equatorial Guinea	–0.3	0.0	–1.5	2.3	0.2	0.8	69
Eritrea	0.02	0.00	–0.35	–0.04	0.13	–0.24	361
Estonia	–0.6	–0.1	–4.8	5.6	–0.8	–0.6	113
Ethiopia	0.0	0.2	0.5	0.2	0.4	1.3	–135
Fiji	0.00	–0.08	–0.05	0.06	0.03	–0.04	144
Finland	–2	–4	–9	11	1	–3	128
France	–3	2	–23	46	7	29	46
Gabon	0.4	–0.3	–0.8	–0.4	0.6	–0.5	390
Gambia	0.000	0.000	–0.020	0.010	0.043	0.032	39
Georgia	0.1	–0.3	–1.9	1.6	–0.3	–0.9	166
Germany	–15	–16	–78	78	6	–26	131
Ghana	–0.1	0.6	–0.4	0.4	0.5	1.0	–7
Greece	–1	0	0	13	2	14	9
Grenada	–0.01	0.00	–0.03	0.04	0.00	0.01	82
Guatemala	0.1	0.5	1.3	0.6	0.9	3.3	–126
Guinea	0.00	–0.13	–0.08	0.12	0.15	0.05	82
Guinea–Bissau	0.00	0.00	0.05	–0.07	0.05	0.03	n.a.
Guyana	0.0	0.0	0.4	0.2	0.0	0.6	–229
Haiti	0.0	0.1	0.5	0.0	0.1	0.7	–569
Honduras	0.1	0.1	0.7	0.1	0.4	1.5	–151
Hungary	–1	0	–11	12	–1	–2	114
Iceland	0.0	–0.7	0.5	0.5	0.1	0.5	26
India	–16	5	–61	182	78	188	28
Indonesia	20	–18	49	–9	17	59	–647

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Iran, Islamic Rep. of	–20	3	30	28	24	65	–26
Ireland	–1	0	–5	14	2	10	34
Israel	–1	0	2	5	7	13	–8
Italy	–9	–3	–3	40	1	25	39
Jamaica	0.0	0.0	1.2	–0.3	0.4	1.3	–1,266
Japan	1	–12	26	29	14	58	–35
Jordan	0.2	0.0	–0.7	0.6	1.9	2.0	21
Kazakhstan	1	1	–26	25	–9	–9	156
Kenya	0.0	0.8	–0.7	–0.1	1.0	1.0	–12
Kiribati	0.000	0.000	–0.007	0.007	0.002	0.002	76
Korea, Rep. of	–8	–16	4	67	18	64	24
Kuwait	–1	0	11	–5	10	16	–229
Kyrgyz Republic	–0.4	0.0	–1.1	1.2	0.5	0.0	98
Lao PDR	0.02	–0.01	0.02	0.07	0.04	0.15	–27
Latvia	–0.9	–0.1	–2.9	2.7	–0.5	–1.7	178
Lebanon	0.0	0.2	1.4	0.8	1.1	3.6	–88
Lesotho	0.00	–0.06	0.05	0.01	0.02	0.02	25
Liberia	0.0	0.0	–0.5	0.4	0.1	0.1	91
Lithuania	–0.9	–0.4	–5.8	3.7	–0.5	–4.0	227
Luxembourg	–0.9	–0.2	–2.2	2.0	0.6	–0.7	126
Macedonia, FYR	–0.2	–0.3	–1.0	0.8	0.2	–0.5	149
Madagascar	0.0	0.0	0.2	0.1	0.2	0.4	–49
Malawi	0.00	–0.04	–0.06	0.04	0.10	0.05	66
Malaysia	–4	2	3	9	13	22	–4
Mali	0.00	0.00	–0.12	0.08	0.07	0.03	78
Malta	0.0	0.0	–0.3	0.5	0.1	0.3	52
Mauritania	–0.2	0.0	–0.3	0.0	0.5	–0.1	129
Mauritius	0.1	0.1	0.2	0.6	0.2	1.1	–40
Mexico	4	–2	–29	47	25	45	37
Moldova	–1.5	–0.2	–1.5	–0.3	–0.4	–3.9	n.a.
Mongolia	0.1	0.0	–3.1	0.8	0.4	–1.8	250
Morocco	0.0	0.1	0.5	2.1	2.2	4.9	–14
Mozambique	–0.1	–1.6	1.5	0.3	0.2	0.2	55
Myanmar	0.6	0.3	–0.9	2.3	0.5	2.8	2
Namibia	0.0	0.0	0.4	0.1	0.2	0.6	–118
Nepal	0.0	0.3	1.0	0.2	0.3	1.7	–248
Netherlands	21	–2	–33	39	7	31	32
New Zealand	0	3	–3	3	2	4	10

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Nicaragua	0.0	0.4	–0.1	0.5	0.3	1.1	–36
Niger	–0.01	0.02	–0.22	–0.02	0.21	–0.02	111
Nigeria	–17	0	–8	0	12	–13	205
Norway	–1	1	–3	6	1	4	37
Oman	1	0	3	1	2	7	–116
Pakistan	0	4	–2	3	12	17	–15
Panama	–0.1	–0.3	–2.8	1.5	1.3	–0.3	111
Papua New Guinea	0.0	–0.1	0.2	–0.4	0.3	0.0	n.a.
Paraguay	0.0	0.0	0.6	–0.3	0.4	0.6	–678
Peru	0.7	–1.2	–0.8	1.5	1.9	2.0	40
Philippines	1	–3	4	4	7	14	–22
Poland	–10	0	–97	81	–1	–27	133
Portugal	–1	2	2	10	1	14	–30
Romania	1	–7	–16	–3	–2	–27	n.a.
Russian Federation	–1	–22	–169	125	–21	–89	185
Rwanda	0.00	0.03	–0.36	0.14	0.25	0.05	86
Samoa	0.00	–0.01	–0.01	0.02	0.00	0.01	72
Saudi Arabia	–12	0	28	–2	29	44	–62
Senegal	0.0	0.0	–0.3	0.3	0.5	0.6	37
Seychelles	0.00	0.00	–0.09	0.10	0.04	0.06	59
Sierra Leone	0.02	0.00	0.26	–0.23	0.08	0.12	n.a.
Singapore	–1	0	–5	13	13	20	22
Slovak Republic	–3	–2	–7	7	0	–4	158
Slovenia	0.1	–0.2	–2.2	3.3	0.0	1.0	71
Solomon Islands	0.00	0.00	0.02	–0.04	0.02	0.01	n.a.
South Africa	1	–2	–9	5	43	38	21
Spain	–1	7	12	50	7	74	–32
Sri Lanka	0.1	1.0	0.3	1.7	0.3	3.5	–72
St. Kitts and Nevis	0.00	0.00	–0.02	0.01	0.01	0.01	75
St. Lucia	0.00	0.00	0.07	0.01	0.02	0.10	–255
St. Vincent and the Grenadines	0.002	0.003	0.002	0.032	0.004	0.043	–20
Sudan	–0.3	0.2	0.6	0.9	0.6	2.0	–33
Suriname	0.0	0.1	–0.1	0.1	0.1	0.1	16
Swaziland	0.0	0.1	0.0	0.1	0.1	0.3	–48
Sweden	0	–6	–8	10	0	–4	135
Switzerland	0	–1	–1	3	1	2	56
Syrian Arab Republic	0	0	3	0	6	9	–62

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Taiwan, China	–4	8	3	45	9	60	–12
Tajikistan	0.2	1.0	0.2	–0.2	0.3	1.4	–1,385
Tanzania	0.0	–0.2	0.0	0.2	0.3	0.3	37
Thailand	–10	1	27	–5	8	21	–470
Togo	0.0	0.1	0.2	0.0	0.2	0.5	–184
Tonga	0.00	0.00	0.00	0.01	0.00	0.01	26
Trinidad and Tobago	–2	0	1	5	1	5	15
Tunisia	–1	0	1	3	1	5	–5
Turkey	–4	8	4	12	15	35	–32
Uganda	0	0	0	0	0	0	27
Ukraine	–6	–12	–24	–20	–17	–78	n.a.
United Arab Emirates	–1	0	–9	–4	31	17	37
United Kingdom	–18	1	–82	79	9	–11	113
United States	15	42	–709	731	322	401	62
Uruguay	0.0	0.3	0.8	0.3	0.1	1.5	–264
Uzbekistan	–2	0	–13	11	8	5	75
Vanuatu	0	0	0	0	0	0	–108
Venezuela, R.B. de	–3	–1	11	–6	13	13	–97
Vietnam	–3	2	4	11	3	16	–20
Yemen, Rep. of	–1	0	0	1	2	3	21
Zambia	0.0	–0.1	–0.2	0.0	0.2	–0.1	124
World	–228	–22	–2,037	2,307	1,572	1,593	59

Sources: U.S. EIA 2009, World Bank 2009, and authors' calculations
Note: n.a. = not applicable (GDP growth is negative).

Table B.6 Decomposition Analysis between 1999–2001 and 2004–06 Based on U.S. EIA Data

million tonnes of CO_2

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Albania	–0.1	0.5	–0.1	0.9	0.1	1.3	–30
Algeria	–6	0	–9	13	6	5	75
Angola	0.4	–0.9	–1.3	6.0	2.4	6.6	21
Antigua and Barbuda	0.01	0.00	–0.01	0.09	0.04	0.13	4
Argentina	–1	0	1	9	7	16	–1
Armenia	–0.1	–0.2	–3.5	5.4	–0.2	1.5	71
Australia	1	0	–19	38	24	44	29
Austria	1	4	0	4	2	11	–85
Azerbaijan	–12	–1	–18	25	2	–3	111
Bangladesh	0	0	2	6	3	11	–15
Belarus	–1	1	–18	23	–1	4	82
Belgium	0	0	–9	10	3	5	64
Belize	–0.01	0.01	0.06	0.11	0.12	0.30	–30
Benin	0.00	0.00	0.59	0.07	0.32	0.98	–153
Bhutan	0.00	–0.06	–0.03	0.08	0.04	0.02	81
Bolivia	–0.6	0.5	1.7	0.6	1.0	3.2	–102
Bosnia & Herzegovina	–0.3	1.2	–0.7	3.3	0.4	3.8	–3
Botswana	–0.14	–0.09	–0.67	0.88	0.25	0.22	80
Brazil	–3	–9	–16	28	25	25	54
Brunei Darussalam	–0.2	0.0	3.0	0.0	0.6	3.5	–456
Bulgaria	–2	1	–10	15	–2	2	85
Burkina Faso	–0.10	0.01	–0.18	0.13	0.17	0.03	91
Burundi	0.000	–0.001	–0.046	–0.019	0.062	–0.004	110
Cambodia	0.00	–0.02	–0.19	0.20	0.05	0.04	82
Cameroon	–0.45	–0.05	–0.68	0.47	0.78	0.06	95
Canada	1	8	–31	51	29	58	27
Cape Verde	0.02	0.00	0.06	0.02	0.02	0.13	–189
Central African Republic	0.000	0.000	0.011	–0.038	0.026	–0.001	n.a.
Chad	0.00	0.00	–0.11	0.09	0.03	0.01	88
Chile	–1	–1	0	9	3	10	23
China	76	5	426	1,771	131	2,409	–27
Colombia	–0.1	–2.4	–7.3	7.3	4.4	2.0	83
Comoros	0.000	0.000	0.003	0.001	0.011	0.016	–33
Congo, Dem. Rep. of	0.05	–0.45	–0.24	0.07	0.37	–0.18	141
Congo, Rep. of	–1.0	0.3	1.3	0.4	0.5	1.5	–83

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Costa Rica	–0.24	–0.11	–0.30	0.63	0.52	0.50	56
Côte d'Ivoire	–0.02	0.12	–0.35	–0.67	0.57	–0.34	–259
Croatia	–0.6	0.0	–2.9	4.9	–0.1	1.3	72
Cyprus	–0.03	0.00	–0.41	0.84	0.51	0.91	33
Czech Republic	–2	–7	–11	22	0	2	90
Denmark	3.2	–1.9	–6.0	3.4	0.8	–0.4	110
Djibouti	0.00	0.00	–0.18	0.09	0.19	0.10	63
Dominica	0.000	0.002	0.003	0.004	0.001	0.011	–125
Dominican Republic	–0.3	–0.2	–0.6	1.8	1.3	2.1	33
Ecuador	–0.1	0.7	–2.1	4.3	1.3	4.2	26
Egypt, Arab Rep. of	–4	3	8	13	13	33	–28
El Salvador	0.02	–0.18	0.08	0.25	0.43	0.61	11
Equatorial Guinea	–4.6	0.0	4.2	2.5	0.4	2.5	12
Eritrea	–0.03	0.00	–0.08	–0.13	0.16	–0.08	364
Estonia	–0.2	0.0	–4.0	7.1	–0.3	2.6	62
Ethiopia	0.0	–0.2	0.2	0.7	0.5	1.3	–3
Fiji	0.00	0.08	0.23	0.09	0.03	0.43	–254
Finland	1.3	1.6	–3.6	6.8	0.7	6.8	9
France	–3	–4	–18	23	14	12	67
Gabon	–0.59	0.01	–0.16	–0.10	0.43	–0.41	223
Gambia, The	0.000	0.000	–0.016	0.016	0.044	0.044	26
Georgia	–0.2	0.1	–1.4	1.8	–0.2	0.1	96
Germany	–7	–8	–19	33	3	2	94
Ghana	0.0	1.1	–0.7	0.8	0.7	1.8	–23
Greece	–1	–2	–12	20	2	6	74
Grenada	0.009	0.000	0.060	0.005	0.009	0.084	–476
Guatemala	0.1	–0.3	0.4	0.4	1.3	1.8	–11
Guinea	0.00	0.00	–0.12	0.07	0.12	0.08	59
Guinea–Bissau	0.002	0.000	0.048	–0.058	0.056	0.049	n.a.
Guyana	–0.009	0.001	–0.050	0.023	0.010	–0.026	178
Haiti	0.00	0.04	0.21	–0.17	0.13	0.21	n.a.
Honduras	0.0	0.6	0.3	0.8	0.6	2.3	–62
Hungary	–2.7	–0.2	–7.8	13.0	–0.7	1.6	87
Iceland	0.02	–0.24	–0.13	0.47	0.18	0.30	54
India	–6	–14	–146	289	83	207	45
Indonesia	6	–10	–35	50	19	29	58
Iran, Islamic Rep. of	–5	–5	21	77	29	117	–10
Ireland	0.2	–1.0	–7.2	8.0	3.8	3.8	68

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Israel	1.1	0.0	–4.4	2.5	6.3	5.6	37
Italy	–6	3	3	11	13	25	–4
Jamaica	–0.05	–0.03	–0.21	0.68	0.26	0.65	31
Japan	15	21	–62	83	8	65	29
Jordan	–1.2	0.0	–0.1	3.0	2.1	3.8	25
Kazakhstan	–7	2	–18	79	3	59	28
Kenya	0.1	–0.6	0.8	0.4	1.2	1.8	–16
Kiribati	–0.001	0.000	0.012	–0.002	0.003	0.012	–5,676
Korea, Rep. of	–12	–7	–38	102	12	56	50
Kuwait	1	0	–12	17	9	15	42
Kyrgyz Republic	0.4	–1.3	–2.0	0.9	0.3	–1.6	233
Lao PDR	0.01	–0.01	–0.07	0.12	0.04	0.09	42
Latvia	–0.4	0.1	–1.9	3.4	–0.3	1.0	68
Lebanon	0.0	–0.3	–3.7	1.9	1.0	–1.1	139
Lesotho	0.001	0.003	–0.017	0.023	0.011	0.020	40
Liberia	0.00	0.00	0.17	–0.14	0.06	0.10	n.a.
Libya	2	–1	4	2	5	12	–69
Lithuania	–0.4	0.0	–3.2	5.5	–0.4	1.6	69
Luxembourg	–0.2	0.8	0.6	1.6	0.6	3.5	–59
Macedonia, FYR	–0.5	–0.6	–0.8	0.7	0.1	–1.1	233
Madagascar	0.02	0.09	0.54	–0.07	0.30	0.88	–282
Malawi	0.00	0.00	0.10	–0.04	0.11	0.17	–130
Malaysia	19	–13	7	22	13	49	–36
Maldives	0.00	0.00	0.07	0.13	0.04	0.25	–45
Mali	0.00	0.02	–0.05	0.08	0.09	0.15	16
Malta	0.02	0.00	–0.05	0.10	0.10	0.16	17
Mauritania	–0.02	–0.01	–0.89	0.22	0.44	–0.26	139
Mauritius	0.05	–0.02	–0.17	0.55	0.17	0.58	19
Mexico	–12	3	–4	26	21	33	28
Moldova	0.0	–0.1	–0.7	2.5	–0.4	1.2	42
Mongolia	–0.1	0.0	–0.9	1.9	0.5	1.3	43
Morocco	–0.4	–0.1	–3.1	6.2	2.0	4.6	44
Mozambique	0.5	0.2	0.3	0.6	0.3	1.8	–123
Namibia	–0.04	0.04	0.20	0.35	0.16	0.72	–39
Nepal	–0.24	–0.36	–0.15	0.20	0.32	–0.22	143
Netherlands	–10	–2	5	12	6	11	39
New Zealand	0.2	0.8	–5.8	4.0	2.6	1.8	73
Nicaragua	0.13	–0.17	0.17	0.38	0.28	0.78	–18

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Niger	0.00	–0.02	–0.06	–0.01	0.21	0.13	38
Nigeria	–4	0	–10	17	12	15	49
Norway	0.5	2.0	–4.6	3.6	1.3	2.8	43
Oman	–0.8	0.0	3.5	4.6	1.2	8.4	–47
Pakistan	–6	–1	–7	15	14	14	51
Panama	–0.1	–0.2	–1.8	1.8	1.2	1.0	68
Papua New Guinea	0.1	0.3	1.2	–0.2	0.4	1.8	–677
Paraguay	0.02	0.05	–0.36	0.05	0.36	0.13	70
Peru	–0.8	0.5	–2.7	4.4	1.7	3.1	49
Philippines	–1	1	–13	10	8	4	75
Poland	–10	0	–46	53	–2	–5	110
Portugal	–0.9	–0.6	–0.7	1.3	1.9	1.0	70
Romania	0	0	–24	30	–3	3	88
Russian Federation	–35	4	–366	549	–34	117	77
Rwanda	0.00	–0.02	–0.17	0.13	0.10	0.05	81
Samoa	0.001	0.002	–0.012	0.026	0.005	0.022	29
Saudi Arabia	18	0	37	28	38	121	–83
Senegal	0.0	–0.1	0.3	0.4	0.6	1.2	–19
Seychelles	0.01	0.00	0.35	–0.06	0.02	0.32	n.a.
Sierra Leone	0.00	0.00	–0.36	0.40	0.21	0.26	57
Singapore	–7	0	3	23	7	26	15
Slovak Republic	0.7	–0.7	–8.3	9.2	0.0	0.9	90
Slovenia	0.1	–0.2	–1.9	3.1	0.1	1.1	65
Solomon Islands	0.001	0.000	0.017	–0.014	0.024	0.028	–179
South Africa	–3	5	–31	55	27	52	36
Spain	–4	6	–6	32	26	54	7
Sri Lanka	–0.3	0.4	–1.0	2.0	0.6	1.8	32
St. Kitts and Nevis	0.000	0.000	0.010	0.012	0.009	0.031	–47
St. Lucia	0.000	0.000	0.032	0.031	0.018	0.081	–65
St. Vincent and the Grenadines	–0.001	0.001	0.000	0.028	0.005	0.033	0
Sudan	0.4	0.5	1.7	1.8	0.9	5.3	–98
Suriname	0.02	0.09	–0.24	0.41	0.06	0.35	27
Swaziland	0.00	0.00	–0.17	0.07	0.09	0.00	103
Sweden	–1	0	–10	7	1	–3	139
Switzerland	–0.1	1.4	–4.8	1.8	1.6	–0.2	107
Syrian Arab Republic	–1.4	–0.4	–7.9	3.4	6.8	0.5	95
Taiwan, China	–2	5	–2	43	7	51	–2

Country/region	C_{eff}	S_{eff}	I_{eff}	G_{eff}	P_{eff}	ΔE	X (%)
Tajikistan	0.1	0.4	–2.0	2.5	0.4	1.4	52
Tanzania	–0.1	0.8	–0.2	0.7	0.5	1.6	–43
Thailand	2	0	15	44	8	69	–33
Togo	0.0	0.1	0.9	–0.1	0.2	1.2	–537
Tonga	0.001	0.000	0.001	0.008	0.003	0.013	–20
Trinidad and Tobago	–4	0	2	13	1	12	15
Tunisia	–0.6	–0.1	–2.5	3.6	1.0	1.4	70
Turkey	–10	1	–9	40	14	36	33
Uganda	0.01	0.10	–0.20	0.24	0.23	0.38	19
Ukraine	–4	–3	–100	138	–14	17	86
United Arab Emirates	–4	0	–16	14	30	24	44
United Kingdom	4	10	–70	61	13	19	74
United States	42	–25	–555	444	281	187	74
Uruguay	0.0	0.7	–1.1	0.3	0.0	0.0	105
Uzbekistan	–1	0	–17	23	7	13	57
Vanuatu	0.000	0.000	0.016	–0.005	0.011	0.022	–277
Venezuela, R.B. de	3	–4	–7	6	13	10	48
Vietnam	0	2	10	19	4	36	–53
Yemen, Rep. of	–0.1	0.0	1.3	0.8	2.3	4.2	–40
Zambia	0.01	0.08	–0.11	0.31	0.21	0.49	4
World	342	211	–886	3,177	1,601	4,445	7

Sources: U.S. EIA 2009, World Bank 2009, and authors' calculations.
Note: n.a. = not applicable (GDP growth is negative).

Table B.7 Ratio of Offsetting Coefficients Calculated Using IEA and U.S. EIA Data

Country/region	1994–96 to 2004–06	1994–96 to 1999–2001	1999–2001 to 2004–06
Albania	1.0	1.6	–0.1
Algeria	0.1	0.1	0.1
Angola	1.2	2.2	0.8
Argentina	–1.4	–0.6	–17
Armenia	1.0	1.3	1.0
Australia	2.0	–2.3	0.9
Austria	–0.6	1.5	0.8
Azerbaijan	0.9	1.3	0.8
Bahrain	—	–0.5	—
Bangladesh	1.0	0.8	1.4
Belarus	1.0	1.0	0.9
Belgium	1.9	1.5	2.4
Benin	2.6	4.4	1.3
Bolivia	0.8	2.5	1.3
Bosnia & Herzegovina	–1.0	–1.0	–0.5
Botswana	0.9	0.9	0.9
Brazil	–19.3	1.8	0.9
Brunei Darussalam	–0.1	–1.0	0.1
Bulgaria	1.4	n.a.	0.9
Cambodia	—	—	0.1
Cameroon	0.5	0.6	0.3
Canada	1.2	0.8	2.4
Chile	–0.4	0.7	2.3
China	1.4	1.0	0.4
Colombia	1.2	1.6	1.2
Congo, Dem. Rep. of	n.a.	n.a.	0.4
Congo, Rep. of	3.9	0.3	2.0
Costa Rica	1.0	1.9	0.2
Côte d'Ivoire	4.0	3.1	0.6
Croatia	0.5	0.3	0.6
Cyprus	0.9	1.1	0.8
Czech Republic	0.8	0.6	1.0
Denmark	1.0	1.0	1.1

Country/region	1994–96 to 2004–06	1994–96 to 1999–2001	1999–2001 to 2004–06
Dominican Republic	1.7	5.2	2.2
Ecuador	–1.0	2.7	0.0
Egypt, Arab Rep. of	–9.0	–0.3	2.1
El Salvador	0.2	0.3	1.2
Eritrea	0.8	0.9	0.5
Estonia	1.3	1.3	1.3
Ethiopia	0.8	0.5	7.8
Finland	1.1	1.0	1.6
France	1.3	1.2	1.3
Gabon	–1.1	–0.8	–1.4
Georgia	1.6	2.1	1.1
Germany	1.2	1.2	1.2
Ghana	4.4	22	0.1
Greece	0.9	2.3	0.8
Guatemala	1.1	1.0	2.9
Haiti	1.2	1.2	n.a.
Honduras	0.8	0.7	0.9
Hong Kong, China	–0.9	0.3	–2.6
Hungary	1.1	1.1	1.1
Iceland	2.2	3.6	1.4
India	0.9	0.8	1.0
Indonesia	3.7	1.4	0.2
Iran, Islamic Rep. of	0.3	0.4	0.0
Ireland	1.3	1.5	1.2
Israel	1.5	–2.7	0.2
Italy	1.1	1.1	1.9
Jamaica	1.5	1.1	0.0
Japan	7.0	–1.3	2.0
Jordan	0.8	0.6	0.9
Kazakhstan	1.9	2.5	1.3
Kenya	0.3	3.0	–1.2
Korea, Rep. of	1.1	1.0	1.1
Kuwait	1.2	0.6	0.5
Kyrgyz Republic	0.7	2.1	–0.1
Latvia	1.1	1.1	1.2

Country/region	1994–96 to 2004–06	1994–96 to 1999–2001	1999–2001 to 2004–06
Lebanon	1.0	0.5	0.8
Libya	—	—	–0.5
Lithuania	0.9	0.9	1.0
Luxembourg	1.1	1.1	1.1
Macedonia, FYR	0.8	1.1	0.7
Malaysia	1.2	15.1	–0.1
Malta	1.7	1.9	–0.7
Mexico	0.9	1.3	–0.2
Moldova	1.2	n.a.	1.7
Mongolia	0.9	0.7	1.5
Morocco	–0.4	2.2	0.1
Mozambique	–1.3	1.0	–0.3
Myanmar	—	29	—
Namibia	0.1	–0.4	1.4
Nepal	0.5	0.7	0.9
Netherlands	2.5	3.2	0.9
New Zealand	–0.4	–9.5	0.5
Nicaragua	0.8	1.2	–0.7
Nigeria	–0.1	–0.4	0.5
Norway	1.7	1.8	1.7
Oman	0.9	1.0	0.8
Pakistan	–0.1	2.3	0.4
Panama	0.2	–0.1	0.7
Paraguay	–0.7	0.3	1.3
Peru	1.0	0.6	1.2
Philippines	1.7	–0.5	1.2
Poland	1.0	1.1	0.9
Portugal	–0.3	0.8	1.4
Romania	1.0	n.a.	0.9
Russian Federation	1.1	1.0	1.2
Saudi Arabia	0.6	1.2	0.4
Senegal	–4.3	–2.4	–0.3
Singapore	4.5	4.8	4.1
Slovak Republic	0.9	0.8	1.1
Slovenia	0.9	0.8	1.0

Country/region	1994–96 to 2004–06	1994–96 to 1999–2001	1999–2001 to 2004–06
South Africa	1.2	2.4	0.7
Spain	0.4	0.2	–0.5
Sri Lanka	2.1	1.5	0.7
Sudan	0.5	–1.0	1.0
Sweden	1.2	1.2	1.1
Switzerland	1.0	1.4	0.7
Syrian Arab Republic	0.5	0.7	0.6
Tajikistan	–13	–0.4	1.3
Tanzania	1.5	2.0	1.7
Thailand	0.7	1.1	0.3
Togo	0.0	0.3	–0.2
Trinidad and Tobago	0.2	–3.2	2.1
Tunisia	1.3	–3.1	0.9
Turkey	1.5	0.8	1.1
Ukraine	1.1	n.a.	1.0
United Arab Emirates	0.7	0.8	0.7
United Kingdom	1.0	0.9	1.2
United States	1.0	0.9	1.1
Uruguay	0.4	0.5	0.9
Uzbekistan	1.3	0.5	2.0
Venezuela, R.B. de	1.4	0.4	0.7
Vietnam	1.5	2.2	1.2
Yemen, Rep. of	12	–1.9	1.8
Zambia	1.6	1.6	1.9
World	1.2	1.0	2.6

Sources: IEA 2009a and 2009b, U.S. EIA 2009, World Bank 2009, and authors' calculations.
Note: — = not available, n.a. = not applicable (GDP growth is negative).

Table B.8 Percentage of Countries with Positive Coefficients in Five-Factor Decomposition Based on U.S. EIA Data

Period and offset	Low income	Lower middle income	Upper middle income	High income	Annex I	Total[a]
			Number of countries			
Full period	36	45	39	42	38	162
Subperiod 1	35	41	37	42	35	156
Subperiod 2	34	46	39	43	38	161
All three periods	31	40	36	42	35	149
			Percentage of countries			
Positive offset						
Full period	58	56	67	83	92	66
Subperiod 1	60	46	59	77	86	61
Subperiod 2	59	59	74	86	92	70
All three periods	42	30	47	71	77	48
Offset ≥ 50%						
Full period	28	20	36	36	61	30
Subperiod 1	37	22	38	42	57	35
Subperiod 2	41	33	44	48	71	41
All three periods	23	8	25	29	49	21
Offset ≥ 100%						
Full period	8	13	21	14	34	14
Subperiod 1	11	12	30	23	43	19
Subperiod 2	18	7	13	7	11	11
All three periods	6	3	8	5	9	5

Sources: U.S. EIA 2009, World Bank 2009, and authors' calculations.
a. Total is the sum of low-, lower-middle-, upper-middle-, and high-income countries.

Appendix C

Results for Six-Factor Decomposition

This appendix presents the results of decomposition analysis according to identity 6 based on emissions and energy consumption data from the IEA for the full period and the two subperiods.

Table C.1 Six-Factor Decomposition Analysis between 1994–96 and 2004–06 Based on IEA Data
million tonnes of CO_2

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Albania	–0.2	0.9	–0.2	0.1	1.5	0.0	2.1
Algeria	2	0	–7	3	16	11	24
Angola	0.8	0.9	–0.4	–2.3	3.1	1.6	3.7
Argentina	–2	2	–4	1	12	14	22
Armenia	–0.1	–0.2	–0.4	–1.0	3.0	–0.2	1.0
Australia	21	2	18	–64	82	40	99
Austria	1	–2	–1	2	12	2	13
Azerbaijan	–1	0	5	–35	27	3	–1
Bangladesh	0	5	2	–4	9	5	17
Belarus	–4	–1	1	–35	41	–3	–1
Belgium	–10	–4	0	–16	21	4	–5
Benin	0.1	1.8	0.0	–0.2	0.2	0.4	2.2
Bolivia	0.1	0.7	2.0	–1.9	1.1	2.0	3.9
Bosnia & Herzegovina	0	2	4	–4	10	1	12
Botswana	–0.1	0.3	–0.2	–1.4	1.9	0.6	1.1
Brazil	7	–2	0	13	28	41	88
Brunei Darussalam	–0.2	0.0	–0.2	0.2	–0.3	1.2	0.7
Bulgaria	3	–4	0	–20	17	–4	–7
Cameroon	–0.06	–0.06	0.07	–0.57	0.48	0.65	0.51
Canada	–11	16	8	–99	119	48	82
Chile	–3	1	2	–1	14	6	19

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
China	–182	291	710	–2,154	3,132	310	2,107
Colombia	–1.6	4.4	1.7	–17.4	5.4	9.4	2.0
Congo, Dem. Rep. of	0.9	–1.2	–0.1	0.6	–0.6	0.6	0.2
Congo, Rep. of	–0.08	0.26	0.09	–0.02	0.05	0.19	0.49
Costa Rica	–0.2	–1.0	0.5	–0.3	1.2	1.1	1.3
Côte d'Ivoire	0.1	1.2	–0.8	1.5	–0.3	1.0	2.7
Croatia	1.3	–0.1	–1.2	–2.1	7.9	–0.6	5.1
Cyprus	0.6	0.0	–0.4	–0.8	1.4	0.8	1.6
Czech Republic	–2	–13	5	–25	33	–1	–3
Denmark	–3	–7	–4	–11	10	2	–12
Dominican Republic	2.0	0.7	–1.8	–2.2	5.4	2.4	6.6
Ecuador	–1.9	1.3	2.8	–1.3	3.3	2.7	6.9
Egypt, Arab Rep. of	2	2	1	9	28	21	63
El Salvador	0.0	–0.1	0.3	–0.1	0.6	0.9	1.5
Eritrea	–0.08	0.12	0.06	–0.37	–0.14	0.23	–0.17
Estonia	–1	0	0	–11	12	–1	–1
Ethiopia	0.3	1.3	0.0	–0.8	0.8	1.0	2.6
Finland	–3	–5	2	–14	21	2	3
France	–8	–10	9	–47	63	19	26
Gabon	0.20	0.09	–0.03	0.23	–0.17	0.32	0.65
Georgia	–1.2	–1.0	0.0	–4.9	4.1	–0.7	–3.7
Germany	–17	–38	–28	–85	109	8	–52
Ghana	0.3	2.0	0.2	–0.9	1.1	1.2	3.9
Greece	–3	0	–2	–8	29	4	19
Guatemala	0.7	1.3	0.0	0.3	0.9	1.9	5.1
Haiti	0.02	0.54	–0.17	0.49	–0.12	0.19	0.95
Honduras	0.2	1.3	0.4	–0.6	0.9	1.0	3.2
Hungary	–5	0	–4	–17	25	–1	–2
Iceland	–0.25	–0.64	0.41	–0.30	0.68	0.22	0.13
India	–28	98	103	–374	445	155	397
Indonesia	34	24	–9	16	34	34	133
Iran, Islamic Rep. of	–17	0	14	8	97	51	154
Ireland	–3	1	–3	–13	22	5	10
Israel	2	0	1	–6	7	12	16
Italy	–11	–9	–5	11	50	13	47
Jamaica	–0.1	0.3	–0.6	1.7	0.3	0.6	2.2
Japan	4	–6	5	–75	111	22	61
Jordan	–0.5	–0.1	–0.3	–0.4	3.1	3.7	5.6

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Kazakhstan	–16	3	17	–102	107	–7	1
Kenya	–1.0	0.9	0.5	–0.4	0.2	2.3	2.6
Korea, Rep. of	–14	–31	33	–66	156	28	107
Kuwait	4	0	3	–3	9	18	30
Kyrgyz Republic	0.1	–0.4	0.0	–2.1	1.7	0.6	–0.1
Latvia	–0.7	–0.5	–0.7	–5.2	6.3	–0.8	–1.5
Lebanon	0.2	0.0	0.9	–3.0	2.4	1.9	2.4
Lithuania	–0.5	–0.8	–0.5	–7.6	8.9	–0.9	–1.3
Luxembourg	–2.5	2.3	–0.6	–1.7	3.6	1.2	2.2
Macedonia, FYR	0.1	–0.7	–0.8	–1.4	1.5	0.3	–1.0
Malaysia	5	3	–4	9	27	24	64
Malta	–0.1	0.0	0.2	–0.6	0.5	0.2	0.2
Mexico	–18	6	44	–65	71	44	81
Moldova	–0.8	–0.6	–0.3	–4.6	3.3	–1.1	–4.2
Mongolia	–0.2	0.0	–0.3	–4.0	3.4	1.1	0.1
Morocco	1	0	1	–1	8	4	13
Mozambique	–0.10	0.24	0.02	–0.61	0.66	0.33	0.55
Namibia	0.0	0.0	0.0	0.1	0.5	0.5	1.0
Nepal	0.1	0.5	0.0	–0.2	0.4	0.5	1.2
Netherlands	–4	–5	–2	–27	36	10	7
New Zealand	9	1	–2	–5	6	4	11
Nicaragua	0.0	0.4	–0.1	0.0	0.8	0.5	1.6
Nigeria	6	3	0	–7	8	11	20
Norway	–7.9	3.9	3.6	–6.2	7.8	2.0	3.2
Oman	–2	0	2	5	5	3	14
Pakistan	0	6	0	–6	16	24	40
Panama	0.2	0.3	–0.3	–0.6	1.2	0.9	1.7
Paraguay	0.02	0.14	0.10	–0.47	–0.24	0.71	0.27
Peru	0.0	0.1	0.6	–4.8	5.6	3.5	4.9
Philippines	–1	–4	15	–24	13	14	11
Poland	–24	6	–4	–149	137	–3	–37
Portugal	–2	1	0	2	10	3	13
Romania	4	–11	–9	–32	29	–5	–24
Russian Federation	–59	–39	166	–700	643	–52	–43
Saudi Arabia	1	0	–29	64	19	58	113
Senegal	0.1	0.6	0.1	–0.2	0.6	0.9	2.1
Serbia	–2	0	–5	1	16	–2	9
Singapore	–6	0	–20	8	13	8	3

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Slovak Republic	–1	–3	0	–15	16	0	–2
Slovenia	0.0	–0.7	0.0	–2.8	5.6	0.1	2.2
South Africa	–5	2	5	–38	44	55	63
Spain	–7	16	–10	7	73	27	106
Sri Lanka	–0.2	2.2	1.0	–1.3	3.3	0.8	5.7
Sudan	–0.1	3.6	0.0	–1.8	2.9	1.6	6.1
Sweden	–7	–4	3	–18	15	1	–10
Switzerland	–0.1	–2.1	–0.5	–2.3	4.4	2.2	1.6
Syrian Arab Republic	–1	0	6	–8	3	11	12
Tajikistan	0.3	–0.2	–0.4	–1.9	1.8	0.7	0.3
Tanzania	0.3	–0.1	0.5	–0.4	0.9	0.8	2.0
Thailand	–14	11	4	24	33	16	74
Togo	0.1	–0.1	0.0	0.0	0.0	0.3	0.3
Trinidad and Tobago	–1	0	–2	3	11	1	11
Tunisia	–0.8	0.1	0.0	–2.3	6.2	1.9	5.1
Turkey	–6	12	–2	–13	49	29	68
Ukraine	–13	–16	–7	–129	124	–31	–71
United Arab Emirates	3	0	15	–34	6	46	36
United Kingdom	–2	4	–4	–143	131	20	5
United States	–7	14	–126	–997	1,124	574	582
Uruguay	0.0	0.3	0.5	–0.5	0.5	0.1	0.9
Uzbekistan	–2	0	–1	–39	34	15	7
Venezuela, R.B. de	11	–3	–9	–1	–1	24	21
Vietnam	–3	30	3	–11	28	6	53
Yemen, Rep. of	0.4	0.2	0.6	2.3	2.3	4.1	9.9
Zambia	–0.1	–0.1	0.0	–0.3	0.3	0.4	0.2
World	–160	209	716	–4,039	5,390	3,147	5,263

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations
Note: n.a. = not applicable (GDP growth is negative).

Table C.2 Six-Factor Decomposition Analysis between 1994–96 and 1999–2001 Based on IEA Data

million tonnes of CO_2

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Albania	0.0	0.5	–0.2	0.2	0.7	–0.1	1.2
Algeria	–0.6	0.1	0.7	–1.9	4.8	4.8	8.0
Angola	0.2	0.2	0.0	–0.8	0.8	0.6	1.1
Argentina	–3.8	0.8	–0.7	2.3	3.7	7.1	9.4
Armenia	–0.10	–0.15	0.38	–0.57	0.96	–0.15	0.37
Australia	16	–1	7	–31	46	18	56
Austria	–0.2	–1.0	–1.8	–1.4	7.5	0.5	3.7
Azerbaijan	0.8	–0.1	4.3	–18.2	7.2	1.4	–4.7
Bahrain	0.3	0.0	0.9	–1.6	1.2	1.5	2.4
Bangladesh	0.1	2.3	0.9	–2.1	3.4	2.2	6.8
Belarus	–2.2	–1.2	–1.2	–16.4	16.1	–1.1	–6.1
Belgium	–4.4	–2.9	–0.6	–6.2	13.5	1.3	0.8
Benin	0.0	1.0	0.0	–0.2	0.1	0.1	1.0
Bolivia	–1.4	0.4	1.3	–1.2	0.5	0.8	0.4
Bosnia & Herzegovina	0.9	1.5	3.1	–3.8	6.6	0.5	8.9
Botswana	–0.1	0.2	–0.2	–0.5	1.0	0.4	0.8
Brazil	4	17	–3	19	6	20	64
Brunei Darussalam	–0.50	0.00	0.11	–0.05	–0.24	0.56	–0.12
Bulgaria	2	–4	2	–11	2	–2	–10
Cameroon	–0.03	–0.16	0.01	–0.28	0.27	0.31	0.13
Canada	2	21	3	–66	73	23	57
Chile	–4	3	1	4	7	3	14
China	–92	7	221	–1,291	1,106	142	92
Colombia	1.6	4.4	0.2	–7.2	–2.0	5.1	2.1
Congo, Dem. Rep. of	0.74	–0.92	–0.05	0.66	–0.60	0.24	0.06
Congo, Rep. of	0.034	–0.035	0.032	–0.050	–0.016	0.076	0.040
Costa Rica	–0.41	–0.48	0.49	–0.41	0.57	0.55	0.29
Côte d'Ivoire	0.5	1.3	–0.2	0.5	0.2	0.6	2.9
Croatia	1.0	0.0	–0.6	–0.6	3.4	–0.5	2.7
Cyprus	0.24	–0.02	–0.13	–0.42	0.72	0.42	0.81
Czech Republic	–0.5	–1.7	2.5	–15.1	9.8	–0.8	–5.7
Denmark	–4	–4	–3	–8	6	1	–11
Dominican Republic	1.1	0.9	–1.4	0.0	3.8	1.2	5.6
Ecuador	–0.7	0.3	0.6	0.6	–0.4	1.3	1.7
Egypt, Arab Rep. of	0	1	0	1	15	9	25

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
El Salvador	–0.10	0.07	0.21	–0.02	0.33	0.45	0.94
Eritrea	–0.01	0.08	–0.04	–0.25	–0.03	0.09	–0.15
Estonia	–0.2	–0.4	0.4	–6.6	5.3	–0.8	–2.2
Ethiopia	0.3	0.3	0.0	–0.2	0.2	0.4	1.0
Finland	–2	–6	1	–10	12	1	–4
France	0	–2	–2	–23	43	7	22
Gabon	0.02	0.00	0.00	0.10	–0.12	0.16	0.17
Georgia	–0.2	–1.2	–0.5	–3.1	1.8	–0.4	–3.6
Germany	–22	–27	6	–86	76	5	–47
Ghana	0.1	1.3	0.1	–0.2	0.4	0.5	2.3
Greece	–3	0	0	0	11	2	11
Guatemala	0.1	1.0	0.2	0.4	0.6	0.8	3.1
Haiti	0.00	0.53	–0.04	0.15	0.00	0.09	0.73
Honduras	0.0	0.8	0.0	–0.3	0.1	0.4	1.1
Hungary	–2	0	–1	–11	12	–1	–3
Iceland	–0.14	–0.48	0.24	–0.06	0.36	0.10	0.02
India	–11	49	61	–157	174	75	191
Indonesia	27	11	–13	40	–8	16	73
Iran, Islamic Rep. of	–9	1	14	–1	27	22	54
Ireland	–3	2	0	–7	15	2	8
Israel	0.8	–0.1	–1.4	–1.5	4.4	6.3	8.4
Italy	–11	–5	5	–6	38	1	22
Jamaica	–0.2	0.2	–0.1	1.3	–0.3	0.4	1.3
Japan	1	–22	–1	1	30	14	24
Jordan	0.5	0.0	–0.7	0.0	0.5	1.8	2.0
Kazakhstan	–6	1	10	–65	24	–9	–44
Kenya	–1.2	1.2	0.6	–0.2	–0.1	1.1	1.3
Korea, Rep. of	–15	–16	21	–10	63	17	60
Kuwait	1	0	4	1	–4	9	10
Kyrgyz Republic	0.0	–0.5	0.3	–2.0	0.8	0.3	–1.2
Latvia	–0.2	–0.6	–0.4	–3.1	2.6	–0.5	–2.1
Lebanon	0.2	0.0	1.0	–0.4	0.8	1.1	2.6
Lithuania	–0.3	–0.6	–0.1	–4.3	3.2	–0.5	–2.6
Luxembourg	–2.0	1.2	–0.9	–1.5	1.8	0.5	–0.9
Macedonia, FYR	0.4	–0.4	–0.1	–1.5	0.8	0.2	–0.6
Malaysia	5	1	–1	7	8	12	32
Malta	–0.05	0.00	0.10	–0.53	0.40	0.08	0.01
Mexico	–5	1	27	–57	45	24	35

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Moldova	–0.8	–0.3	2.1	–4.9	–0.4	–0.5	–4.8
Mongolia	0.0	0.0	0.4	–2.7	0.9	0.5	–0.9
Morocco	0.5	–0.1	0.3	0.5	2.0	2.0	5.2
Mozambique	–0.16	0.20	0.03	–0.31	0.29	0.15	0.20
Myanmar	0.0	0.9	0.0	–2.2	2.3	0.4	1.3
Namibia	–0.02	–0.12	–0.03	–0.01	0.09	0.24	0.16
Nepal	0.1	0.9	0.0	–0.1	0.2	0.3	1.4
Netherlands	–2	–4	–2	–26	27	5	–1
New Zealand	3.7	1.3	–1.3	0.0	2.5	1.4	7.7
Nicaragua	0.0	0.6	–0.1	–0.1	0.4	0.3	1.0
Nigeria	6.0	–0.5	–0.9	–0.2	0.1	4.9	9.3
Norway	–3.0	1.1	1.1	–3.0	4.9	1.0	2.0
Oman	–0.5	0.0	2.2	1.7	1.3	1.7	6.3
Pakistan	0	4	2	–1	3	11	18
Panama	–0.5	0.3	0.4	–0.1	0.5	0.5	1.1
Paraguay	0.04	0.10	0.01	0.00	–0.29	0.37	0.24
Peru	–0.5	0.4	–0.1	–0.6	1.5	1.8	2.5
Philippines	1	–4	8	–6	4	7	10
Poland	–11	2	1	–111	81	–1	–39
Portugal	–2	2	0	2	9	1	13
Romania	2	–9	–7	–11	–3	–1	–30
Russian Federation	–14	–19	70	–222	118	–20	–86
Saudi Arabia	4	0	–9	23	–2	25	41
Senegal	0.1	0.3	0.1	0.1	0.3	0.4	1.2
Serbia	0.6	–1.5	–3.3	0.4	2.8	–1.2	–2.2
Singapore	0.1	0.0	–11.0	0.1	5.1	5.1	–0.5
Slovak Republic	–1.2	–1.8	–0.8	–6.0	7.0	0.2	–2.5
Slovenia	0.0	–0.1	0.0	–1.4	2.9	0.0	1.3
South Africa	6	–4	–3	–18	4	33	18
Spain	–5	7	–5	6	44	6	53
Sri Lanka	0.0	1.8	0.4	–0.2	1.6	0.3	3.8
Sudan	–1.4	1.8	0.0	–0.9	0.9	0.6	1.1
Sweden	–1.2	–3.5	–0.4	–9.8	8.6	0.3	–5.9
Switzerland	–0.4	–0.7	0.1	–1.8	2.8	0.8	0.8
Syrian Arab Republic	–1.7	0.0	1.7	2.4	0.1	5.1	7.6
Tajikistan	0.15	–0.23	–0.19	–0.31	–0.25	0.34	–0.50
Tanzania	0.36	–0.74	0.03	0.00	0.19	0.31	0.13
Thailand	–8	6	4	16	–5	8	21

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Togo	0.1	–0.1	0.0	0.0	0.0	0.1	0.3
Trinidad and Tobago	–0.6	0.0	–1.8	4.2	3.3	0.4	5.4
Tunisia	–0.1	0.1	0.2	–0.8	3.1	1.1	3.5
Turkey	0	6	6	–5	12	15	33
Ukraine	–17	–9	14	–39	–18	–16	–84
United Arab Emirates	1	0	4	–10	–3	22	14
United Kingdom	–12	1	–5	–67	73	8	–2
United States	8	22	–78	–521	704	310	445
Uruguay	–0.14	0.32	0.24	0.11	0.25	0.13	0.91
Uzbekistan	–3	0	1	–6	12	9	12
Venezuela, R.B. de	4	–1	–1	1	–6	12	9
Vietnam	–1	11	1	–6	9	2	17
Yemen, Rep. of	0.1	0.1	0.7	0.3	1.4	1.8	4.4
Zambia	–0.03	–0.31	0.00	–0.06	–0.02	0.22	–0.20
World	–205	–41	263	–2,313	2,247	1,532	1,483

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations
Note: n.a. = not applicable (GDP growth is negative).

Table C.3 Six-Factor Decomposition Analysis between 1999–2001 and 2004–06 Based on IEA Data

million tonnes of CO_2

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Albania	–0.33	0.48	0.04	–0.21	0.86	0.08	0.92
Algeria	2	0	–8	5	11	6	16
Angola	0.6	0.7	–0.4	–1.5	2.3	0.9	2.7
Argentina	2	1	–4	–1	8	7	13
Armenia	0.0	–0.1	–0.9	–0.4	2.1	–0.1	0.6
Australia	5	3	11	–34	36	23	43
Austria	1.0	–1.0	0.6	3.4	3.9	1.7	9.6
Azerbaijan	–1	0	0	–15	18	1	3
Bangladesh	0	3	1	–2	5	3	10
Belarus	–2	1	2	–17	23	–1	5
Belgium	–6	–1	1	–11	8	2	–6
Benin	0.1	0.6	0.0	0.0	0.1	0.3	1.2
Bolivia	1.7	0.2	0.5	–0.4	0.6	1.0	3.6
Bosnia & Herzegovina	–1.1	1.1	–0.1	0.0	3.1	0.4	3.5
Botswana	0.1	0.1	0.0	–1.0	0.9	0.3	0.3
Brazil	3	–22	3	–8	25	22	24
Brunei Darussalam	0.36	0.00	–0.31	0.21	0.01	0.56	0.83
Bulgaria	0.6	–0.1	–1.3	–8.1	13.5	–1.8	2.9
Cambodia	–0.1	0.9	0.0	–0.8	1.1	0.3	1.3
Cameroon	0.0	0.1	0.1	–0.3	0.2	0.3	0.4
Canada	–14	–6	5	–33	47	26	25
Chile	0.6	–2.2	0.6	–5.3	8.5	3.1	5.3
China	–62	286	427	–477	1,714	127	2,015
Colombia	–3.3	0.0	1.6	–10.4	7.5	4.5	–0.2
Congo, Dem. Rep. of	0.15	–0.28	–0.02	–0.06	0.06	0.32	0.17
Congo, Rep. of	–0.13	0.31	0.05	0.05	0.08	0.09	0.45
Costa Rica	0.2	–0.5	0.0	0.1	0.6	0.5	1.0
Côte d'Ivoire	–0.5	–0.1	–0.8	1.3	–0.6	0.5	–0.2
Croatia	0.3	–0.1	–0.7	–1.5	4.6	–0.1	2.4
Cyprus	0.36	–0.02	–0.26	–0.34	0.66	0.40	0.80
Czech Republic	–1.5	–10.6	2.4	–9.7	22.8	–0.3	3.1
Denmark	0.4	–2.5	–0.4	–2.2	3.1	0.8	–0.9
Dominican Republic	1.0	–0.3	–0.5	–2.6	1.9	1.4	0.9
Ecuador	–1.1	1.0	2.2	–2.1	3.9	1.2	5.2
Egypt, Arab Rep. of	3	2	0	9	12	12	38

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
El Salvador	0.06	–0.17	0.09	–0.08	0.24	0.41	0.56
Eritrea	–0.07	0.04	0.09	–0.11	–0.10	0.13	–0.02
Estonia	–0.3	0.2	–0.7	–3.9	6.2	–0.3	1.2
Ethiopia	–0.1	1.1	0.0	–0.7	0.7	0.5	1.6
Finland	–0.5	1.6	1.3	–3.5	7.4	0.8	7.0
France	–9	–8	12	–24	21	13	4
Gabon	0.19	0.09	–0.04	0.12	–0.04	0.15	0.48
Georgia	–0.7	0.2	0.4	–1.3	1.6	–0.2	0.0
Germany	4.1	–11.7	–33.0	1.2	31.9	2.4	–5.0
Ghana	0.2	0.6	0.1	–0.9	0.9	0.7	1.6
Greece	–0.5	–0.9	–1.1	–8.3	17.7	1.5	8.4
Guatemala	0.7	0.3	–0.2	–0.3	0.4	1.2	2.0
Haiti	0.03	–0.05	–0.17	0.44	–0.16	0.13	0.22
Honduras	0.1	0.4	0.4	–0.2	0.8	0.5	2.0
Hungary	–3.0	–0.3	–2.5	–5.8	12.6	–0.7	0.2
Iceland	–0.11	–0.14	0.17	–0.24	0.31	0.12	0.11
India	–17	48	39	–222	279	80	207
Indonesia	5	14	6	–33	50	20	61
Iran, Islamic Rep. of	–6	–1	–2	10	72	27	99
Ireland	0.1	–0.2	–3.3	–6.3	7.9	3.8	2.0
Israel	1.7	–0.2	2.3	–4.3	2.2	5.7	7.5
Italy	0	–5	–11	17	11	12	25
Jamaica	0.11	0.07	–0.49	0.31	0.61	0.24	0.84
Japan	3	16	5	–77	82	8	37
Jordan	–1.1	–0.1	0.6	–0.4	2.7	1.9	3.6
Kazakhstan	–8	2	4	–23	68	3	45
Kenya	0.4	–0.5	–0.1	–0.1	0.4	1.2	1.3
Korea, Rep. of	3	–15	13	–60	96	11	47
Kuwait	3	0	–2	–5	15	9	19
Kyrgyz Republic	0.1	0.2	–0.3	0.1	0.7	0.2	1.1
Latvia	–0.5	0.0	–0.3	–1.7	3.2	–0.2	0.5
Lebanon	0.0	0.0	–0.1	–2.9	1.9	0.9	–0.3
Libya	0.8	0.0	0.9	–3.9	1.8	4.2	3.7
Lithuania	–0.1	–0.1	–0.3	–2.8	5.0	–0.3	1.3
Luxembourg	–0.1	0.8	0.4	0.1	1.4	0.5	3.1
Macedonia, FYR	–0.28	–0.31	–0.70	–0.01	0.74	0.10	–0.46
Malaysia	0	2	–4	1	21	12	32
Malta	–0.09	0.00	0.13	–0.01	0.08	0.08	0.18

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Mexico	–13	5	16	–5	25	20	46
Moldova	0.0	–0.2	–1.9	0.4	2.8	–0.5	0.6
Mongolia	–0.1	0.0	–0.7	–1.0	2.3	0.6	1.0
Morocco	0.5	0.3	0.3	–1.4	6.2	2.0	7.9
Mozambique	0.09	0.01	–0.01	–0.28	0.37	0.17	0.35
Namibia	0.02	0.15	0.01	0.13	0.38	0.18	0.87
Nepal	–0.06	–0.48	0.00	–0.14	0.20	0.31	–0.18
Netherlands	–2.2	–1.4	0.1	–1.0	8.3	4.2	7.9
New Zealand	5.4	–1.0	–0.9	–6.0	3.7	2.4	3.7
Nicaragua	0.05	–0.31	0.06	0.13	0.34	0.26	0.52
Nigeria	–0.5	4.5	0.6	–8.1	8.5	5.8	10.7
Norway	–5.0	2.9	2.5	–3.2	2.9	1.1	1.2
Oman	–1.2	0.0	–0.7	3.9	4.2	1.1	7.3
Pakistan	0	2	–2	–5	14	13	22
Panama	0.78	–0.11	–0.80	–0.47	0.72	0.49	0.61
Paraguay	–0.01	0.04	0.09	–0.49	0.05	0.35	0.04
Peru	0.5	–0.4	0.7	–4.3	4.3	1.7	2.5
Philippines	–2	0	7	–20	9	7	1
Poland	–11	4	–5	–36	53	–2	2
Portugal	–0.8	–1.6	–0.8	0.1	1.2	1.8	0.0
Romania	1.6	–1.4	–1.8	–17.3	27.7	–2.9	5.8
Russian Federation	–44	–20	92	–462	508	–32	43
Saudi Arabia	–4	0	–20	42	23	32	72
Senegal	0.00	0.26	0.01	–0.33	0.34	0.53	0.82
Serbia	–2.2	2.1	–1.2	0.3	12.5	–0.5	10.9
Singapore	–6.5	0.0	–8.0	8.3	7.8	2.3	3.7
Slovak Republic	0.3	–1.3	1.0	–8.7	9.0	0.0	0.2
Slovenia	0.0	–0.5	0.0	–1.4	2.7	0.1	0.9
South Africa	–11	6	8	–19	41	20	45
Spain	–2	9	–5	1	28	23	52
Sri Lanka	–0.2	0.2	0.8	–1.4	1.9	0.6	1.9
Sudan	2.1	1.2	–0.1	–0.7	1.7	0.8	5.0
Sweden	–5.3	–0.7	3.3	–8.3	6.2	0.9	–4.0
Switzerland	0.3	–1.3	–0.6	–0.5	1.6	1.4	0.8
Syrian Arab Republic	1	0	4	–11	3	6	4
Tajikistan	0.1	0.1	–0.2	–1.5	2.0	0.3	0.8
Tanzania	–0.2	0.9	0.5	–0.4	0.6	0.4	1.9
Thailand	–5	5	0	5	41	7	53

Country/region	C_{eff}	S_{eff}	V_{eff}	I^*_{eff}	G_{eff}	P_{eff}	ΔE
Togo	–0.08	–0.02	0.01	0.00	–0.03	0.14	0.02
Trinidad and Tobago	–0.2	0.0	–0.1	–2.5	8.3	0.4	5.9
Tunisia	–0.8	0.0	–0.3	–1.6	3.3	0.9	1.5
Turkey	–7	6	–9	–9	39	14	34
Ukraine	4	–6	–19	–79	126	–13	13
United Arab Emirates	1	0	12	–24	10	22	23
United Kingdom	10	3	1	–75	57	12	7
United States	–16	–8	–49	–490	429	271	137
Uruguay	0.13	–0.06	0.30	–0.65	0.29	0.01	0.03
Uzbekistan	1	0	–1	–35	24	7	–5
Venezuela, R.B. de	7	–2	–8	–2	5	12	12
Vietnam	–2	19	2	–4	18	4	36
Yemen, Rep. of	0.4	0.1	–0.4	2.3	0.8	2.4	5.5
Zambia	–0.04	0.21	0.00	–0.21	0.27	0.18	0.41
World	63	262	446	–1,591	3,059	1,542	3,780

Sources: IEA 2009a and 2009b, World Bank 2009, and authors' calculations
Note: n.a. = not applicable (GDP growth is negative).

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