CORRESPONDENCE:

Decomposing the 2010 global carbon dioxide emissions rebound

To the Editor — Peters *et al.*[1] show that global carbon dioxide emissions from fossil-fuel combustion, cement production and gas flaring grew faster than the historical average annual rate during 2010, negating the decrease in 2009 associated with the global financial crisis. We extend the work of Peters *et al.* by using decomposition analysis to show that the rising energy intensity of the global economy was an important factor in the 2010 emissions surge, together with an increase in the carbon intensity of the energy mix. We expect the 2010 surge to be exceptional.

The percentage change in carbon dioxide emissions from energy (emissions from fossil-fuel combustion, but excluding those from cement production and gas flaring) can be decomposed into changes in (1) gross domestic product (GDP), (2) the ratio of primary energy use to GDP (energy intensity), and (3) the ratio of carbon dioxide to primary energy use (carbon intensity of energy) (Table 1). For this decomposition, we use the latest data from the International Energy Agency[2], extended to 2010 using growth rates from BP[3], the International Monetary Fund[4] and the Organisation for Economic Co-operation and Development (OECD)[5] (Supplementary Table S1).

In 2010, global energy intensity rose after strong declines in the years leading up to the global financial crisis, and the carbon intensity of energy also increased (Fig. 1). Both factors compounded the effect of strong economic growth (global GDP rose by 5.2% during 2010). Over the previous four decades, energy intensity increased on only three occasions (1976, 1987 and 1990), and the carbon intensity of energy declined in each case. The only year in which global energy intensity increased faster than it did in 2010 was 1990, during the collapse of the Soviet Union. If energy intensity in 2010 had fallen at the long-term average of 1.3% yr^{-1} rather than growing by 0.4%, and the carbon intensity of energy had reduced at the long-term average of 0.2% yr^{-1} rather than increasing by 0.2%, then global emissions growth in 2010 would have been 3.7% instead of 5.8%.

Table 1 | Decomposition of growth in global carbon dioxide emissions from fossil fuels.

	Annual % changes in ...			
Year(s)	GDP	Energy/GDP	Carbon dioxide/energy	Carbon dioxide emissions
2010	5.2	0.4	0.2	5.8
1972–2010 average	3.5	−1.3	−0.2	2.0
Decadal averages				
1972–1980	4.1	−1.0	−0.2	2.8
1981–1990	2.9	−0.9	−0.5	1.5
1991–2000	3.2	−1.8	−0.2	1.1
2001–2010	4.0	−1.4	0.2	2.7

GDP is in constant year-2000 purchasing-power-parity-adjusted US dollars. Energy is total primary energy supply measured in tonnes of oil equivalent. Carbon dioxide emissions are those from fuel combustion, measured in tonnes of carbon dioxide. Average growth rates are compound annual growth rates for growth in the years indicated (from the previous year's base). Data are estimates reported by the data sources and are subject to uncertainty. Data sources and definitions are detailed in the Supplementary Methods.

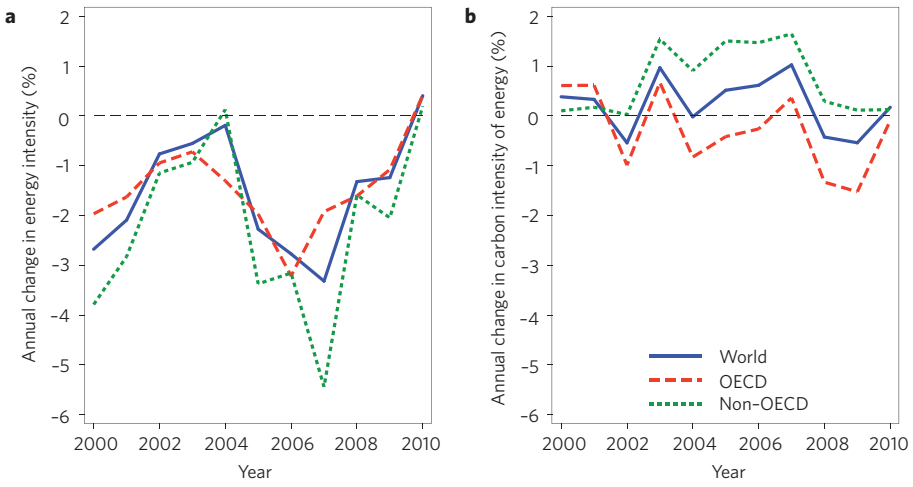

Figure 1 | Energy intensity and carbon intensity of energy. Annual change in energy intensity (**a**) and the carbon intensity of energy (**b**) during 2000–2010.

Energy intensity rose in both OECD and non-OECD countries in 2010 (Fig. 1). Possible explanations include relatively subdued fossil-fuel prices — prices remained below 2008 levels during 2010 (ref. 6) — and fiscal stimulus spending on energy-intensive activities such as construction. Despite the rise in global energy intensity in 2010, energy intensity remained below pre-crisis levels (Supplementary Table S2).

The carbon intensity of energy fell in OECD countries over the 2001–2010 decade as a result of a gradual reorientation of energy away from oil and coal and towards natural gas and renewables[7]. The carbon intensity of energy rose in non-OECD countries as their use of coal increased[7]. Globally, the carbon intensity of energy increased slightly over the decade as well as in 2010, in part due to the rising share of developing countries in global energy use.

Estimates for carbon dioxide emissions, energy use and GDP are subject to uncertainty[8,9], and the 2010 data will be

further revised. Energy and emissions data for 2011 are not yet available. It is likely, though, that the 2010 emissions surge was exceptional and that emissions growth slowed in 2011 (as noted by Peters *et al.*[1]). The latest IMF[4] data suggest that the growth rate of world GDP declined to 3.8% yr^{-1} in 2011, and fossil-fuel prices were higher than they were in 2010 (ref. 6), which tends to reduce growth in energy demand. For 2012, the IMF has revised its global GDP growth projection down to 3.3% yr^{-1}. Barring any highly unusual developments in energy intensity or the carbon intensity of energy, this would mean moderate carbon dioxide emissions growth again this year.

Over the medium term, policy efforts to improve energy efficiency and shift to a lower-carbon energy supply, combined with the greater availability of natural gas and falling costs of renewable-energy technologies, may lead to a dampening of emissions growth. But the challenge of reducing global emissions remains enormous. Much greater reductions in the energy intensity of the global economy and/or the carbon intensity of energy will be needed than have been observed historically if ambitions of restricting global warming to 2 °C above pre-industrial levels are to be met. ❐

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Author contributions

All authors contributed to the analysis. F.J. led the work. P.J.B. and P.J.W. contributed data analysis and writing. A.M. and D.I.S. provided input to the research design and writing.

Additional information

The authors declare no competing financial interests. Supplementary information accompanies this paper on www.nature.com/natureclimatechange. Reprints and permissions information is available online at http://www.nature.com/reprints.

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