Carbon productivity

Carbon dioxide (CO_2) from the combustion of fossil fuels and biomass accounts for 90% of total greenhouse gas (GHG) emissions. It is thus a key factor in countries' ability to deal with climate change. The stabilisation of GHG concentrations in the atmosphere depends on implementation of coherent national and international policies that aim at structural and technological changes. It depends on countries' ability to further decouple CO_2 and other GHG emissions growth from economic growth, and reduce the overall level of emissions.

Climate change is of global concern for its effects on ecosystems, human settlements and agriculture, and the frequency of extreme weather events. It could have significant consequences for human well-being and socio-economic activities. This, in turn, could affect global economic output.

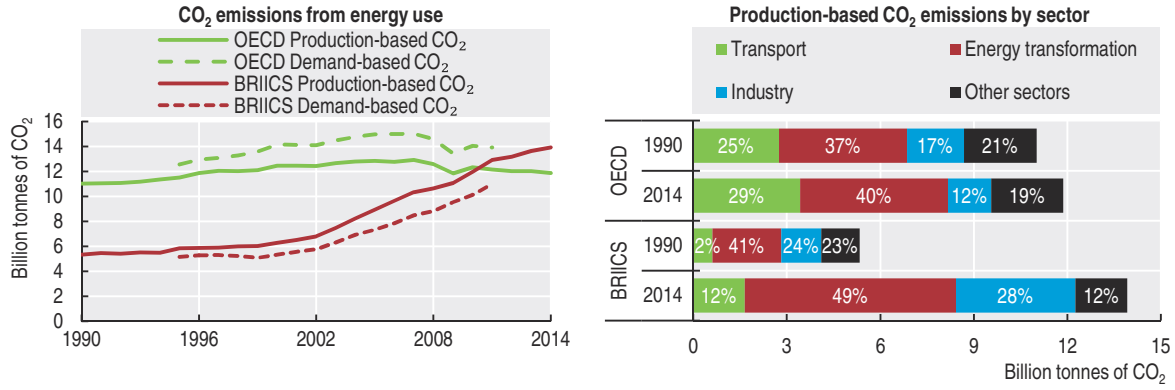
International production networks and global value chains are increasingly interdependent. This means that domestic mitigation efforts must be placed in a global context. Further, they must build on a good understanding of carbon flows associated with international trade and final domestic demand. With increasing trade flows and the relocation of carbon-intensive production abroad, reductions in domestic emissions can be partially or wholly offset (and sometimes exceed) elsewhere in the world. The links between trade, economic growth and the environment are, however, complex. Policies must account for various factors, including pro-competitive benefits of trade for growth and development.

Achieving the aims of the 2015 Paris Agreement will require structural changes to overcome the carbon dependency of our economies. First, it will require core climate policy instruments, such as an explicit carbon price and phase out of all fossil fuel subsidies. Beyond these steps, governments must align policies across a diverse range of non-climate areas.

Carbon prices are an essential element to decarbonise the economy. They are indispensable to induce cost-effective abatement, to steer investment towards low-carbon infrastructure technologies and to discourage carbon-intensive production and consumption. Globally, countries are far from exploiting the full potential of emissions pricing policies. Most emissions across OECD and BRIICS (Brazil, the Russian Federation, India, Indonesia, the People's Republic of China [hereafter China] and South Africa) are not priced at all, and 90% are priced at less than EUR 30 per tonne of CO_2 (see chapter on *Taxes and subsidies*).

Current policies do not provide stable and sufficient economic incentives for firms to reduce the costs of future mitigation. Nor do they provide incentives for investments that take account of rising climate risks. Introducing a predictable long-term path of carbon prices will allow firms to adapt their investment plans to expected future increases in carbon prices. This is particularly important for investment in long-lived assets.

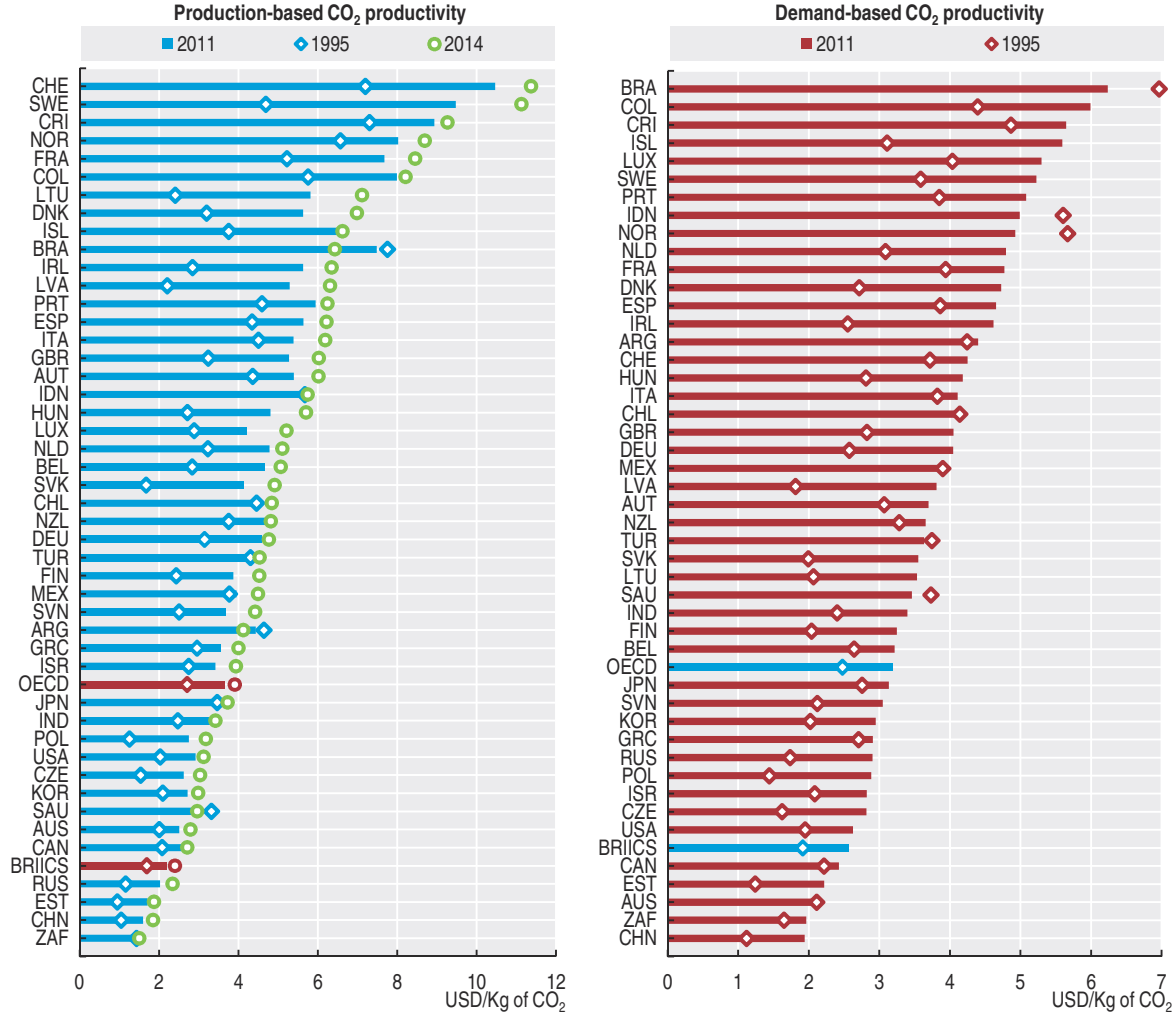
Figure 1.1. **Global CO_2 emissions from energy use increased**



Source: IEA (2016), "CO_2 emissions by product and flow (Edition 2016)", *IEA CO_2 Emissions from Fuel Combustion Statistics* (database); OECD (2015), "Carbon dioxide embodied in international trade", *OECD Structural Analysis Statistics: Input-Output* (database).

StatLink http://dx.doi.org/10.1787/888933484433

Figure 1.2. **CO_2 productivity improved in most countries**



Source: IEA (2016), "CO_2 emissions by product and flow (Edition 2016)", *IEA CO_2 Emissions from Fuel Combustion Statistics* (database); OECD (2015), "Carbon dioxide embodied in international trade", *OECD Structural Analysis Statistics: Input-Output* (database).

StatLink http://dx.doi.org/10.1787/888933484446

Progress towards green growth can be assessed against trends in CO_2 emission productivity from the production and demand (footprint) perspectives, and the level of decoupling achieved between GHG emissions and economic growth. These trends can further be related to domestic objectives and international commitments and to changes in atmospheric concentrations of GHG.

Main trends and recent developments

Despite a slowdown in the OECD area, global CO_2 emissions continued to grow

CO_2 emissions from energy use are still growing worldwide, mainly due to increases in transport and energy sectors. In 2014, global energy-related CO_2 emissions reached a record high of 32.38 billion tonnes, or 58% more than in 1990. Production-based emissions growth has decelerated in OECD countries in the wake of the 2008 financial crises. In part, this reflects an on-going decline in the contribution of industry to overall economic activity. In BRIICS economies, emissions have continued to rise sharply (Figure 1.1).

Most countries have achieved only a relative decoupling between emissions and economic growth, although some managed to reduce emission levels in absolute terms

The carbon productivity of OECD economies has improved, as CO_2 emissions increased at a lower rate than real GDP (relative decoupling). Half of OECD countries have decreased emissions in absolute terms (absolute decoupling). Beyond decreases in economic activity, this reflects shifts in industrial structure, in energy supply mix and improved energy efficiency (see chapter on *Energy productivity*). Nine out of ten of the Nationally Determined Contributions (NDCs) submitted at the 2015 Paris Climate Summit included a reference to energy efficiency. Yet, countries such as Chile, Japan and Turkey have made limited progress in raising carbon productivity since 1995. In Saudi Arabia, Brazil and Argentina, carbon productivity has actually decreased (Figure 1.2a, Figure 1.3a).

Most reporting is based on the production perspective. This includes emissions generated on the national territory without taking trade flows into account. Countries may thus show absolute decoupling from a production perspective, but not in terms of their final demand. This is due both to changing trade patterns and to the shift of polluting industries to lower-cost locations, often with more lax environmental regulations.

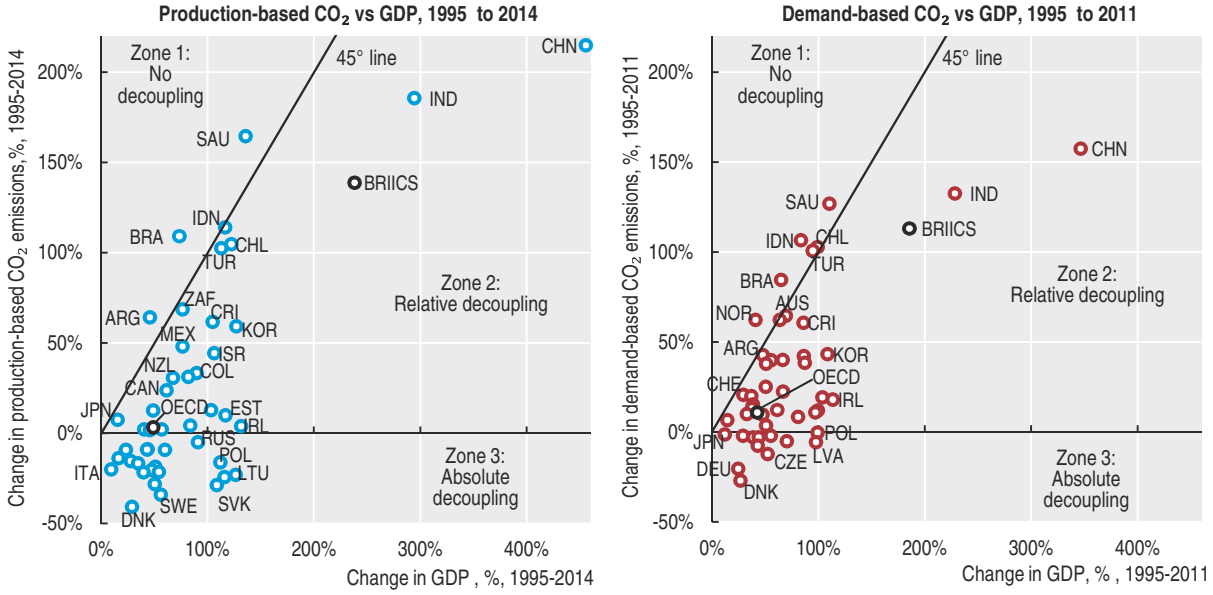
Decoupling demand-based CO_2 emissions presents an even greater challenge

A more nuanced picture thus emerges when emissions are considered from the perspective of final demand. Total emissions generated to satisfy domestic final demand in OECD countries have increased faster than emissions from domestic production. Over 1995-2011, only 12 OECD countries achieved absolute decoupling of demand-based CO_2 emissions from real GDP (e.g. Denmark and Germany). This could also reflect improvements on the production side through cleaner energy use (consumption of cleaner domestic production). In three OECD countries (e.g. Norway) and three non-OECD economies (e.g. Indonesia) demand-based CO_2 emissions increased faster than income (Figure 1.2b, Figure 1.3b). High oil prices in 2011 and lower export shares on GDP might partly explain the trends in demand-based productivity in some countries.

Most OECD countries are "net-importers" of CO_2 emissions because these emissions from domestic final demand for goods and services exceed emissions from domestic

Figure 1.3. **Most countries have decoupled CO_2 emissions from economic growth**

OECD and G20



Source: IEA (2016), "CO_2 emissions by product and flow (Edition 2016)", *IEA CO_2 Emissions from Fuel Combustion Statistics* (database); OECD (2015), "Carbon dioxide embodied in international trade", *OECD Structural Analysis Statistics: Input-Output* (database).

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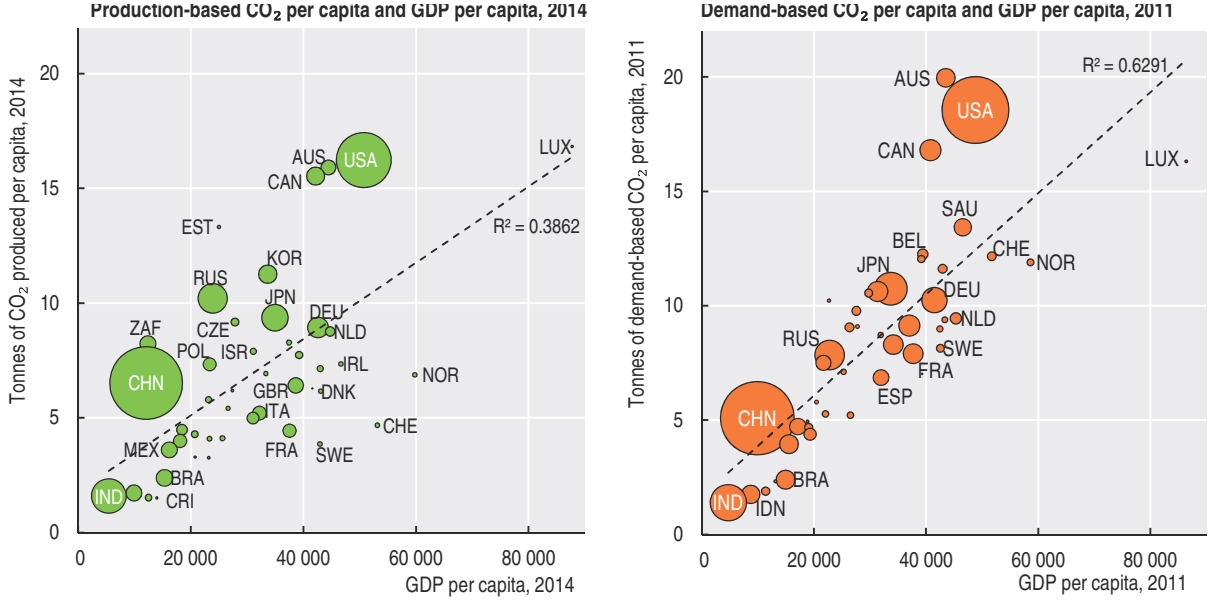
Figure 1.4. **Embodied CO_2 per capita is highly correlated with living standards**

OECD and G20



Note: The size of the bubble represents the level of emissions.

Source: IEA (2016), "CO_2 emissions by product and flow (Edition 2016)", *IEA CO_2 Emissions from Fuel Combustion Statistics* (database); OECD (2015), "Carbon dioxide embodied in international trade", *OECD Structural Analysis Statistics: Input-Output* (database).

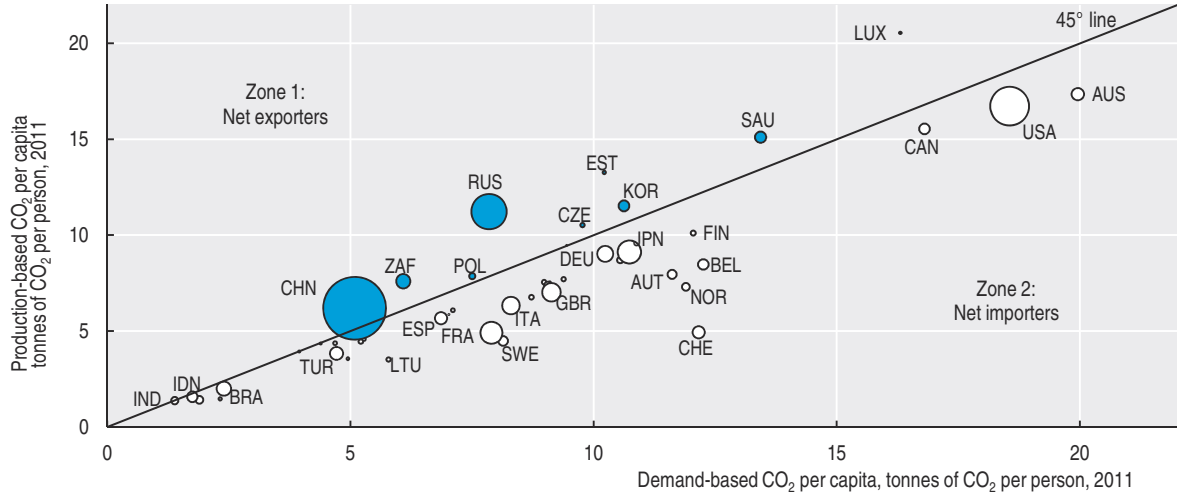
StatLink http://dx.doi.org/10.1787/888933484465

production (Figure 1.1a, Figure 1.5). This can be partly explained by three factors: i) displacement of energy-intensive production to non-OECD economies; ii) growth of imports (e.g. due to lower prices of imported goods, or higher overall domestic consumption); or iii) imports with a higher carbon footprint. These trends reflect a host of factors, including changes in international production patterns, specialisation in production and changes in the comparative advantages of countries.

Decoupling demand-based CO_2 emissions is challenging because embodied CO_2 emissions per capita are highly correlated with material living standards, more so than production-based CO_2 which more closely reflects the structure and energy intensity of the economy (Figure 1.4).

Figure 1.5. **Most OECD countries are net importers of CO_2**

OECD and G20



Note: The size of the bubble represents the level of net exports of embodied CO_2. White bubbles indicate negative values of net exports (i.e. net imports). The 45-degree line shows equal emissions of production- and demand-based CO_2.

Source: IEA (2016), "CO_2 emissions by product and flow (Edition 2016)", *IEA CO_2 Emissions from Fuel Combustion Statistics* (database); OECD (2015), "Carbon dioxide embodied in international trade", *OECD Structural Analysis Statistics: Input-Output* (database).

StatLink http://dx.doi.org/10.1787/888933484471

Measurability and interpretation

The indicators presented in this chapter relate to the following:

- **Production-based CO_2 productivity** reflects the economic value generated (in terms of real GDP) per unit of CO_2 emitted. Production-based emissions refer to gross direct CO_2 emissions from fossil fuel combustion, emitted within the national territory. They exclude bunkers, sinks and indirect effects.
- **Demand-based CO_2 productivity** reflects the economic value generated per unit of CO_2 emitted to satisfy domestic final demand. Demand-based CO_2 emissions (or CO_2 embodied in domestic final demand) include the CO_2 from energy use emitted during the various stages of production (in the country or abroad) of goods and services consumed in domestic final demand. Comprehensive data are not available on the monetary values of domestic final demand across all countries shown here. Thus, the indicator is expressed in terms of embodied CO_2 per unit of real GDP. See also *Glossary*.
- **Net exports of CO_2** reflect the difference between the CO_2 from energy use emitted in the production of goods and services in a country, and the CO_2 emitted to satisfy domestic

final demand. "Net exports" are positive if production-based emissions are higher than demand-based emissions. Conversely, if CO_2 emissions embodied in domestic final demand are higher than emissions from production within the national territory, the country is a "net importer" of CO_2.

Carbon productivity indicators inform about the relative decoupling between economic activity and carbon emissions into the atmosphere. They provide insight into how much carbon productivity has improved. They also measure how much of the improvement is due to domestic policies and how much to displacement or substitution effects. The demand perspective helps explain production-based trends.

These indicators should be read in connection with information on total GHG emissions, energy productivity and efficiency, renewable energy sources, energy prices and taxes, and carbon pricing. Their interpretation should take into account the structure of countries' energy supply, trade patterns and climatic factors.

Energy productivity is not the same as carbon productivity, although the two are closely related. As fossil fuel use declines and more "clean energy" technologies are deployed, CO_2 productivity becomes decoupled from energy productivity.

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Further reading

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