## Title
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# Consumption-based accounting of $CO_2$ emissions

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**$CO_2$ emissions from the burning of fossil fuels are the primary cause of global warming. Much attention has been focused on the $CO_2$ directly emitted by each country, but relatively little attention has been paid to the amount of emissions associated with the consumption of goods and services in each country. Consumption-based accounting of $CO_2$ emissions differs from traditional, production-based inventories because of imports and exports of goods and services that, either directly or indirectly, involve $CO_2$ emissions. Here, using the latest available data, we present a global consumption-based $CO_2$ emissions inventory and calculations of associated consumption-based energy and carbon intensities. We find that, in 2004, 23% of global $CO_2$ emissions, or 6.2 gigatonnes $CO_2$, were traded internationally, primarily as exports from China and other emerging markets to consumers in developed countries. In some wealthy countries, including Switzerland, Sweden, Austria, the United Kingdom, and France, >30% of consumption-based emissions were imported, with net imports to many Europeans of >4 tons $CO_2$ per person in 2004. Net import of emissions to the United States in the same year was somewhat less: 10.8% of total consumption-based emissions and 2.4 tons $CO_2$ per person. In contrast, 22.5% of the emissions produced in China in 2004 were exported, on net, to consumers elsewhere. Consumption-based accounting of $CO_2$ emissions demonstrates the potential for international carbon leakage. Sharing responsibility for emissions among producers and consumers could facilitate international agreement on global climate policy that is now hindered by concerns over the regional and historical inequity of emissions.**

carbon intensity of economy | carbon intensity of energy | emissions embodied in trade | fossil fuels | Kaya identity

Emissions from the burning of fossil fuels are the primary cause of rapid and accelerating growth in atmospheric $CO_2$ (1). Between 2000 and 2008, emissions grew at a rate of 3.4% $yr^{-1}$, a marked increase from the rate of 1.0% $yr^{-1}$ throughout the 1990s (2). Although global emissions have slowed since 2007 and are expected to have decreased in 2009 in response to a decline in the world gross domestic product (GDP) brought about by the global financial crisis, the longer-term surge of emissions since 2000 has been driven not only by growth of the global population and per-capita GDP, but also by unanticipated global increases in the energy intensity of GDP (energy per unit GDP) and the carbon intensity of energy (emissions per unit energy) (2, 3). These drivers are most evident in emerging markets where economic growth and industrialization have been rapid, particularly in China. Less apparent is that a substantial fraction of the growth in these countries satisfies the demand of consumers in developed countries (4). There is little evidence that carbon-intensive industries are being sited in developing countries in direct response to climate policy (i.e., "strong" carbon leakage); however, industrial expansion occurring in those countries for other reasons (i.e., "weak" carbon leakage) may unintentionally undermine ongoing efforts to regulate emissions (5–7). Moreover, the geographical separation of production and consumption complicates the fundamental questions of who is responsible for emissions and how the burden of mitigation ought to be shared (8).

It is intuitive that individuals who benefit from a process should bear some responsibility for the associated emissions (9). Yet, national inventories such as those conducted annually by parties to the United Nations Framework Convention on Climate Change (10) account for only those emissions produced within sovereign territories ($F_{Pr}$), ignoring the benefit conveyed to consumers through international trade. In recognition of this shortcoming, a number of studies over the past decade have sought to compare production- and consumption-based emissions inventories (for a comprehensive, up-to-date review, see ref. 11). Recent studies have quantified the emissions "embodied" in global trade (i.e., emitted during the production and transport of traded goods and services) among 87 regions in 2001 (12, 13). Here, we present results from a fully coupled multiregional input–output (MRIO) model constructed from 2004 global economic data disaggregated into 113 countries/regions and 57 industry sectors. Our model allocates global $CO_2$ emissions to countries and industry sectors according to the demand of consumers for finished goods (i.e., final demand, as opposed to the intermediate demand of industry for raw materials or unfinished goods).

The details of our analytic approach are described in *Materials and Methods*. In summary, the MRIO analysis is based on monetary flows between industrial sectors and regions (in practice, most regions in the present analysis are individual countries), considering the total economic output of each sector in each region, each sector's output produced in one region and consumed in another, and a matrix of intermediate consumption where columns reflect the input from sectors in each region required to produce one unit of output from each sector in another region. From this framework, as described in *Materials and Methods*, $CO_2$ emissions associated with consumption in each region may be calculated using region- and industry-specific data of $CO_2$ emissions per unit of output (14). Energy consumption in each region can be determined analogously. Note that our calculations trace all emissions associated with consumed goods back to the original source that produced the emissions even if products were transshipped through other countries/regions or were intermediate constituents in a multiregional supply chain. For example, it is not uncommon for an imported product to embody carbon emissions that were produced in the importing region itself. Our calculations take these complex relations into account.

The difference between production emissions ($F_{Pr}$) and consumption emissions ($F_{Cr}$) represents the net effect of emissions embodied in trade (EET) and therefore equals emissions embodied in exports (EEE) less emissions embodied in imports (EEI). A positive difference reflects the net export of emissions and a negative value indicates the net import of emissions. Results are discussed as factors of the Kaya identity (15, 16):

$$F = P \times \left(\frac{G}{P}\right) \times \left(\frac{E}{G}\right) \times \left(\frac{F}{E}\right) = P \times g \times e \times f = P \times g \times h, \quad [1]$$

where $F$ represents global emissions, $P$ is population, $G$ is world GDP or gross world product, $E$ is global energy consumption,

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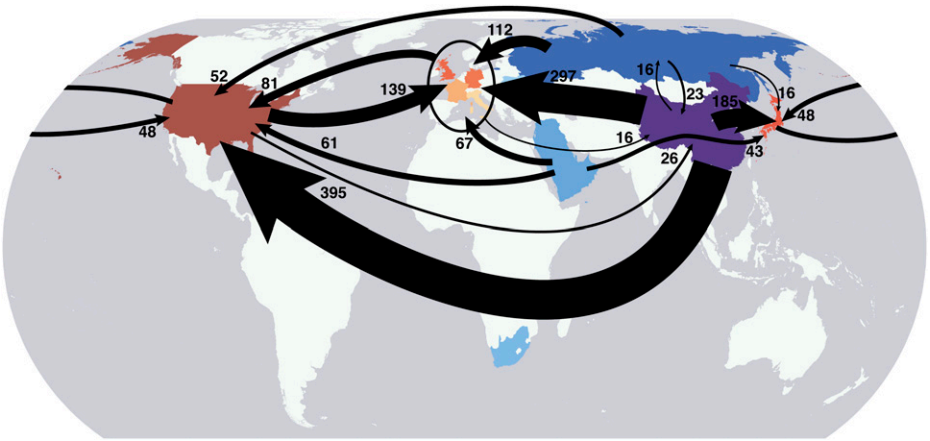


**Fig. 1.** Largest interregional fluxes of emissions embodied in trade (Mt $CO_2$ $y^{-1}$) from dominant net exporting countries (blue) to the dominant net importing countries (red). Fluxes to and from Western Europe are aggregated to include the United Kingdom, France, Germany, Switzerland, Italy, Spain, Luxembourg, The Netherlands, and Sweden.

$g = G/P$ is per-capita GDP, $e = E/G$ is energy intensity of world GDP, $f = F/E$ is carbon intensity of energy consumption, and $h = F/G$ is carbon intensity of world GDP. Where denoted by subscript $r$, these terms have been disaggregated into countries/regions whose sum equals the world total. We also apply the intensity relationships in assessing traded goods and their embodied emissions or energy and denote these instances with subscript $t$.

Our analysis includes $F$ derived from the combustion of fossil fuels, omitting emissions from the oxidation of nonfuel hydrocarbons, transport fuel from international "bunkers," and non-$CO_2$ greenhouse gases (*SI Text*). In comparison, $E$ includes all "commercial" primary energy: fossil fuels, nuclear, and renewables (hydro, solar, wind, geothermal, and biomass) (*SI Text*). GDP and the trade flows in this study are defined and measured using market exchange rates. Adjusting to purchasing power parity would reduce the apparent wealth gap between developed and developing countries as well as $e_r$ and $h_r$ in poorer countries/regions, but would not affect our qualitative conclusions.

## Results

Because the most current database available with adequate sectoral resolution describes the state of the world in 2004, all results apply to the year 2004. Furthermore, we will use the term "countries" to describe the spatial disaggregation of this data, recognizing that we use this term loosely to refer also to some collections of related countries with relatively small economies that are combined in the original database, as described in the *SI Text*.

**Emissions Embodied in Trade.** Approximately 6.2 gigatonnes (Gt) of $CO_2$, 23% of all $CO_2$ emissions from fossil-fuel burning ($F$), were emitted during the production of goods that were ultimately consumed in a different country. Where exported from emerging markets to developed countries, these emissions reinforce the already large global disparity in per-capita emissions and reveal the incompleteness of regional efforts to decarbonize.

The 10 countries and Middle East region highlighted in Fig. 1 are the largest net exporters (blue) and importers (red) of EET, together accounting for 71% of the total difference in regional emissions $F_{Cr}$ instead of $F_{Pr}$ in 2004. In other countries, the balance of EET is close to zero, although gross flows are sometimes large (Table S1 and Fig. S1). For example, in Australia, Canada, South Korea, and Taiwan, both EEI and EEE are on the order of 100 megatonnes (Mt) $CO_2$.

Superimposed vectors in Fig. 1 represent the largest interregional fluxes of EET (≥10 Mt $CO_2$ $y^{-1}$). The dominant global feature is the export of emissions embodied in goods from China to consumers in the United States, Japan, and Western Europe. In China alone, 1.4 Gt of $CO_2$ emissions were linked to consumption in other countries/regions.

The balance of EET for the top net importers/exporters is presented in Fig. 2, along with some detail of the industry sectors accounting for traded emissions. The prodigious imbalance in China's EET is obtained through exports of machinery (134 Mt $CO_2$), electronics (117 Mt), apparel (80 Mt), textiles (37 Mt), chemical, rubber, and plastic products (44 Mt), and large exports of intermediate goods (787 Mt). Comparatively modest emissions imported to China are dominated by machinery (32 Mt) and electronics (9 Mt). Chemicals, rubber, and plastics, along with petroleum products make up the largest component of emissions exported from Russia (20 Mt) and the Middle East (28 Mt), whereas imported machinery offset 12 and 20 Mt, respectively.* Unclassified manufactured products represent more exports from India than any other sector (25 Mt). In South Africa, substantial emissions are embodied in exported machinery (4 Mt) and motor vehicles and parts (4 Mt).

Emissions imported to the United States exceed those of any other country or region, primarily embodied in machinery (91 Mt), electronics (77 Mt), motor vehicles and parts (75 Mt), chemical, rubber, and plastic products (52 Mt), unclassified manufactured products (52 Mt), wearing apparel (42 Mt), and intermediate goods (654 Mt). These imports are offset by considerable US exports of transport services (49 Mt $CO_2$), machinery (42 Mt), electronics (26 Mt), chemical, rubber, and plastics products (25 Mt), motor vehicles (22 Mt), and intermediate goods (263 Mt). The balance of trade is similar in Western Europe and Japan, with substantial emissions imported in each case to meet demand for apparel, electronics, chemicals, machinery, and transport services. Emissions embodied in exports from the motor vehicles and parts sector of Japan and Germany are also significant: 28 and 39 Mt, respectively.

**Carbon Intensity of Trade.** The carbon intensity of trade (in kg $CO_2$ per US$ of imports or exports in Fig. 3 and Fig. S2) is the product of the $CO_2$ emissions per unit energy ($f_t$) and energy consumption per US$ of trade ($e_t$). The high carbon intensity of exports from emerging markets such as China, Russia, and India thus reflects both the prevalence of carbon-intensive fuels such as coal in these countries as well as the low value of energy-intensive exports. In contrast, exports from Western Europe and Japan are more highly valued per unit of energy required to produce them,

*Note that carbon embodied in exports of petroleum products does not include the carbon physically contained in the products, but only the emissions required to produce and transport them. The carbon contained in these fossil fuels would appear in the inventory of production emissions of the country where the $CO_2$ is released to the atmosphere. That $CO_2$ emission would be assigned to the inventory of consumption emissions of the country where the goods or services produced by those emissions was consumed.

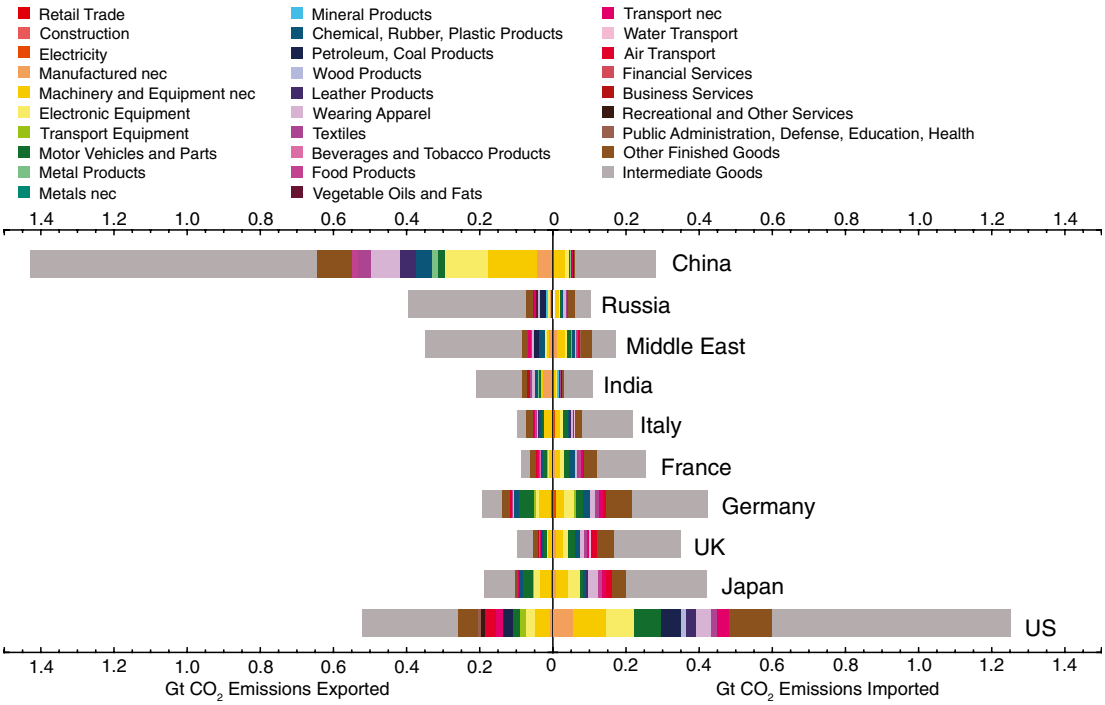


**Fig. 2.** Balance of $CO_2$ emissions embodied in imports and exports of the largest net importing/exporting countries (and Middle East region). Colors represent trade in finished goods by industry sector. Traded intermediate goods (gray) are those used by industries in the importing country to meet consumer demand for domestic goods. nec, "not elsewhere classified."

and a greater proportion of the required energy is generated using low-carbon technologies. The carbon intensity of exports from the mature US economy is much less than that of emerging markets, but still more than double that of Western Europe.

In contrast, goods imported to Western Europe and Japan embody much more $CO_2$ per US$ than do their exports, reflecting the import of energy-intensive products from elsewhere. The carbon intensity of imports to China, Russia, India, and the Middle East is consistently far less than that of their exports, although it varies widely primarily on the basis of $e_t$. For example, imports to India, Russia, the Middle East, and China entail 14.7, 14.6, 10.0, and 8.9 megajoules (MJ) per US$, respectively. In the United States, carbon intensity of imports is greater than that of exports, but not to the same extent as in Western Europe or Japan, suggesting that there is a closer balance of manufacturing and service industries composing US trade.

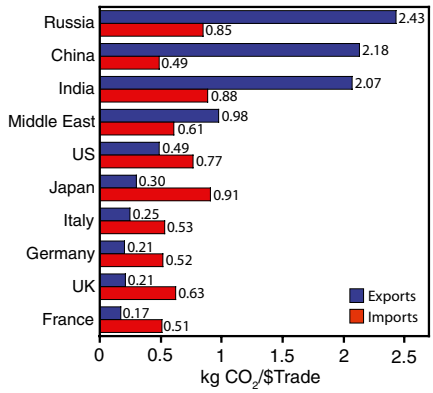


**Fig. 3.** Mean $CO_2$ intensity of imports and exports to and from the largest net importing/exporting countries (and Middle East region). Trade is valued at exporter prices.

**Regional Emissions.** The net effect of EET is concentrated geographically (Fig. 4, *Upper*). China is by far the largest net exporter of emissions, followed by Russia, the Middle East, South Africa, Ukraine, and India and, to a lesser extent, Southeast Asia, Eastern Europe, and areas of South America (Fig. 5, *Row 2 Left*). The primary net importers of emissions are the United States, Japan, the United Kingdom, Germany, France, and Italy (Fig. 5, *Top Left*). Although the overall mass of emissions is much less, the other countries of Western Europe are all net importers, as are New Zealand, Mexico, Singapore, and many areas of Africa and South America (Fig. 4, *Upper*). Similarly, Canada, Australia, Indonesia, the Czech Republic, and Egypt are among the countries whose net exports of emissions are small.

Normalizing the difference between $F_{Cr}$ and $F_{Pr}$ by GDP ($G_r$) highlights that net exporters of emissions typically have developing or recovering economies and deemphasizes the larger economies where net imports of emissions are greatest overall (Fig. 4, *Middle*). Net imports of emissions are large relative to $G_r$ in some wealthy but smaller economies with limited natural resources (e.g., Hong Kong and Singapore) and in many of the least developed countries (e.g., Africa, Afghanistan, Bhutan, and Central America) where a large fraction of imported emissions are embodied in food products (Fig. 5, *Top Center*).

On a per-capita basis, net imports of emissions to the United States, Japan, and countries in Western Europe are disproportionately large, with each individual consumer associated with 2.4–10.3 tons of $CO_2$ emitted elsewhere (Fig. 4, *Bottom*, and Fig. 5, *Top Right*; gross flows per capita are shown in Fig S3). Net exports of emissions from China, Russia, and the Middle East are also substantial: from 0.9 to 2.0 tons per capita (Fig. 4, *Bottom*, and Fig. 5, *Row 2*, *Right*). Interpreted as an indicator of the global equity of emissions in trade, these figures suggest that individual consumers in the most affluent and least populous countries of Western Europe, for example, are importing the same mass of emissions as are exported by 5–10 people in China.

On the basis of consumption the top emitters remain among the largest of the world's economies (Fig. 5, *Row 3*, *Left*; Fig. S4),

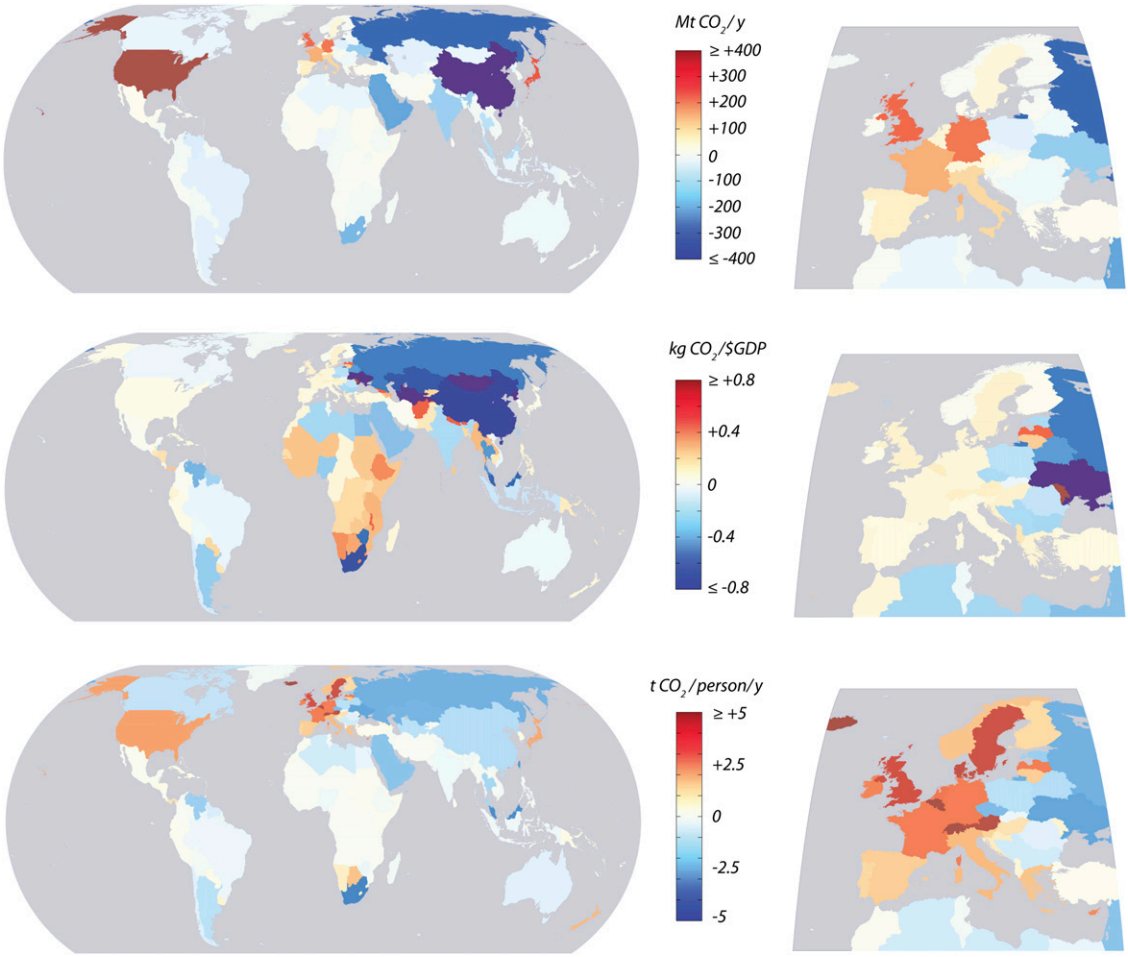


**Fig. 4.** Global differences between consumption ($F_{Cr}$) and production ($F_{Pr}$) emissions (i.e., the net effect of emissions embodied in trade) in 2004 by mass of $CO_2$ emissions in the region (*Top*) and also normalized per unit GDP (*Middle*) and per capita (*Bottom*). Twenty-seven countries/regions with GDP <10 G$ (1 G$ = 1 billion $US) in 2004 are excluded and appear white. Excluded countries/regions represent 155 G$ in 2004 (0.38% of world GDP), 319 million people (4.98% of global *P*), and 184 Mt $CO_2$ (0.7% of global *F*).

just as the countries/regions with the lowest emissions are among the smallest economies (Fig. 5, *Bottom Left*). However, carbon intensity of GDP ($h_r = F_{Cr}/G_r$) is greatest in the former Soviet Union (Ukraine, Kazakhstan, Belarus, and Russia), Eastern Europe, and Iran where the energy intensity of GDP ($e_r = E_{Cr}/G_r$) is high due to the prevalence of heavy industry and/or energy products, and economies have struggled since the collapse of the Soviet Union (Fig. 5, *Row 3 Center*; Fig. S5). In contrast and despite net import of emissions, many Western European countries and Japan boast low values of $h_r$ as a result of both low carbon intensity of energy ($f_r = F_{Cr}/E_r$) generated by nuclear and hydropower (e.g., France and Sweden) and the low energy intensity of GDP ($e_r = E_{Cr}/G_r$) in economies led by robust high technology and service industries (Fig. 5, *Bottom Center*).

Nonetheless, affluent lifestyles in some of these same European countries lead to per-capita consumption emissions ($F_{Cr}/P_r = g_r h_r$) that are quite high (e.g., 10.5–12.5 tons/person in Norway, Switzerland, and Sweden) (Fig. S6, *Lower*). Per-capita emissions associated with consumption in the United States are among the highest at 22.0 tons, surpassed only by Luxembourg, where per-capita emissions of 34.7 tons are likely overstated as a result of the large fraction of the country's workforce that resides in neighboring countries (Fig. 5, *Row 3 Right*). Per-capita emissions are lowest in the least developed countries of Africa and Asia (Fig. 5, *Bottom Right*), in some cases about 1% of those in the United States, Singapore, Australia, Canada, Belgium, and Hong Kong.

## Discussion

Consumption-based accounting reveals that substantial $CO_2$ emissions are traded internationally and therefore not included in traditional production-based national emissions inventories. The net effect of trade is the export of emissions from China and other emerging markets to consumers in the United States, Japan, and Western Europe. In the large economies of Western Europe, net imported emissions are 20–50% of consumption emissions ($F_{Cr}$); the net imported emissions fall to 17.8% and 10.8% in Japan and the United States, respectively. In contrast, net exports represent 22.5% of emissions produced in China. Thus, to the extent that constraints on emissions in developing countries are the major impediment to effective international climate policy, allocating responsibility for some portion of these emissions to final consumers elsewhere may represent an opportunity for compromise. Because economic welfare in a region benefits from the production of goods within its territory, there are quantitative approaches aimed at sharing responsibility for emissions among producers and consumers (14, 17, 18).

The difference between consumption- and production-based accounting is greatest at the extremes of carbon intensity of GDP ($h_r = F_r/G_r$) where trade imbalances are also large. For example, where $h_r$ is high and net exports are large, as in emerging markets reliant on energy-intensive manufacturing of goods for export, >19% of production emissions ($F_{Pr}$) may be embodied in net exports (Fig. 6, *Upper*). Where $h_r$ is low and net imports are large,

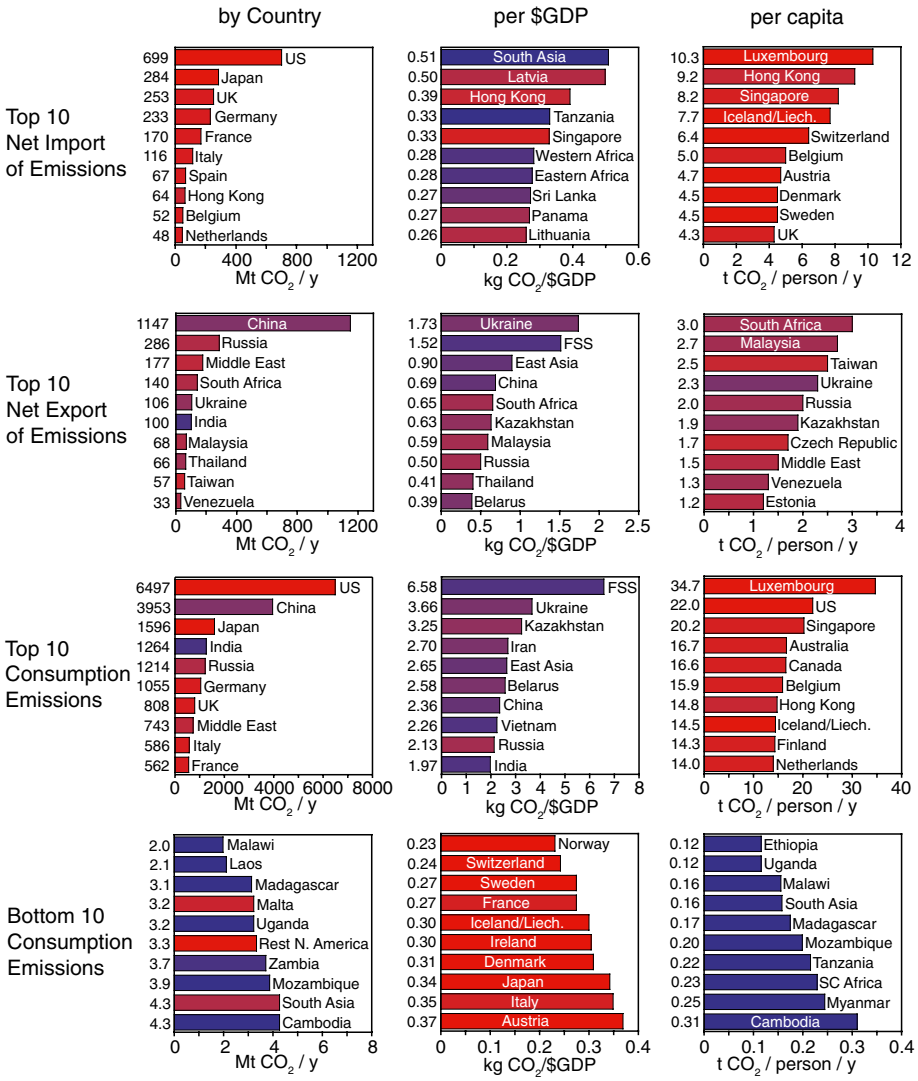


**Fig. 5.** Top 10 countries/regions by net imports, net exports, and consumption emissions and bottom 10 countries/regions by consumption emissions, all presented as regional totals (*Left*) per unit GDP (*Center*) and per capita (*Right*). The color of bars corresponds to deciles of regional GDP per capita from the most affluent countries/regions in red to the least developed countries/regions in blue. The South Asia region aggregates Afghanistan, Bhutan, and the Maldives. The Western Africa region aggregates Benin, Burkina Faso, Cote d'Ivoire, Cape Verde, Ghana, Guinea, Guinea-Bissau, Gambia, Liberia, Mali, Mauritania, Niger, Saint Helena, Sierra Leone, and Togo. The Eastern Africa region aggregates Burundi, Comoros, Djibouti, Eritrea, Kenya, Mayotte, Reunion, Rwanda, Somalia, Sudan, and the Seychelles. The Middle East region aggregates Bahrain, Iraq, Israel, Jordan, Kuwait, Lebanon, Occupied Palestinian Territory, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, the United Arab Emirates, and Yemen. The former Soviet states (FSS) region aggregates Tajikistan, Turkmenistan, and Uzbekistan (other former Soviet states are modeled separately). The East Asia region aggregates Macau, Mongolia, and the Democratic People's Republic of Korea (North Korea). The Rest of North America region (Rest N. America) aggregates Bermuda, Greenland, Saint Pierre, and Miquelon. The South Central Africa region (SC Africa) aggregates Angola and the Democratic Republic of the Congo.

as in service economies or impoverished countries with some combination of low production emissions, limited natural resources, and high GDP, >35% of consumption emissions may be embodied in net imports (Fig. 6, *Lower*).

Regional differences in the energy and carbon intensity of GDP ($e_r = E_r/G_r$ and $h_r = F_r/G_r$, respectively) diminish as a result of considering emissions embodied in trade: the range of $e_r$ declines from a factor of ~22 to ~9 and for $h_r$ from a factor ~10 to ~8 when trade is taken into consideration. The decreased variability of these intensities when using consumption-based accounting is another indication that affluent countries are importing emissions from the less developed. Regional variation in the carbon intensity of energy across countries ($f_r = F_r/E_r$) also decreases markedly, the range declining from a factor of ~10 to ~3 when emissions embodied in trade are taken into account. Thus, despite apparent decarbonization of the energy supply in some countries, consumption of internationally traded goods tends to equalize the carbon intensity of energy consumed worldwide.

Finally, we note that consumption-based accounting of emissions acts to further decouple population ($P_r$) and emissions ($F_r$) by shifting substantial emissions from emerging markets such as China and India to much less populous developed countries (Fig. S7). In terms of global equity, the prosperity of developed countries was not only founded on two centuries of fossil fuel emissions, but also in some cases is now being maintained by emissions produced in developing countries. Apart from an opportunity to inform effective climate policy, therefore, consumption-based accounting of emissions provides grounding for ethical arguments that the most developed countries—as the primary beneficiaries of emissions and with greater ability to pay—should lead the global mitigation effort (19, 20).

## Materials and Methods

Data on trade, economic input–output by sector, GDP, population, energy consumption, and combustion-based $CO_2$ emissions of each region sector were all taken from Version 7 of the Global Trade Analysis Project (GTAP), which compiles the primary data from voluntary contributions of each region (21). The regional input–output tables contributed were then harmonized with the structure of the GTAP by aggregation and/or disaggregation of sectors, and the volume of output and trade is scaled to conform with macroeconomic data of the World Bank. Population data in the GTAP database are derived from the World Bank and the CIA World Factbook. Energy ($E_{Pr}$) and emissions ($F_{Pr}$) data for each sector were calculated by GTAP according to fossil fuel inputs (22). We further adjusted regional energy consumption to include all primary "commercial" sources of energy (ref. 23; *SI Text*) and regional $CO_2$ emissions to match published data from the Carbon Dioxide Information Analysis Center (CDIAC) (*SI Text*).

The currency and quality of primary data and the unknown magnitude of the adjustments made by GTAP are the main sources of uncertainty in our results. For example, although the volume of monetary flows in the GTAP data reflect macroeconomic data from 2004, the structural relationships between sectors in the input–output tables of some countries is older in

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some cases (21). Although it is impossible to quantify uncertainty due to the circumstances of the its creation, we note that the GTAP data set is widely used for global economic analysis and that our results are generally consistent with those of recent analyses of specific regions or bilateral trade (11–13).

The MRIO analysis is based on monetary flows between industrial sectors and countries/regions,

$$\begin{pmatrix} x^1 \\ x^2 \\ x^3 \\ \vdots \\ x^m \end{pmatrix} = \begin{pmatrix} A^{11} & A^{12} & A^{13} & \dots & A^{1m} \\ A^{21} & A^{22} & A^{23} & \dots & A^{2m} \\ A^{31} & A^{32} & A^{33} & \dots & A^{3m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ A^{m1} & A^{m2} & A^{m3} & \dots & A^{mm} \end{pmatrix} \begin{pmatrix} x^1 \\ x^2 \\ x^3 \\ \vdots \\ x^m \end{pmatrix} + \begin{pmatrix} \sum_s y^{1r} \\ \sum_s y^{2r} \\ \sum_s y^{3r} \\ \vdots \\ \sum_s y^{mr} \end{pmatrix}, \quad [2]$$

where $x^r$ is a vector of total economic output of each sector in region $r$, $y^{qr}$ is a vector of each sector's output produced in region $q$ and consumed in region $r$, and $A^{qr}$ is a normalized matrix of intermediate consumption where columns reflect the input from sectors in region $q$ required to produce one unit of output from each sector in region $r$. As opposed to input–output models that allocate emissions according to bilateral trade (EEBT; refs. 14 and 24), here each submatrix $A^{qr}$ is constructed by splitting bilateral trade data into components satisfying intermediate and final demand. This is done by using the input–output relationships of imports to region $r$, distributed according to the share of all imports to region $r$ made up of exports from $q$ (see the appendix of ref. 14). From this framework, $CO_2$ emissions associated with consumption in each region ($F_{Cr}$) may be calculated as

$$F_{Cr} = h_r(I - A)^{-1} c^r, \quad [3]$$

where $h$ is a vector of region-specific $CO_2$ emissions per unit of industry output, $I$ is the identity matrix, $A$ is the block matrix shown in Eq. **2**, and $c^r$ is the vector

$$c^r = \begin{pmatrix} y^{1r} \\ y^{2r} \\ y^{3r} \\ \vdots \\ y^{mr} \end{pmatrix}. \quad [4]$$

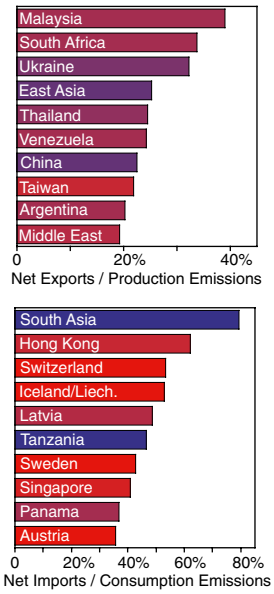


**Fig. 6.** Countries/regions where net exports make up the largest fraction of production emissions (*Upper*) and net imports make up the largest fraction of consumption emissions (*Lower*). The color of bars corresponds to deciles of regional GDP per capita from the most affluent countries/regions in red to the least developed countries/regions in blue. Regional aggregations of countries are defined in the legend of Fig. 5.

Energy consumption in each region ($E_{Ci}$) can be determined analogously by substituting for $h_r$ a different vector ($e_r$) of region-specific energy consumption per unit of industry output. The emissions or energy consumption related to final demand from each sector can also be determined by setting demand from all other sectors in $c^r$ equal to zero (25), and imports to final demand can be isolated by removing $y^{rr}$ from $c^r$. For further details, the methodological differences between bilateral (EEBT) and our MRIO analysis have recently received careful attention by other authors (14).

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