

GLOBAL INEQUALITIES IN OWNERSHIP-BASED CARBON FOOTPRINTS

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The logo for the World Inequality Lab features the text 'WORLD', 'INEQUALITY', and 'LAB' stacked vertically. The word 'WORLD' is followed by a horizontal row of dots. The word 'INEQUALITY' is followed by a grid of dots that forms a staircase shape, increasing in height from left to right. The word 'LAB' is preceded by a horizontal row of dots.

Global inequalities in ownership-based carbon footprints

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Abstract

The global distribution of greenhouse gas emissions is shaped not only by where goods are produced or consumed but also by who owns the firms that produce them. Country-level studies have started linking emissions to asset ownership, but global estimates remain unavailable. Here we estimate ownership-based emissions across 197 jurisdictions over 2010–2022, linking emissions to asset owners using data on wealth, portfolios, capital stocks and foreign investment. We find that ownership-based footprints are highly concentrated, with inequality exceeding that in wealth and in other carbon accounting frameworks, because wealthier individuals hold more carbon-intensive asset classes. Across countries, foreign ownership emissions are growing in importance and could reshape emission responsibility between regions. Large western European countries have reduced production-based emissions, yet their foreign ownership-based emissions have not declined. Emerging policy responses such as carbon border adjustments address consumption-based international transfers, but emissions linked to the ownership of production remain largely unaccounted for.

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1 Introduction

The unequal distribution of greenhouse gas (GHG) emissions is a defining feature of global climate change (Chancel, 2022; Ivanova & Wood, 2020; Oswald et al., 2020; Otto et al., 2019; Wiedmann et al., 2020). Recent research has demonstrated a renewed interest in carbon accounting frameworks that move beyond purely production-based or consumption-based approaches (Chancel, 2022; Dietzenbacher et al., 2020; Gallego & Lenzen, 2005; Jakob et al., 2021; Kander et al., 2015; Marques et al., 2012; Ortiz et al., 2020; Peters et al., 2015; Pottier & Le Treut, 2023; Starr et al., 2023). Earlier work introduced the concept of ownership-based emission footprints, allocating scope 1 GHG emissions to firm owners, rather than final consumers, revealing that this perspective provides a useful complementary lens for assessing emission inequality within and between countries (Chancel & Rehm, 2025). However, consistent estimates of ownership-based emission footprints at the global level remain unavailable.

In this study, we address these limitations by producing annual, internationally comparable distributional estimates of ownership-based emission footprints in a large set of countries and at the global level over the 2010–2022 period. To do so, we construct a global dataset that integrates the most recent and reliable methods and data sources available to our knowledge, using national wealth distributions from the World Inequality Database (Blanchet et al., 2024), air emissions accounts and global emission databases (Eurostat, 2024; IEA and JRC, 2024; Remond-Tiedrez & Rueda-Cantuche, 2019), evidence on the asset portfolios held across wealth distributions (Bauluz et al., 2022; Blanchet & Martínez-Toledano, 2023; HFCN, 2021; Piketty et al., 2018), data on public and private capital stocks (Xiao et al., 2021) and data on cross-border investment positions (Cadestin et al., 2018; Damgaard et al., 2024). We define ownership-based footprints (or emissions) as all national emissions in an ownership-based framework (that is, including government ownership and direct household emissions) and private ownership-based footprints (or emissions) as the subcategory of emissions that are linked to assets and firms owned by private individuals (Figure 1). Ownership-based footprints define a country's footprint as the production emissions of activities owned by its residents, regardless of where production occurs. Our global dataset covers 197 jurisdictions and 98–100% of the world in terms of global GHG emissions, wealth, population and gross domestic product.

Ownership-based emission footprints offer insights into the structure of carbon inequality both within and across countries, which cannot be studied in other frameworks (Box 1). At the global level, they show how the ownership of polluting firms and their associated emissions is concentrated and how this concentration has evolved over time. They also reveal whether wealthier groups hold assets that are, on average, more or less carbon intensive than those owned by others. Across countries, ownership-based footprints can identify whether countries' net foreign ownership emissions are positive or negative. A positive position implies that the GHG emissions of foreign production owned by domestic investors exceed those in domestic firms owned by foreigners. International ownership patterns of polluting firms and assets remain an understudied dimension in climate research, which has largely focused on policies that are based on the location of producers or consumers (Döbbling-Hildebrandt et al., 2024; Köppl & Schratzenstaller, 2023) rather than investors, studying instruments such as national carbon taxes (Andersson, 2019), carbon border adjustment mechanisms (Beaufils et al., 2023; Klemetsen et al., 2020) or emissions trading schemes (Dechezleprêtre et al., 2023; Klemetsen et al., 2020). Comparing ownership-based footprints with production- and consumption-based footprints across countries and regions helps us understand whether ownership structures reinforce other types of global emission imbalances, such as the net emission transfers between regions due to the import and export of goods and services in a consumption-based framework (Grubb et al., 2022). Some earlier studies examined multinational enterprises' emissions (López et al., 2019; Ortiz et al., 2020; Zhang et al., 2020), but these studies typically assign the emissions of subsidiaries to the headquarters of the group rather than to the countries where the ultimate owner individuals are located.

– *Insert Figure 1* –

– *Insert Box 1* –

2 Results

2.1 The role of top wealth groups as owners of polluting assets

Our findings underscore the outsized role of global top wealth groups as owners of polluting firms and assets (Figure 2). In 2022, the global top 1% wealth group (around 70–80 million

individuals) accounted for nearly 41% of private ownership emissions (29.9 Gt of CO₂-equivalent emissions (CO₂e)), exceeding the group's 36% share in global wealth. More than three quarters of private ownership emissions (77%) can be linked to the global top 10% wealth group. Average per capita emissions from privately owned assets were close to 165 tCO₂e for individuals in the global top 1% wealth group (and 33 tCO₂e for the top 10%) in 2022. This compares with average global private ownership-based emissions of 4 tCO₂e per capita. When looking at all ownership-based emissions (including government ownership emissions, for instance), the global average is close to 6.5 tCO₂e (Figure 2 and Supplementary Table 10). The average private ownership emissions of an individual in the global top 1% group exceed global per capita emissions by a factor of more than 25 (Figure 2). Ownership-based emissions are also substantially more concentrated at the top than consumption-based emissions (Bruckner et al., 2022). We did not find a decline in global top wealth groups' private ownership emissions between 2010 and 2022. Instead, our estimates suggest that the top 1% per capita emissions linked to private asset ownership stood at 158 tCO₂e in 2010 and 165 tCO₂e in 2022 (Table 1). Within the top 10% group, per capita averages were 31 tCO₂e in 2010 and 33 tCO₂e in 2022. Globally, per capita GHG emissions were approximately stable over the period (Supplementary Table 10), while private ownership emissions increased somewhat (5–6%) due to an increase in the global share of private ownership emissions over 2010–2022 (Table 1).

– *Insert Figure 2* –

– *Insert Table 1* –

The top wealth groups' emission shares from private asset ownership are higher than these groups' respective shares in global wealth. We show that this finding can be explained by two effects (Table 1). First, accounting for foreign ownership emissions increases top wealth groups' emission shares. This implies that members of the global top wealth groups are disproportionately located in countries that tend to own more polluting assets abroad than the rest of the world owns in their own countries (for example, Germany or the UK). Second, the emission share of top wealth groups increases significantly after we account for the asset portfolios held across wealth distributions within countries: consistent with earlier work (Chancel & Rehm, 2025), individuals in the top wealth groups hold a larger share of high-carbon-intensity asset classes (such as firm equity

and self-employed businesses) relative to total wealth than other groups, who tend to hold more low-intensity assets such as housing. Accounting for cross-border investment and asset portfolios (jointly) increases the global top 10%'s private ownership emission share from 67–68% to 77% in 2022 (Table 1). This pattern also holds at the country level. In 2022, the difference between the private ownership emission share and the top 1% wealth share ranges from 3 percentage points (China and the USA) to 16–19 percentage points (France, Germany and India) while the other top 25 emitting countries fall within that range (Supplementary Table 13).

– *Insert Figure 3* –

Country-level estimates confirm that private ownership emissions are highly concentrated among top wealth groups within countries, but magnitudes vary in line with the carbon intensity of economies as well as wealth inequality levels. Per capita values for the national top 1% stand at 36 (Nigeria), 48 (Pakistan), 90–100 (India, Indonesia and Vietnam), 219 (UK), 249 (France), 252 (Japan), 331 (Germany), 419 (USA) or 693 (Russia) tCO₂e (Figure 3 and Extended Data Table 1). At 172 tCO₂e per person, China's top 1% group lies relatively close to the global top 1% group in terms of its private ownership emissions (165 tCO₂e).

To put these numbers in perspective, the ownership emissions of top wealth groups are several orders of magnitude higher than production-based per capita emissions (Figure 3 and Extended Data Table 1). Top 1% private ownership emissions exceed per capita production-based emissions by factors of 16 (China), 24 (USA), 35 (India), 39 (Russia), 35 (Germany), 29 (UK) and 39 (France) in 2022. The factor lies in the 16–45 range in all top 25 emitting countries in 2022. The largest relative difference is observed in South Africa, where the top 1% wealth group's private ownership emissions stand at 385 tCO₂e compared with per capita production-based emissions of 8.5 tCO₂e in 2022 (Extended Data Table 1).

This degree of emissions concentration significantly exceeds the inequality measured in other carbon accounting frameworks (Hubacek et al., 2017; Starr et al., 2023; Wiedmann et al., 2020). In particular, the richest groups' ownership-based footprints markedly outweigh these groups' consumption-based footprints; ownership-based carbon inequality is thus generally higher than inequality in consumption-based frameworks. Earlier country-specific work found that the top 1%'s ownership-based footprints are higher than the group's consumption-based footprints by a factor

of 4 in the USA and 11–14 in France and Germany (Chancel & Rehm, 2025). These differences reflect both the investment strategies of investors across countries and differences in consumption choices (for example, the top 1%’s consumption-based footprint in the USA is significantly higher than in France or Germany). Ownership-based footprints also appear to be more concentrated than consumption-based footprints in other countries, according to available estimates (Bogra et al., 2025; Cachola & Pacca, 2023; European Union, 2024; Li et al., 2025).

Between 2010 and 2022, the global share of private ownership emissions increased from 54% to 58%, due to a relative decline in government-owned emissions (Supplementary Table 10). Globally, this overall increase in the share of private ownership emissions is reflected in even higher ownership emissions at the top and an increasing gap between top groups and the rest of the population in terms of per capita footprints over 2010–2022. In countries that reduced production-based emissions over 2010–2022, private ownership emissions among top wealth groups tended to increase or decline at a slower rate than production-based emissions. In most countries where production-based emissions increased, top ownership emissions rose faster than per capita production-based emissions (Extended Data Table 1). For example, production-based emissions per person in the USA decreased by 17% in 2010–2022. Over the same period, aggregate private ownership emissions decreased by 12% from 13 to 11 tCO₂e per capita, while they decreased by only 5% in the top 1% wealth group from 441 to 419 tCO₂e per person (Extended Data Table 1).

We also produced simplified estimates that distribute all global emission categories to individuals—that is, including government ownership emissions and direct household emissions rather than private ownership emissions only. Direct household emissions include, for example, those emissions linked to private heating and transport. Under this scenario, the global top 10% accounted for 60% of emissions in 2022 in our benchmark estimate, with bounds ranging from 53% to 66%, depending on the conventions used (Figure 2 and Supplementary Table 6). Per capita emissions amount to 44 tCO₂e in the global top 10% wealth group and 5 tCO₂e in the middle 40% group in 2022, compared with 33 tCO₂e and 2 tCO₂e when we consider private ownership-based emissions only (Figure 2). Private ownership emissions account for almost 80% of total emissions of the global top 1% versus less than 20% in the global bottom 50% wealth group (Figure 2).

For the three countries previously analysed in an ownership-based framework (Chancel & Rehm, 2025), we found that our simplified methodology aligns closely with the earlier estimates.

For example, top 10% shares in private ownership-based footprints are comparable in the USA (73% using this paper's methodology versus 72% in the more detailed paper, 2019), Germany (73% versus 68%, 2017) and France (87% versus 84%, 2017). The remaining differences are largely attributable to revisions in the underlying wealth inequality data since 2017.

2.2 Net foreign ownership emissions of countries and regions

We identified large differences across countries regarding their net foreign ownership emission position, defined as the difference between emissions of firms producing abroad but owned by domestic residents and emissions of domestic firms owned by foreign countries' residents (Figure 4 and Extended Data Table 2). This perspective complements other approaches used to compare emissions internationally, such as those based on comparing production-based and consumption-based emissions. Major western European economies, such as the UK, France, Italy and Germany, stand out as significant net importers of ownership-based emissions, with adjustments for cross-border investment increasing their production-based emissions by 16–40% in 2022 (Extended Data Table 3). These gaps are of a similar magnitude as the net emissions transfers through international trade under consumption-based accounting. Importantly, the gap between ownership- and production-based emission positions has grown in these countries over the 2010–2022 period, driven by declining domestic production-based emissions alongside stable or rising foreign ownership emissions. Similar patterns are observed in Japan and South Korea. In contrast, countries in central and eastern Europe, as well as most developing and emerging economies, show negative net foreign ownership emissions. This indicates that foreign-owned production emissions in these countries exceeds the emissions linked to their residents' investments abroad.

The positions of some of the world's largest economies illustrate a variety of patterns, which highlight that a country's net foreign asset and ownership emission positions do not have to move in the same direction. For instance, the USA records a slightly positive net foreign ownership position despite its negative net foreign asset position. China maintains a small but persistent negative position, with the highest absolute level of foreign-owned production emissions worldwide (Supplementary Table 7). Financial centres such as Switzerland, Singapore and Luxembourg show large positive positions that probably reflect their role as intermediaries in global investment

networks. Box 2 discusses additional country examples and provides further details on regional patterns.

– *Insert Box 2* –

– *Insert Figure 4* –

3 Discussion

Ownership-based emission footprints highlight a previously underexplored dimension of global climate inequality. Across country groups, we identified stark patterns in net foreign ownership emissions, which intensified in 2010–2022. It is a well-known fact that while production-based emissions have declined in many industrialized economies, these countries remain large net emission importers in a consumption-based carbon accounting framework through the purchase of foreign-made goods and services (Grubb et al., 2022). We show that many of these countries are also net emission owners of polluting production facilities abroad. In other words, not only does western Europe import foreign-made goods and the embedded emissions, but European investors also own significant parts of the polluting foreign production processes, including in central and eastern Europe. While local production emissions declined in 2010–2022 (for example, in large western European countries, Japan and South Korea), these countries' foreign ownership emissions did not. This implies that emission transfers linked to cross-border investment gained in importance since 2010, at least in relative terms.

Our results also reveal the extent to which emission footprints of the world's wealthiest groups go beyond these groups' immediate consumption and lifestyle choices and include the investment decisions they make (Figure 3). A scenario might be possible in which certain top wealth holders reduce their consumption-based footprint and private energy use (for example, through producing their own renewable energy, upgrading their heating systems or driving electric vehicles) but continue to hold vast carbon-intensive asset portfolios. Focusing on production- or consumption-based estimates then might not be sufficient to assess responsibilities and capacities to mitigate emissions. These challenges could also have an impact on which climate policies are considered fair (Dechezleprêtre et al., 2025).

The global patterns we identified could magnify over the coming years, particularly as the transfer of trade-related emissions from lower-income to higher-income countries appears to have peaked, according to some studies (Grubb et al., 2022; Peters et al., 2011; Wood et al., 2020; Yamano et al., 2024). Most global foreign direct investment is now directed towards developing economies, while more than two thirds of that investment still originates from developed countries (Supplementary Figure 9) (UNCTAD, 2024). More stringent domestic policies could also incentivize investors to invest their savings more heavily in carbon-intensive foreign production that serves foreign markets.

The global ownership patterns therefore seem to point towards a specific blind spot in climate policies. Countries have introduced policies aimed at reducing local emissions and, increasingly, consider measures to address carbon-intensive imports originating from other countries with less stringent climate policies (Beaufils et al., 2023; Klemetsen et al., 2020). To date, few or no measures have been proposed to address emissions associated with investors from high-income countries financing emissions-intensive production in developing regions, especially when such activity is tied to serving final demand in other developing countries.

Previously, we suggested that an emissions-adjusted tax on owning high-emitting assets could serve as a complementary tool to incentivize investment in lower emission assets. Additional instruments, such as regulations on foreign carbon-intensive investments held by residents, could also be envisaged to address foreign ownership-based emissions. Such policies would recognize the agency that owners and investors have over production choices and technologies at home and abroad (Bammens & Hünermund, 2020; Saeed et al., 2023; Su & Zhao, 2025), in addition to final consumers and the government. Policies of this type could also be more progressive in terms of their distributional impact than instruments that apply to consumption-based emissions and would target a group that might have a higher ability to change their behaviour, which could make them politically more feasible (Dechezleprêtre et al., 2025). Globally, ownership-based carbon pricing could incentivize developing countries to strengthen climate policies domestically if investors' home countries (for example, in western Europe) credited carbon pricing levied in developing countries against ownership-based taxes calculated for their countries' investors.

Before implementation, the impact of any ownership-based policy will have to be carefully studied, in particular through which channels these policies could contribute to emission reductions,

how the economic incidence would be distributed and how such measures could impact economic development efforts. Policy measures might also differentiate between ownership types that can come with different levels of control (for example, small shareholders of publicly traded companies). The ownership-based framework and the footprints presented in this study provide a starting point for such inquiries at the country and global levels. We highlight that ownership-based carbon footprint measures, as in any other carbon accounting framework, cannot be interpreted as the responsibility for emissions without further assumptions. Responsibility may depend on the level of control, agency, intentionality, information and alternatives (Chancel & Rehm, 2025; Fahlquist, 2009; Lenzen & Murray, 2010; Paul et al., 1999). Methods of shared attribution, such as the mixed-based approach developed earlier (or other methods developed in the literature (Lenzen et al., 2007; Zhang et al., 2023)), could be a way to recognize in the policy design that consumers and owners share the responsibility for GHG emissions.

Our study mobilizes the best data sources available to our knowledge to put a spotlight on a new dimension of global emissions dynamics and inequality. But significant improvements remain necessary to increase the quality of global ownership and wealth data, regarding portfolio compositions across wealth distributions in particular. Recent initiatives, such as the EU Sustainable Finance Disclosure Regulation and the Corporate Sustainability Due Diligence Directive, illustrate growing efforts to extend accountability requirements across financial and corporate value chains. Yet more standardized reporting frameworks will be necessary to systematically monitor ownership-based emissions.

This study provides a global account of ownership-based emissions, within and between countries. Advancing this research agenda will require a better understanding of how people perceive carbon footprints and how wealth-based emissions complement existing production-based and consumption-based accounting methods (Köchling et al., 2025). The backward-looking estimates presented here could be expanded to assess future ownership emissions linked to already-planned or ongoing fossil fuel projects (Kühne et al., 2022). More broadly, unequal contributions to emissions should always be considered jointly with other dimensions of climate inequality, including the uneven distribution of climate impacts as well as the effects of climate change itself on the distribution of income and wealth (Burke et al., 2015; Chancel et al., 2025; Diefenbaugh & Burke, 2019; Emmerling et al., 2024; Hsiang et al., 2017).

4 Methods

4.1 Ownership-based emission footprints for individuals, the government and countries

Private ownership-based emissions are defined as the annual scope 1 GHG emissions attributable to the capital assets held by an individual (Figure 1). Emissions considered include CO₂, CH₄, N₂O, hydrofluorocarbons, perfluorocarbons, NF₃ and SF₆ converted into tCO₂e on the basis of their 100-year global warming potential. We use the concept of scope 1 emissions to avoid double counting of emissions at the global level while implementing an approach that remains tractable and interpretable. For instance, an individual who owns 50% of a firm's equity would be assigned 50% of that firm's direct emissions. Emissions from coal combustion are attributed to the owner of the coal-fired power plant, rather than to the owners of firms or households that use the electricity produced or to the owners of firms involved in coal extraction. Other definitions are possible that move beyond scope 1 emissions, such as a mixed approach, which separates investment-related emissions in a demand-based framework (Chancel & Rehm, 2025; Weber, 2022). Holding financial assets that do not confer ownership rights, such as corporate or government bonds or bank deposits, does not contribute to an individual's emission footprint in the framework. The framework could be adapted so that holding these assets also contributes to the footprints of individuals, although issues such as the risk of double counting would have to be addressed when global estimates are provided. Here, a strict ownership perspective is followed, assuming that firm decisions are ultimately made by firm owners.

This perspective, introduced in earlier work (Chancel & Rehm, 2025; Weber, 2022), is intended to complement existing methods that assign emissions to individuals (on the basis of consumption or direct energy use) or to firms (on the basis of production). The rationale is that production emissions are partly the result of decisions made by individuals who own the underlying assets and that these individuals benefit financially from polluting activities. Complementing conventional carbon footprinting approaches with ownership-based footprints can provide a more comprehensive picture of an individual's or country's total emission footprint, particularly for those with substantial wealth.

National emissions in the ownership-based approach ($E_c^{\text{own-natl}}$) in country c are defined as the sum of private ownership-based emissions (E_c^{priv}), government ownership emissions (E_c^{gov}) and

direct household emissions (E_c^{HH}), after accounting for the cross-border ownership of polluting assets. The government is attributed ownership-based emissions on the basis of GHG emissions in firms and activities it (partially) owns. The ownership-based footprint of country c can be expressed as a function of the national production-based footprint (E_c^{prod}) and the net foreign emission position ($E_c^{\text{own,abroad}} - E_c^{\text{for-own,dom}}$):

$$E_c^{\text{own-natl}} = E_c^{\text{prod}} + E_c^{\text{own,abroad}} - E_c^{\text{for-own,dom}}$$

We can split the total emissions of production located abroad and owned by residents ($E_c^{\text{own,abroad}}$) into the part that is owned by private households ($E_c^{\text{priv-own,abroad}}$) and the part owned by the government ($E_c^{\text{gov-own,abroad}}$). We can then define E_c^{priv} in c as:

$$E_c^{\text{priv}} = \left(E_c^{\text{prod}} - E_c^{\text{HH}} - E_c^{\text{gov-own,dom}} \right) + E_c^{\text{priv-own,abroad}} - E_c^{\text{for-own,dom}}$$

4.2 Aggregate production-based, consumption-based and ownership-based emission footprints

Production- and consumption-based emissions by country are sourced from the Eurostat-FIGARO project's emissions database (January 2025 vintage) (Eurostat, 2024; Remond-Tiedrez & Rueda-Cantuche, 2019). The production-based emissions of the 45 countries included in the FIGARO database account for 79% of global emissions in 2022. For countries not covered in the dataset, we allocated emissions reported under the 'rest of the world' category using country-level emissions data from the EU-EDGAR database (version 8.0) (IEA and JRC, 2024). These data did not allow us to attribute international aviation and shipping emissions to countries, which explains why the global GHG emissions coverage is close to 98% in our dataset (Supplementary Methods 1). We used public and private capital stocks from the IMF Investment and Capital Stock Dataset (Xiao et al., 2021) to divide ownership of polluting activities between the government and private households within countries, on the basis of the public capital stock share (s_c^{pub}). In cases where data on direct household emissions were unavailable, we imputed missing values using the average share observed across countries and residual global private household emissions. We used additional data from GCP Global Carbon Budget 2023 to compare production- and consumption-based emissions in

countries not covered in the FIGARO database, in particular for the regional comparisons in Figure 4 (Peters et al., 2012). More details about all data series, imputations and how data sources were combined to arrive at the 197 jurisdictions in the final global dataset are provided in Supplementary Methods 1.

4.3 Net foreign ownership emission positions

For each country, we constructed a proxy for the share of domestic production owned abroad, along with a breakdown of investor countries. Standard datasets on international investment include financial assets that do not confer ownership rights over productive assets, such as sovereign or corporate bonds, and they often do not trace investments to their ultimate owner countries, which could distort results. To proxy foreign-owned production, we therefore relied on the share of value added in foreign-controlled enterprises (φ_c) using the OECD Analytical Activities of Multinational Enterprises database (Cadestin et al., 2018). The rationale is that this method can better capture the share of domestic polluting activity owned by foreigners (Supplementary Methods 4). We present results under two alternative methods and demonstrate that the general patterns regarding the international ownership of emissions do not change (Supplementary Figure 1). Using these alternative methods, the patterns we identified would be magnified (for example, we would find even larger net foreign ownership emissions in western Europe), and a greater share of emissions would be attributed to financial centres such as Luxembourg and Switzerland. To allocate foreign-owned emissions to investor countries, we drew on the international FDI dataset developed by Damgaard et al. (Damgaard et al., 2024), which adjusts reported cross-border equity positions for investment in special-purpose entities, round-tripping and offshore investment vehicles. We defined the share of country c in the inward investment stock of country c' as $s_{c'}^c$. With this approach, we attempted to identify ultimate investor countries to yield a mapping of global investment–emission linkages that is more aligned with our ownership–emissions concept than relying on conventional bilateral FDI statistics. The study used the latest available data point for each country, corresponding to 2020 for foreign ownership shares and 2017 for the investor country breakdown of international ownership emissions. In the absence of more recent data, we carried forward the most recent available shares and country breakdowns to subsequent years. Implicitly, we assumed that foreign and domestically owned activities in each country follow the average carbon intensity of that

country's productive activities. While this remains a data limitation of the approach, the choice was motivated by recent findings that differences are not substantial (Borga et al., 2022) and that it probably does not impact the sign of the net foreign ownership emission position of countries. We performed a number of sensitivity checks and found that, even under the most extreme assumptions, the sign of the net foreign emission position would flip in only two countries out of the 25 most polluting economies in 2022 from slightly negative to slightly positive or the reverse (Supplementary Figure 11).

Private ownership-based emissions (E_c^{priv}) are then proxied by:

$$E_c^{\text{priv}} = \left(1 - s_c^{\text{pub}}\right) \left[(1 - \varphi_c) \left(E_c^{\text{prod}} - E_c^{\text{HH}} \right) + E_c^{\text{own,abroad}} \right]$$

with:

$$E_c^{\text{own,abroad}} = \sum_{c' \neq c} s_{c'}^c E_{c'}^{\text{for-own,dom}}$$

4.4 Distributional ownership-based emission footprints

This study takes advantage of the unique country-level and global wealth distribution datasets developed over recent decades using the Distributional National Accounts (DINA) methodology (Blanchet et al., 2024; Piketty et al., 2018) by a large international network of researchers. These estimates are consolidated in the World Inequality Database, which over the 2010–2022 period covers 216 countries and jurisdictions. To account for the asset portfolio composition, we relied on a variety of sources, including the Household Finance and Consumption Survey for European countries (HFCN, 2021), the DINA micro-files for the USA (Piketty et al., 2018) and a recent study for China (Bauluz et al., 2022). Specifically, we used the data series produced by Blanchet and Martínez-Toledano (Blanchet & Martínez-Toledano, 2023) for European countries, and we constructed a composite country distribution based on the average wealth portfolios in developed countries for countries without country-level data. The wealth distribution itself is sourced from the World Inequality Database. We explain the data sources, imputations and additional sensitivity analysis in detail in Supplementary Methods 1 and 5. We also provide a list of studies that demonstrate empirically in a large number of countries that the portfolio weight of firm ownership,

and private equity in particular, increases with wealth (Supplementary Table 5).

Aggregate private ownership emissions in a country (E_c^{priv}) are attributed in proportion to pension, self-employed and equity assets owned by the respective wealth groups within each country. Although housing is a major asset class among wealth owned by households, it has a very low emission intensity in the ownership-based accounting framework, primarily because heating emissions are treated as direct household emissions and construction emissions contribute to the footprint of construction firm owners. Earlier work indicates that including heating emissions in the footprints of house owners instead of those of tenants (where the two are not the same person) would only modestly increase emission inequality. In the simplified method we used here, we allocated private ownership emissions (E_c^{priv}) only in proportion to pension, self-employment and equity assets (within countries) and did not assign any emissions to housing assets. We finally aggregated country-level data on wealth and ownership-based emissions to construct the global distribution of both.

When we present estimates of the distribution of all global emissions in the ownership-based framework ($E_c^{\text{own-natl}}$), instead of private ownership emissions only, we apply the following attribution method: emissions from government-owned assets are attributed as a lump-sum amount to individuals within each country if they serve education and health purposes and in proportion to income for other types of government activity. Direct household emissions are assigned, in this scenario, using a wealth-to-household emission elasticity parameter that we estimate on the basis of more granular data we have in France, Germany and the USA (Chancel & Rehm, 2025). Supplementary Methods 5 provides more details on conventions used and their impact on results. Because the assumptions made will remain subject to debate, these estimates should be understood as providing a general intuition as to how overall emissions may be distributed in an ownership-based framework if government ownership emissions and direct household emissions are distributed to individuals as well.

References

- Alstadsæter, A., Johannesen, N., & Zucman, G. (2018). Who owns the wealth in tax havens? Macro evidence and implications for global inequality. *Journal of Public Economics*, 162, 89–100. <https://doi.org/10.1016/j.jpubeco.2018.01.008>
- Andersson, J. J. (2019). Carbon taxes and CO2 emissions: Sweden as a case study. *American Economic Journal: Economic Policy*, 11(4), 1–30. <https://doi.org/10.1257/pol.20170144>
- Bammens, Y., & Hünermund, P. (2020). Nonfinancial considerations in eco-innovation decisions: the role of family ownership and reputation concerns. *Journal of Product Innovation Management*, 37, 431–453. <https://doi.org/10.1111/jpim.12550>
- Bauluz, L., Novokmet, F., & Schularick, M. (2022). *The Anatomy of the Global Saving Glut* (CEPR Discussion Paper No. 17215). Centre for Economic Policy Research. <https://cepr.org/publications/dp17215>
- Beaufils, T., Ward, H., Jakob, M., & Wenz, L. (2023). Assessing different European Carbon Border Adjustment Mechanism implementations and their impact on trade partners. *Communications Earth & Environment*, 4, 131. <https://doi.org/10.1038/s43247-023-00788-4>
- Blanchet, T., Chancel, L., Flores, I., & Morgan, M. (2024). *Distributional National Accounts Guidelines – Methods and Concepts Used in the World Inequality Database* (tech. rep.). World Inequality Lab. <https://wid.world/document/distributional-national-accounts-guidelines-2020-concepts-and-methods-used-in-the-world-inequality-database/>
- Blanchet, T., & Martínez-Toledano, C. (2023). Wealth inequality dynamics in Europe and the United States: understanding the determinants. *Journal of Monetary Economics*, 133, 25–43. <https://doi.org/10.1016/j.jmoneco.2022.11.010>
- Bogra, S., Creutzig, F., & Pichler, P. (2025). India's household GHG emissions from basic goods: regional patterns and inequalities. *Journal of Industrial Ecology*, 29, 1736–1747. <https://doi.org/10.1111/jiec.70059>
- Borga, M., Pegoue, A., Legoff, G. M., Sanchez Rodelgo, A., Entaltsev, D., & Egesa, K. (2022). *Measuring Carbon Emissions of Foreign Direct Investment in Host Economies* (IMF Working Papers No. 2022/086). International Monetary Fund. <https://doi.org/10.5089/9798400206863.001>

- Bruckner, B., Hubacek, K., Shan, Y., Zhong, H., & Feng, K. (2022). Impacts of poverty alleviation on national and global carbon emissions. *Nature Sustainability*, 5, 311–320. <https://doi.org/10.1038/s41893-021-00842-z>
- Burke, M., Hsiang, S. M., & Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature*, 527, 235–239. <https://doi.org/10.1038/nature15725>
- Cachola, C. d., & Pacca, S. A. (2023). Carbon footprint of Brazilian families based on the Household Budget Survey and input-output analysis. *Ambiente & Sociedade*, 26, e00392. <https://doi.org/10.1590/1809-4422asoc2022039r2vu2023L4OA>
- Cadestin, C., De Backer, K., Desnoyers-James, I., Miroudot, S., Rigo, D., & Ye, M. (2018). *Multinational enterprises and global value chains: the OECD analytical AMNE database* (OECD Trade Policy Papers No. 211). OECD. <https://doi.org/10.1787/d9de288d-en>
- Chancel, L., & Rehm, Y. (2025). Accounting for the carbon footprint of capital ownership advances the understanding of emission inequality. *Climatic Change*, 178, 211. <https://doi.org/10.1007/s10584-025-04044-w>
- Chancel, L., & Rehm, Y. (2026). Replication package and data: Global inequalities in ownership-based carbon footprints. <https://doi.org/10.5281/zenodo.19366483>
- Chancel, L. (2022). Global carbon inequality over 1990–2019. *Nature Sustainability*, 5(11), 931–938. <https://doi.org/10.1038/s41893-022-00955-z>
- Chancel, L., Mohren, C., Bothe, P., & Semieniuk, G. (2025). Climate change and the global distribution of wealth. *Nature Climate Change*, 15(4), 364–374. <https://doi.org/10.1038/s41558-025-02268-3>
- Damgaard, J., Elkjaer, T., & Johannesen, N. (2024). What is real and what is not in the global FDI network? *Journal of International Money and Finance*, 140, 102971. <https://doi.org/10.1016/j.jimonfin.2023.102971>
- Dechezleprêtre, A., et al. (2025). Fighting climate change: international attitudes toward climate policies. *American Economic Review*, 115, 1258–1300. <https://doi.org/10.1257/aer.20230501>
- Dechezleprêtre, A., Nachtigall, D., & Venmans, F. (2023). The joint impact of the European Union emissions trading system on carbon emissions and economic performance. *Journal of Environmental Economics and Management*, 118, 102758. <https://doi.org/10.1016/j.jeem.2022.102758>

- Dietzenbacher, E., Cazcarro, I., & Arto, I. (2020). Towards a more effective climate policy on international trade. *Nature Communications*, *11*(1). <https://doi.org/10.1038/s41467-020-14837-5>
- Diffenbaugh, N. S., & Burke, M. (2019). Global warming has increased global economic inequality. *Proceedings of the National Academy of Sciences*, *116*, 9808–9813. <https://doi.org/10.1073/pnas.1816020116>
- Döbbeling-Hildebrandt, N., et al. (2024). Systematic review and meta-analysis of ex-post evaluations on the effectiveness of carbon pricing. *Nature Communications*, *15*, 4147. <https://doi.org/10.1038/s41467-024-48512-w>
- Emmerling, J., et al. (2024). A multi-model assessment of inequality and climate change. *Nature Climate Change*, *14*, 1254–1260. <https://doi.org/10.1038/s41558-024-02151-7>
- European Union. (2024). *Carbon and environmental footprint inequality of household consumption in the EU—a new methodology* (tech. rep.). Publications Office of the European Union. <https://doi.org/10.2760/841471>
- Eurostat. (2024). *Methodological Note: FIGARO Greenhouse Gas Emissions* (tech. rep.). Publications Office of the European Union. https://ec.europa.eu/eurostat/documents/1798247/6191529/Methodological+Note_GHG_estimates_FIGARO_21_June_2024.pdf/b23da1a7-d8bb-6834-0608-7fc9bb293ddc?t=1719303162181
- Fahlquist, J. N. (2009). Moral responsibility for environmental problems—individual or institutional? *Journal of Agricultural and Environmental Ethics*, *22*, 109–124. <https://doi.org/10.1007/s10806-008-9134-5>
- Galaz, V., et al. (2018). Tax havens and global environmental degradation. *Nature Ecology & Evolution*, *2*, 1352–1357. <https://doi.org/10.1038/s41559-018-0497-3>
- Gallego, B., & Lenzen, M. (2005). A consistent input–output formulation of shared producer and consumer responsibility. *Economic Systems Research*, *17*, 365–391. <https://doi.org/10.1080/09535310500283492>
- Grubb, M., et al. (2022). Carbon leakage, consumption, and trade. *Annual Review of Environment and Resources*, *47*, 753–795. <https://doi.org/10.1146/annurev-environ-120820-053625>

- HFCN. (2021). *Household Finance and Consumption Survey: Methodological Report for the 2021 Wave* (ECB Statistics Paper Series No. 45). European Central Bank. <https://www.ecb.europa.eu/pub/pdf/scpsps/ecb.sps45~4bbcfb02eb.en.pdf>
- Hsiang, S., et al. (2017). Estimating economic damage from climate change in the United States. *Science*, 356, 1362–1369. <https://doi.org/10.1126/science.aal4369>
- Hubacek, K., Baiocchi, G., Feng, K., Muñoz Castillo, R., Sun, L., & Xue, J. (2017). Global carbon inequality. *Energy, Ecology and Environment*, 2(6), 361–369. <https://doi.org/10.1007/s40974-017-0072-9>
- IEA and JRC. (2024). *GHG Emissions of All World Countries—EDGAR* (tech. rep.). Publications Office of the European Union. <https://doi.org/10.2760/4002897>
- Ivanova, D., & Wood, R. (2020). The unequal distribution of household carbon footprints in Europe and its link to sustainability. *Global Sustainability*, 3. <https://doi.org/10.1017/sus.2020.12>
- Jakob, M., Ward, H., & Steckel, J. C. (2021). Sharing responsibility for trade-related emissions based on economic benefits. *Global Environmental Change*, 66. <https://doi.org/10.1016/j.gloenvcha.2020.102207>
- Kander, A., Jiborn, M., Moran, D. D., & Wiedmann, T. O. (2015). National greenhouse-gas accounting for effective climate policy on international trade. *Nature Climate Change*, 5(5), 431–435. <https://doi.org/10.1038/nclimate2555>
- Klemetsen, M. E., Rosendahl, K. E., & Jakobsen, A. L. (2020). The impacts of the EU ETS on Norwegian plants' environmental and economic performance. *Climate Change Economics*, 11, 2050006. <https://doi.org/10.1142/S2010007820500062>
- Köchling, J., et al. (2025). The carbon perception gap in actual and ideal carbon footprints across wealth groups. *Nature Communications*, 16, 6180. <https://doi.org/10.1038/s41467-025-61505-7>
- Köppl, A., & Schratzenstaller, M. (2023). Carbon taxation: a review of the empirical literature. *Journal of Economic Surveys*, 37, 1353–1388. <https://doi.org/10.1111/joes.12531>
- Kühne, K., Bartsch, N., Tate, R. D., Higson, J., & Habet, A. (2022). “Carbon Bombs”—mapping key fossil fuel projects. *Energy Policy*, 166, 112950. <https://doi.org/10.1016/j.enpol.2022.112950>
- Lenzen, M., & Murray, J. (2010). Conceptualising environmental responsibility. *Ecological Economics*, 70, 261–270. <https://doi.org/10.1016/j.ecolecon.2010.04.005>

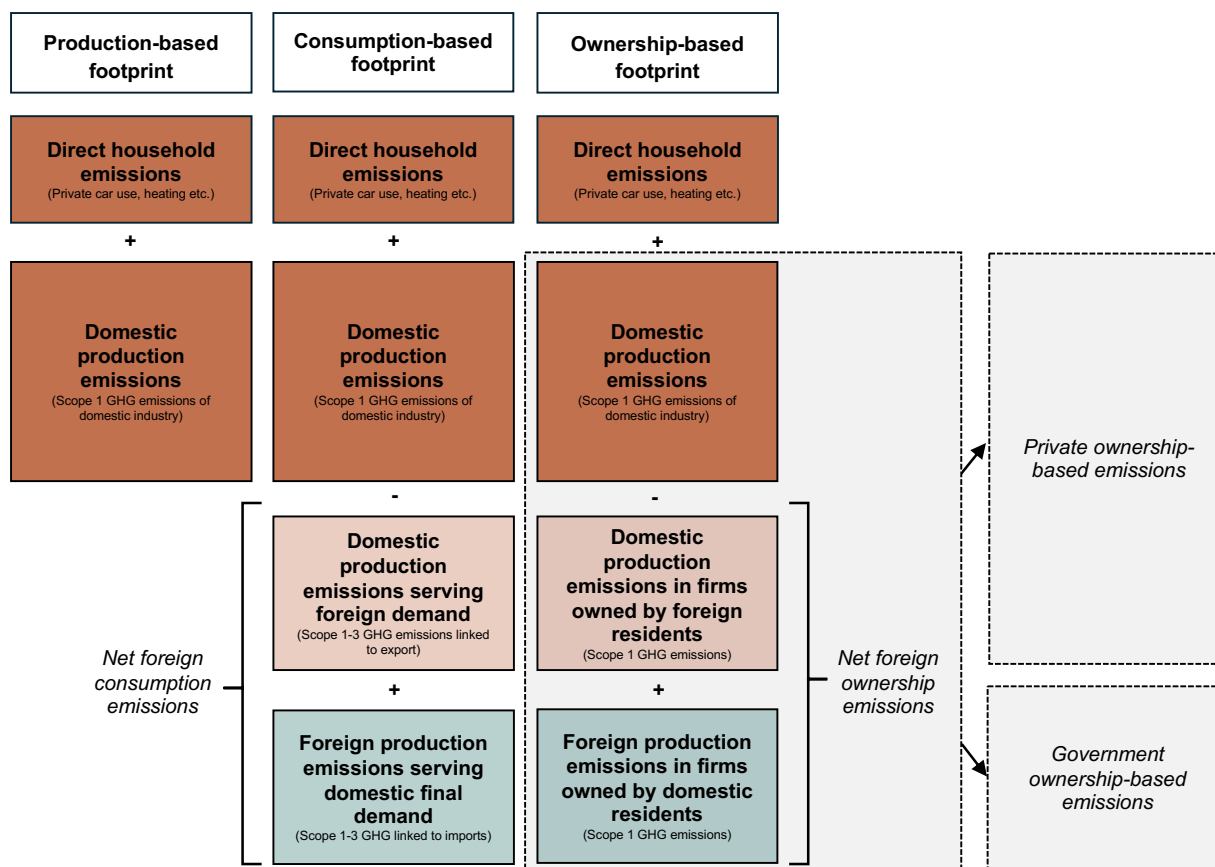
- Lenzen, M., Murray, J., Sack, F., & Wiedmann, T. (2007). Shared producer and consumer responsibility—theory and practice. *Ecological Economics*, *61*, 27–42. <https://doi.org/10.1016/j.ecolecon.2006.05.018>
- Li, M., Wiedmann, T., & Shen, T. (2025). Towards consumption-based carbon inequality metrics: socioeconomic and demographic insights from Chinese households. *Sustainability*, *17*, 4916. <https://doi.org/10.3390/su17114916>
- López, L. A., Cadarso, M. Á., Zafrilla, J., & Arce, G. (2019). The carbon footprint of the U.S. multinationals' foreign affiliates. *Nature Communications*, *10*, 1672. <https://doi.org/10.1038/s41467-019-09473-7>
- Marques, A., Rodrigues, J., Lenzen, M., & Domingos, T. (2012). Income-based environmental responsibility. *Ecological Economics*, *84*, 57–65. <https://doi.org/10.1016/j.ecolecon.2012.09.010>
- Novokmet, F., Piketty, T., & Zucman, G. (2018). From Soviets to oligarchs: inequality and property in Russia 1905–2016. *The Journal of Economic Inequality*, *16*, 189–223. <https://doi.org/10.1007/s10888-018-9383-0>
- Ortiz, M., López, L. A., & Cadarso, M.-Á. (2020). EU carbon emissions by multinational enterprises under control-based accounting. *Resources, Conservation and Recycling*, *163*. <https://doi.org/10.1016/j.resconrec.2020.105104>
- Oswald, Y., Owen, A., & Steinberger, J. K. (2020). Large inequality in international and intranational energy footprints between income groups and across consumption categories. *Nature Energy*, *5*, 231–239. <https://doi.org/10.1038/s41560-020-0579-8>
- Otto, I. M., Kim, K. M., Dubrovsky, N., & Lucht, W. (2019). Shift the focus from the super-poor to the super-rich. *Nature Climate Change*, *9*, 82–84. <https://doi.org/10.1038/s41558-019-0402-3>
- Paul, E. F., Miller, F. D., & Paul, J. (Eds.). (1999). *Responsibility. Social Philosophy and Policy* (Vol. 16, Pt. 2). Cambridge University Press.
- Peters, G. P., Andrew, R. M., Solomon, S., & Friedlingstein, P. (2015). Measuring a fair and ambitious climate agreement using cumulative emissions. *Environmental Research Letters*, *10*, 105004. <https://doi.org/10.1088/1748-9326/10/10/105004>
- Peters, G. P., Davis, S. J., & Andrew, R. (2012). A synthesis of carbon in international trade. *Biogeosciences*, *9*, 3247–3276. <https://doi.org/10.5194/bg-9-3247-2012>

- Peters, G. P., Minx, J. C., Weber, C. L., & Edenhofer, O. (2011). Growth in emission transfers via international trade from 1990 to 2008. *Proceedings of the National Academy of Sciences*, *108*, 8903–8908. <https://doi.org/10.1073/pnas.1006388108>
- Piketty, T., Saez, E., & Zucman, G. (2018). Distributional national accounts: methods and estimates for the United States. *The Quarterly Journal of Economics*, *133*, 553–609. <https://doi.org/10.1093/qje/qjx043>
- Pottier, A., & Le Treut, G. (2023). Quantifying GHG emissions enabled by capital and labor: Economic and gender inequalities in France. *Journal of Industrial Ecology*, *27*(2), 624–636. <https://doi.org/10.1111/jiec.13383>
- Remond-Tiedrez, I., & Rueda-Cantuche, J. M. (2019). *EU Inter-Country Supply, Use and Input–Output Tables–Full International and Global Accounts for Research in Input–Output Analysis (FIGARO)* (tech. rep.). Publications Office of the European Union. <https://ec.europa.eu/eurostat/documents/3888793/10109187/KS-TC-19-002-EN-N.pdf>
- Saeed, A., Riaz, H., Liedong, T. A., & Rajwani, T. (2023). Does family matter? Ownership, motives and firms' environmental strategy. *Long Range Planning*, *56*, 102216. <https://doi.org/10.1016/j.lrp.2022.102216>
- Starr, J., Nicolson, C., Ash, M., Markowitz, E. M., & Moran, D. (2023). Income-based U.S. household carbon footprints (1990–2019) offer new insights on emissions inequality and climate finance. *PLOS Climate*, *2*, e0000190. <https://doi.org/10.1371/journal.pclm.0000190>
- Su, W., & Zhao, X. (2025). The impact of common institutional ownership on green innovation of China's energy firms. *Humanities and Social Sciences Communications*, *12*, 1387. <https://doi.org/10.1057/s41599-025-05570-9>
- UNCTAD. (2024). *World Investment Report 2024* (tech. rep.). United Nations Conference on Trade and Development. <https://unctad.org/publication/world-investment-report-2024>
- Weber, I. M. (2022). Big Oil's profits and inflation: winners and losers. *Challenge*, *65*, 151–159. <https://doi.org/10.1080/05775132.2022.2156156>
- Wiedmann, T., Lenzen, M., Keyßer, L. T., & Steinberger, J. K. (2020). Scientists' warning on affluence. *Nature Communications*, *11*(1). <https://doi.org/10.1038/s41467-020-16941-y>

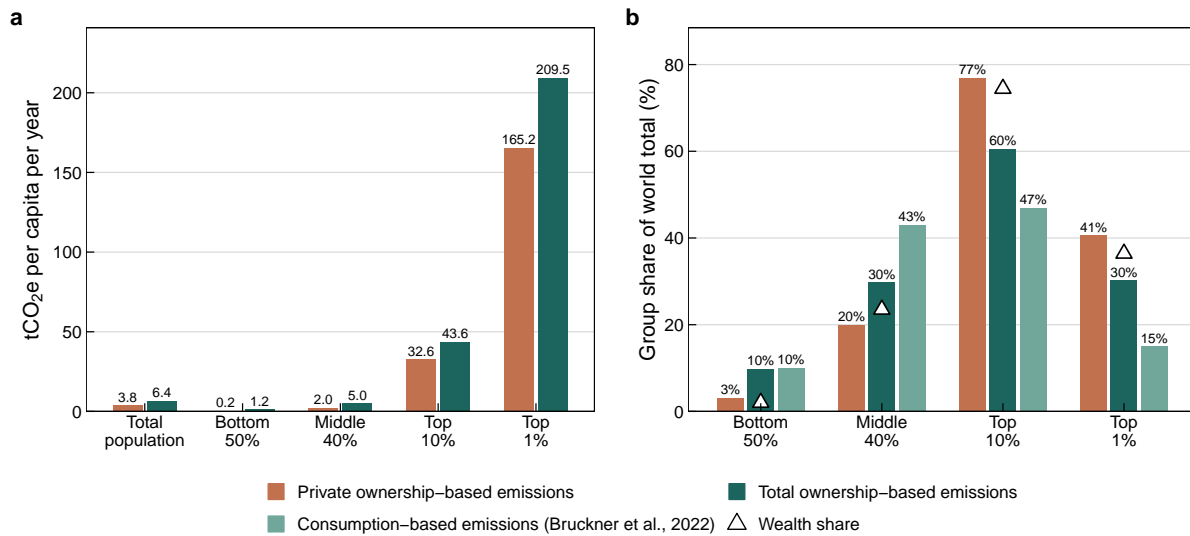
- Wood, R., et al. (2020). Beyond peak emission transfers: historical impacts of globalization and future impacts of climate policies on international emission transfers. *Climate Policy*, 20, 14–27. <https://doi.org/10.1080/14693062.2019.1619507>
- Xiao, Y., Amaglobeli, D., & Matsumoto, R. (2021). *IMF ICSD Dataset* (tech. rep.). International Monetary Fund. https://infrastructuregovern.imf.org/content/dam/PIMA/Knowledge-Hub/dataset/InvestmentandCapitalStockDatabaseUserManualandFAQ_May2021.pdf
- Yamano, N., Lioussis, M., & Cimper, A. (2024). *Measuring Greenhouse Gas Footprints in Global Production Networks* (OECD Science, Technology and Industry Working Papers No. 2024/12). OECD Publishing. <https://doi.org/10.1787/fc426ab9-en>
- Zhang, Y., Hu, S., Yan, D., & Jiang, Y. (2023). Proposing a carbon emission responsibility allocation method with benchmark approach. *Ecological Economics*, 213, 107971. <https://doi.org/10.1016/j.ecolecon.2023.107971>
- Zhang, Z., et al. (2020). Embodied carbon emissions in the supply chains of multinational enterprises. *Nature Climate Change*, 10, 1096–1101. <https://doi.org/10.1038/s41558-020-0895-9>

Figures and Tables

Figure 1: Ownership-based footprints compared to other carbon accounting frameworks



Note: The ownership-based footprint concept compared to consumption- and production-based footprints at the country level. Private ownership-based emissions include emissions linked to private households' firm and asset ownership. Here we distribute private ownership emissions to individuals using wealth distribution and composition data. Private households' electricity emissions are included in electricity plant owners' footprints. Residential heating emissions are included in direct household emissions as per air emissions accounting guidelines. These emissions could potentially be included in production emissions of the real estate sector and then distributed to owners rather than tenants where they are not the same person. At the global level, 58% of GHG emissions (29 916 MtCO₂e) correspond to private ownership-based emissions, 30% to government ownership emissions (15 361 MtCO₂e) and 12% to direct household emissions (6 094 MtCO₂e) in 2022 (Supplementary Table 10).

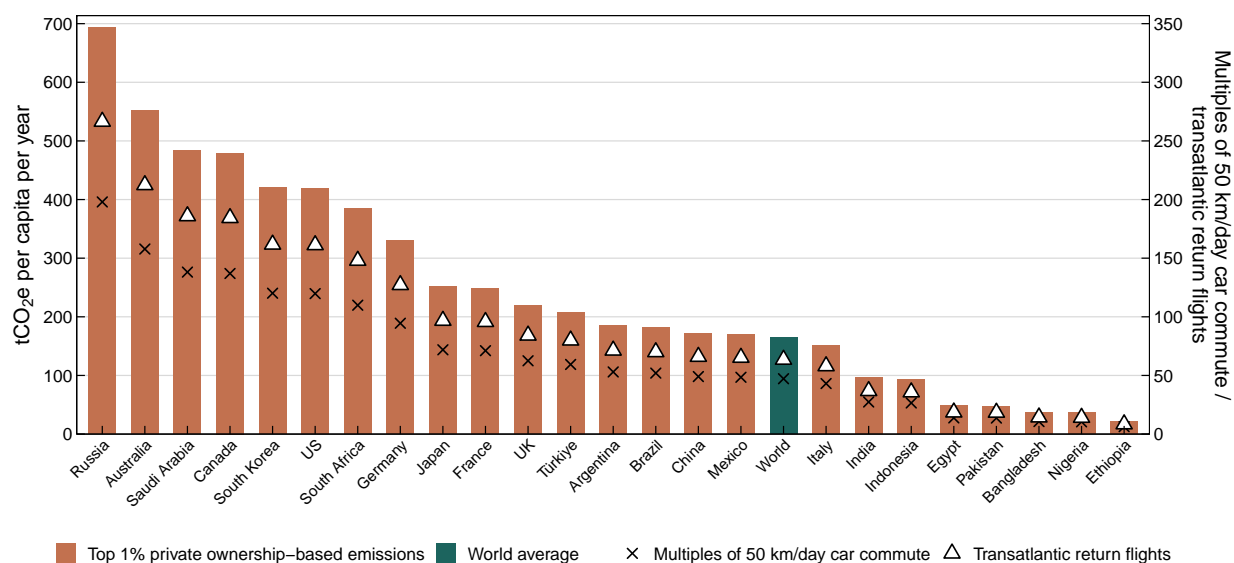
Figure 2: Global distribution of ownership-based GHG emissions in 2022

Note: **a**, Per capita emissions in each group in tCO₂e. **b**, Group share in global emissions. The light green bars show results from an earlier study that estimated global emission inequality on the basis of a framework that distributes emissions in a final demand-based framework to final consumers, but on the basis of ranking individuals by emissions rather than by wealth (Bruckner et al., 2022). Groups are defined in terms of net personal wealth. Private ownership-based emissions include scope 1 emissions associated with firms and assets owned by individuals (Figure 1). Total emissions include government ownership emissions and direct household emissions, in addition to private ownership-based emissions.

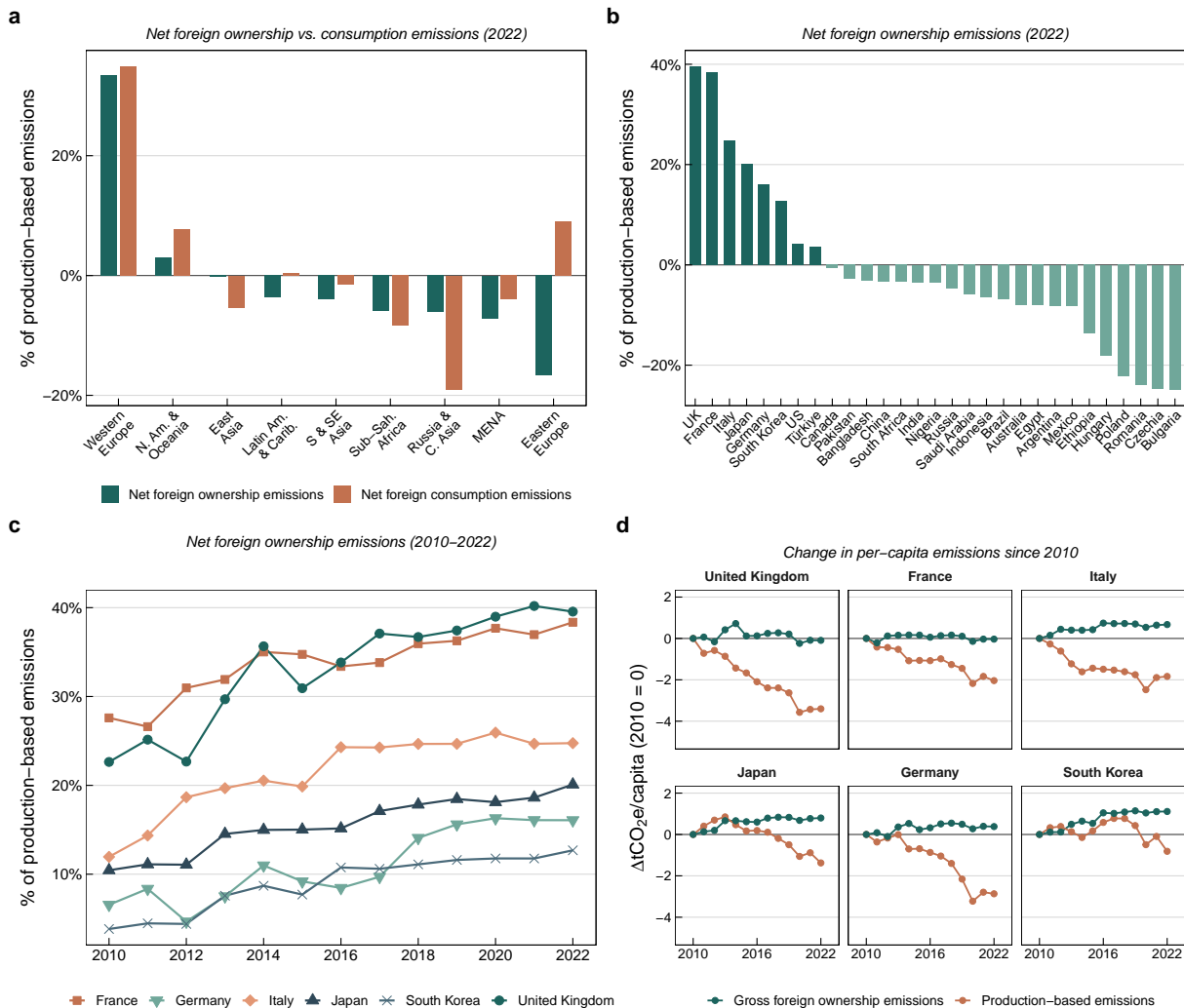
Table 1: Global private ownership-based emissions in 2010 and 2022

Year	Category	Bottom 50%	Middle 40%	Top 10%	Top 1%	Total population
(a) Per capita emissions (tCO₂e) by net wealth group						
2010	Private ownership-based emissions	0.2	1.9	31.0	158.3	3.6
	Excl. portfolio composition	0.2	2.5	28.6	137.8	3.6
	Excl. net foreign ownership emissions	0.2	2.6	27.5	132.1	3.5
2022	Private ownership-based emissions	0.2	2.0	32.6	165.2	3.8
	Excl. portfolio composition	0.2	2.7	29.3	144.9	3.8
	Excl. net foreign ownership emissions	0.3	2.8	28.4	140.0	3.7
(b) Group shares (%) by net wealth group						
2010	Private ownership-based emissions	3.1%	20.3%	76.6%	38.5%	100.0%
	Excl. portfolio composition	2.2%	27.3%	70.4%	33.9%	100.0%
	Excl. net foreign ownership emissions	2.5%	28.9%	68.6%	32.8%	100.0%
	<i>Net wealth</i>	1.4%	23.9%	74.8%	35.9%	100.0%
2022	Private ownership-based emissions	3.1%	19.9%	77.0%	40.6%	100.0%
	Excl. portfolio composition	3.2%	27.6%	69.2%	33.7%	100.0%
	Excl. net foreign ownership emissions	3.5%	29.0%	67.5%	32.8%	100.0%
	<i>Net wealth</i>	2.0%	23.5%	74.5%	36.4%	100.0%

Note: Private ownership-based emissions include scope 1 emissions associated with firms and assets owned by individuals (Figure 1). *Excl. portfolio composition* refers to estimating private ownership-based emissions without accounting for the changing portfolio composition across the wealth distribution—that is, using only overall wealth to distribute private ownership-based emissions within countries. *Excl. net foreign ownership emissions* refers to estimating private ownership-based emissions without accounting for cross-border investment—that is, using only domestic production-based emissions to distribute emissions to asset holders. *Excl. net foreign ownership emissions* also does not account for the portfolio composition so that the additional considerations from the bottom to the upper rows are additive.

Figure 3: Top 1% private ownership-based emissions per capita in 2022

Note: Per capita emissions in the top 1% wealth group expressed in tCO₂e per year (left *y* axis). Private ownership-based emissions include scope 1 emissions of firms and assets owned by individuals. Transatlantic return flight emissions (Paris–New York) in economy class are estimated at 2.6 tCO₂e and include non-CO₂ effects. Commuting emissions for a daily 50-km trip on 250 days per year using a medium-sized petrol car are estimated at 3.5 tCO₂e. Private ownership emissions of the average individual in the top 1% wealth group in France are similar to (1) the emissions of 90 annual return flights between Paris and New York or (2) 66 times the emissions produced by a daily 50-km commute by car (that is, similar to driving 3 300 km per day). A more conservative flight emissions estimate would further increase the multiples. Countries include G20 members and the five largest countries by population outside the G20. Results for more countries are presented in Extended Data Table 1 and in the online database released with the paper.

Figure 4: Net foreign ownership emissions versus consumption and production emissions

Note: **a**, Net foreign ownership and net foreign consumption emissions in world regions, expressed in percentages of the region's production-based emissions. Regions with positive net foreign consumption emissions are net importers of emissions through international trade. Consumption-based estimates refer to 2021 and are sourced from the Global Carbon Project's Carbon Budget 2023. The composition of country groupings and the unabbreviated name of country groups are shown in Supplementary Table 1. Sensitivity checks by country sample are presented in Supplementary Figure 5. The values are presented in Extended Data Table 2. **b**, Net foreign ownership emissions in selected countries in 2022. The countries include G20 members, the five largest countries by population outside the G20 and five countries from central-eastern Europe. **c**, Net foreign ownership emissions in 2010–2022 in the six countries with the largest net foreign ownership positions among the top 25 emitters in 2022. **d**, Change in gross foreign ownership emissions and production-based per capita emissions in tCO₂e since 2010. Supplementary Figure 13 includes net foreign ownership emissions.

Boxes

Box 1 | Ownership-based carbon accounting

The framework used in this paper distinguishes ownership-based emission footprints from production- and consumption-based footprints (Figure 1). A country's production-based footprint includes resident economic actors' scope 1 production emissions as well as private households' direct emissions (such as private transport emissions or heating-related emissions). A country's consumption-based footprint includes, in addition to its production-based footprint, the net emission transfers embedded in its imports and exports. In this paper, we focus on ownership-based footprints, which define a country's footprint as the production emissions of activities owned by the country's residents, regardless of whether the production takes place domestically or abroad.

The distinction between consumption-based and ownership-based emissions can also be made at the level of the individual. Consumption-based footprints include the emissions necessary to satisfy an individual's final demand choices, while an individual's private ownership-based footprint includes emissions related to firms and assets owned by the person. For example, if an individual owns 10% of a cement plant, 10% of the plant's scope 1 GHG emissions would be included in that individual's private ownership-based footprint. Under consumption-based accounting, the cement plant's emissions are included in the footprint of final consumers of goods and services that use cement as an input.

The following examples further illustrate the ownership-based framework:

- The emissions of a privately owned gas-powered car are included in the footprint of the private household that uses the car.
- The emissions of a coal-fired plant producing electricity for the household are included in the footprint of the plant's owners as private or government ownership emissions.
- The emissions of company cars in privately owned firms are included in the footprint of these companies' owners as private ownership emissions.
- The jet engine emissions of an international airline are included (conceptually) in the footprint of the airline's owners.
- State-owned enterprises' emissions are included in the government's ownership footprint.

Box 2 | Patterns in foreign ownership emissions across countries and regions

Major western European countries stand out both as net importers of emissions under consumption-based carbon accounting and as countries with large positive net foreign ownership emissions in the ownership-based framework (Figure 4 and Extended Data Table 2). For example, in the UK, France, Italy and Germany, adjusting emissions for cross-border investment increases each country's production-based emissions in 2022 by 40%, 38%, 25% and 16%, respectively (Figure 4 and Extended Data Table 3). This implies that, in addition to importing (net) emissions through purchasing foreign-made goods, western European investors hold significant ownership stakes in polluting production abroad—and these emissions exceed those related to production in western Europe that is owned by the rest of the world. In 2022, net foreign ownership emissions in the western Europe region show similar orders of magnitude (+33% of production-based emissions) as the net emission transfers via international trade (+35%) (Figure 4). This co-movement does not have to persist in the future, however: wealthy countries could reduce both their production- and consumption-based emissions while still maintaining high levels of ownership-based emissions.

We found a marked relative increase in net foreign ownership emissions in major western European countries over 2010–2022 (Figure 4). While production-based emissions (measured in tCO₂e per capita) declined, gross foreign ownership emissions (measured in tCO₂e per capita) remained stable (or even increased) over the 2010–2022 period (Figure 4 and Supplementary Figure 13). We observed similar patterns in South Korea and Japan.

Countries in central and eastern Europe tend to show persistent and significant negative net foreign ownership emissions (Figure 4). This country group includes Poland, Romania, Czechia, Hungary and Bulgaria, among others (Supplementary Table 1). The rest of the world tends to own polluting production facilities in these countries, and these emissions exceed emissions released abroad in facilities owned by investors from these countries. Large western European economies and the USA, whose domestic economies are relatively less carbon intensive per US dollar of gross domestic product, are among the largest inward investors in many of these countries. Russia also shows a negative net foreign ownership emission position, which appears to be widening over the 2010–2022 period (Supplementary Table 9). In our dataset, the largest foreign holders of Russian emissions are based in Cyprus and the Bahamas, countries known to hold offshore wealth (Alstadsæter et al., 2018). This may signal that parts of the “foreign”-owned emissions in Russia are in fact owned by Russian residents or expatriates registered in countries such as Cyprus or the Bahamas. There is also strong evidence that Russian-owned assets abroad are structurally underreported (Novokmet et al., 2018). Although our data sources adjust investment figures to account for round-tripping, this adjustment is probably imperfect and underestimates emissions from Russian residents, and in particular those at the top of the distribution.

Despite the USA's substantial negative net foreign investment position, its net foreign ownership emission position was slightly positive in 2022, at 259 MtCO₂e, or approximately 4% of production-based emissions (Figure 4 and Extended Data Table 3). The difference highlights that a country's net foreign ownership emission position does not have to mirror its net foreign asset position in direction or size. One reason is that a country's net foreign asset position is composed of a broader set of assets, including sovereign and corporate bonds, than those relevant for ownership emissions. The carbon intensity of domestic production can also differ from that in foreign countries where investors hold their investments. Finally, changes in market values, such as a prolonged boom in local equity valuations, could magnify a country's negative net foreign asset position while leaving net foreign emission positions unchanged, *ceteris paribus* (Supplementary Methods 4).

China maintained a slightly negative net foreign ownership emission position from 2010 to 2022, at around –3 to –4% of the country's production-based emissions or –490 MtCO₂e in 2022. China appears as a country that both exports (net) emissions via international trade in a consumption-based framework and records a negative foreign ownership emission position. Inward foreign direct investment (FDI) stocks in China in 2022 exceeded outward FDI stocks, according to United Nations Conference on Trade and Development data. The gap between production-based and consumption-based emissions in China (that is, the extent to which the rest of the world imports emissions from China through international trade) has declined over the period, in both relative and absolute terms (Eurostat, 2024; Remond-Tiedrez & Rueda-Cantuche, 2019). At the same time, net foreign emissions remained constant relative to China's domestic production emissions (Supplementary Table 9).

Net foreign ownership emissions are negative in India. The net position is driven by the relatively low emissions linked to India's investment abroad (relative to production-based emissions in the country, which are the fourth highest in the world in 2022), rather than foreigners owning a particularly large share of Indian production and emissions (Supplementary Table 7): the net emission position stood at –135 MtCO₂e in 2022, or –3.5% of the country's production-based emissions.

Other countries outside the high-income group show a relatively consistent pattern. In most cases, net foreign ownership emissions are negative throughout the period, including in Brazil, Indonesia, Mexico, South Africa, Pakistan, Vietnam, Thailand, Nigeria, Argentina, Egypt, Algeria, Bangladesh, the Philippines and Colombia (Extended Data Table 3). South Africa and Vietnam stand out as countries with both negative net foreign emissions and negative emission transfers through trade (Peters et al., 2012; Remond-Tiedrez & Rueda-Cantucho, 2019) (that is, emissions embodied in their exports exceed those embodied in their imports).

We found large positive net foreign ownership emissions in countries such as Switzerland, Singapore, Luxembourg and the Netherlands (Supplementary Table 7). These positions probably reflect not only foreign investments made by residents of these countries in foreign production activities but also the role these countries play as hubs for holding foreign firms on behalf of investors based elsewhere (Supplementary Methods 4). This study aimed to reduce such distortions by using data sources that identify the countries of ultimate ownership. However, the large positive positions we found in these countries (in percentage of domestic production emissions) suggest that information about global foreign wealth remains incomplete, and they align with earlier studies highlighting the impact of limited transparency (Galaz et al., 2018). The online database flags these countries to signal the uncertainty regarding their estimates. Aside from Russia and Saudi Arabia, Australia and Canada stand out as the only high-income countries within the top 25 most polluting countries in 2022 with a consistently negative net foreign ownership emission position (Supplementary Table 9). These countries have large emission-intensive natural resource sectors so that even limited foreign investment in these countries can result in ownership emissions that exceed those of domestic investors investing elsewhere.

Extended Data Tables

ED Table 1: Per capita private ownership emissions by wealth group in 2010 vs. 2022

Country/Region	Total population		Bottom 50%		Middle 40%		Top 10%		Top 1%		Prod.-based	
	2010	2022	2010	2022	2010	2022	2010	2022	2010	2022	2010	2022
World	4	4	0	0	2	2	31	33	158	165	6	6
China	3	5	0	1	1	2	20	39	95	172	8	11
United States	13	11	0	0	8	7	92	80	441	419	22	18
India	1	2	0	0	1	1	10	13	58	96	2	3
Russia	10	11	1	0	5	3	77	94	475	693	15	18
Brazil	3	4	0	0	1	2	26	28	160	182	6	6
Japan	7	7	1	1	4	4	48	47	245	252	11	9
Indonesia	2	3	0	0	2	2	16	21	63	93	3	4
Iran	6	6	0	0	3	3	41	44	225	254	10	10
Germany	9	7	1	1	5	4	62	53	356	331	12	9
Saudi Arabia	11	10	1	1	5	5	86	79	514	483	24	24
Canada	13	13	1	1	8	8	89	89	454	479	21	19
South Korea	10	11	0	0	6	6	79	82	388	420	14	14
Mexico	3	3	0	0	1	1	28	26	178	170	6	5
Australia	19	15	2	1	12	10	134	105	668	552	27	22
Türkiye	4	5	0	0	2	2	27	35	152	208	6	6
South Africa	7	6	0	0	1	1	63	52	449	385	11	8
Pakistan	1	1	0	0	1	1	9	9	44	48	2	2
United Kingdom	9	7	0	0	6	4	60	50	258	219	11	7
Viet Nam	2	2	0	0	1	1	15	18	78	96	3	5
Thailand	3	3	0	0	2	2	25	27	150	164	6	6
France	6	5	0	0	2	2	56	48	273	249	8	6
Italy	6	6	1	1	5	6	35	29	170	151	9	7
Poland	6	5	1	0	4	3	41	37	214	221	11	10
Nigeria	1	1	0	0	1	1	7	7	37	36	2	2
Argentina	5	5	0	0	3	3	35	35	183	185	8	8

Note: Emissions in tCO₂e unless stated otherwise. Groups defined in terms of net personal wealth. The top 25 polluting countries represent 81% of global emissions in 2022. Results for more countries are available in the online dataset released with the paper.

ED Table 2: Foreign ownership emissions by world regions and country income groups in 2022

	Production-based	Net foreign ownership	Ownership-based	% of prod.-based	per capita (tCO ₂ e)	Population (million)	Countries (n)
<i>World regions</i>							
Western Europe	3 347	+1 118	4 465	+33.4%	+2.6	431	20
North America & Oceania	7 502	+228	7 730	+3.0%	+0.5	425	16
East Asia	17 511	-45	17 466	-0.3%	-0.0	1 663	8
Latin America & the Caribbean	3 507	-127	3 379	-3.6%	-0.2	653	39
South & Southeast Asia	7 810	-312	7 498	-4.0%	-0.1	2 618	19
Sub-Saharan Africa	2 402	-142	2 260	-5.9%	-0.1	1 219	48
Russia, Caucasus & Central Asia	3 703	-224	3 479	-6.1%	-0.8	292	11
Middle East & North Africa	4 574	-326	4 248	-7.1%	-0.6	578	19
Eastern Europe	1 014	-169	845	-16.7%	-1.4	121	17
<i>Income groups</i>							
High income	18 596	+1 688	20 284	+9.1%	+1.2	1 406	71
Upper middle income	24 038	-1 111	22 927	-4.6%	-0.4	2 852	52
Lower middle income	7 710	-444	7 266	-5.8%	-0.1	3 037	49
Low income	1 027	-133	894	-13.0%	-0.2	706	25

Note: Emissions in MtCO₂e unless stated otherwise. Positive net values indicate that a country owns more emissions abroad than foreign owners control domestically; negative values indicate the opposite. Net foreign ownership emissions are zero at the global level. Country groupings are available in Supplementary Table 1.

ED Table 3: Production versus ownership-based emissions in the top 25 polluting countries in 2022

Country/Region	Production-based (MtCO ₂ e)	% of world total	Net foreign ownership (MtCO ₂ e)	% of prod.-based	Ownership-based (MtCO ₂ e)
World	51 371	100.0%	–	–	51 371
China	15 158	29.5%	–490	–3.2%	14 668
United States	6 075	11.8%	+259	+4.3%	6 335
India	3 897	7.6%	–135	–3.5%	3 762
Russia	2 608	5.1%	–124	–4.8%	2 484
Brazil	1 301	2.5%	–89	–6.8%	1 212
Japan	1 172	2.3%	+235	+20.1%	1 407
Indonesia	1 144	2.2%	–73	–6.4%	1 071
Iran	917	1.8%	–124	–13.5%	793
Germany	794	1.5%	+128	+16.1%	922
Saudi Arabia	788	1.5%	–46	–5.9%	742
Canada	754	1.5%	–5	–0.7%	749
South Korea	706	1.4%	+90	+12.7%	796
Mexico	697	1.4%	–57	–8.2%	639
Australia	571	1.1%	–45	–8.0%	526
Türkiye	555	1.1%	+20	+3.5%	574
South Africa	529	1.0%	–18	–3.4%	511
Pakistan	526	1.0%	–15	–2.8%	511
United Kingdom	506	1.0%	+200	+39.6%	706
Viet Nam	471	0.9%	–70	–14.9%	401
Thailand	447	0.9%	–32	–7.1%	415
France	433	0.8%	+166	+38.4%	599
Italy	424	0.8%	+105	+24.8%	529
Poland	403	0.8%	–90	–22.2%	313
Nigeria	393	0.8%	–14	–3.6%	379
Argentina	375	0.7%	–31	–8.2%	345

Note: Emissions in MtCO₂e unless stated otherwise. Positive net values indicate that a country owns more emissions abroad than foreign owners control domestically; negative values indicate the opposite. The top 25 polluting countries represent 81% of global emissions in 2022. Results for more countries are available in the online dataset released with the paper.

Data and code availability

The data used in this paper are publicly available, except those from the Household Finance and Consumption Survey. Asset portfolio data derived from the Household Finance and Consumption Survey can be shared by the authors in line with the survey's data access conditions. Datasets with country-level and global estimates are available via Zenodo at <https://doi.org/10.5281/zenodo.19366484> (Chancel & Rehm, 2026). The code used to produce the estimates and results in this paper is also available via Zenodo at <https://doi.org/10.5281/zenodo.19366484> (Chancel & Rehm, 2026).

Supplementary Information

- [Supplementary Information](#)