

A just transition: how can we fairly assign climate responsibility?

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Introduction

There is no question that to prevent human-induced climate change from destroying our ability to survive on the planet, it is essential to move quickly and sharply to achieve massive reductions in carbon emissions. However, this can only happen if all countries (and different groups within countries) are given the means and incentives to do this in a just and equitable manner. In this paper, we argue that recognising and addressing existing global inequalities is central to addressing the climate challenge. Current methods of assigning responsibility for the required reductions in carbon emissions fail to take account of this. In addition, climate change alleviation efforts in low- and middle-income countries are being constrained by the current tendencies in cross-border trade, the pressures created by global finance, and the control of knowledge and technology by large corporations based in rich countries. In fact, the global economic architecture even incentivises more carbon-emitting investment and production. Without addressing these central concerns, international efforts to reduce carbon emissions are unlikely to be successful, with catastrophic consequences. It is therefore urgently necessary to change the basis on which climate responsibility is allocated across countries and to restructure global economic, financial and technology transfer systems to ensure that all countries can meet just and viable commitments for carbon reduction.

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One of the required changes is a significantly larger provision of climate finance from rich countries to the rest of the world. We also need financial regulations that actively disincentivise carbon-intensive investment by financial investors (both public/multilateral and private) and incentivise alternative renewable energy sources and improvement of energy efficiency. Restrictions to knowledge-sharing in the form of “intellectual property rights” should be removed as they create monopolies over access to the required technologies. Finally, we need new trade rules that are not simply protectionist measures against low- and middle-income countries but encourage less carbon use while adequately compensating those who would lose from such changes. These changes are certainly ambitious and will necessitate a complete overhaul of the current international economic architecture and the economic policies of most governments. But an overhaul is essential given the scale of the challenge.

Different methods of assigning national responsibility for carbon emissions

It would appear obvious that natural processes – and the Anthropocene effects on them – do not observe national boundaries. The atmosphere and the ocean do not rely on visas to cross borders, nor do the implications of climate change or degradation of nature within one country or area stay confined to that location. Inevitably, therefore, one of the most pressing global concerns, that of rising temperatures driven by excessive carbon dioxide (CO₂) emissions, cannot be assessed only within national boundaries nor addressed by purely national measures. Nevertheless, climate change, which now presents an existential threat to all humanity, is

still considered in national terms even on international platforms, but national policies usually fall short in addressing it. In this context, methods to determine how “climate responsibility” is assigned across different countries have become critical: they form the basis of climate negotiations and national commitments to control greenhouse gas emissions, most recently in November 2021 at the United Nations COP26 climate summit in Scotland.

The standard method for determining responsibility for carbon emissions by country is based on CO₂ equivalent emissions (here referring to CO₂ and other anthropogenic greenhouse gases collectively) generated during production within national boundaries. In this approach, the responsibility for carbon emissions is fully placed on producers of goods and services within the specified location (area, nation or region). This covers all production across the value chain of any product or service. This is the approach used by the United Nations Framework Convention on Climate Change (UNFCCC) as well as by negotiators in the successive Conference of the Parties (COP) meetings, and is by far the most widely used concept for climate responsibility.

A major problem with this approach is that it does not take into account the ability of national economies to exploit cross-border trade. By sourcing high-carbon products and services from other countries, nations can effectively “export” their emissions. This process accelerated significantly over the past two decades and has substantially changed the way that rich countries in particular use up the global carbon budget, by shifting from direct emissions to “indirect” emissions through cross-border trade.

In response, there is a myriad of recent research on the level of carbon emissions involved in satisfying domestic demand, whereby responsibility for lifecycle emissions is allocated to the final consumers of goods and services. Tucker, Pollitt and Henkemans (2020) provide a review of such estimates, some of which are considered in detail below. The “simplest” exercises involve estimations of carbon emissions as expressed in final demand (consumption and investment). In practice this is challenging since it requires various assumptions about production structures and emissions embedded in imports. The estimations provided below, in *Recent trends in national carbon emissions*, are based on this approach.

Some of the more sophisticated attempts to measure a more “just” carbon footprint combine the average of consumption-based and income-based emissions (Rodrigues et al., 2006; Qian et al., 2018) and then weigh these by the Environmental Sustainability Index (do Couto, 2020). There are other ways to allocate responsibility for emissions that are not based on national territorial boundaries. For instance, estimates of extraction-based emissions that cover the full life cycle of extracted natural resources (typically fossil fuels). In that case, those who extract the resource are responsible for downstream emissions enabled by the sale of that resource/fuel (Liang et al., 2017; Marques et al., 2012, Steininger et al., 2016). The quantity of liable emissions is typically determined by the proportion of intermediate and primary inputs flowing into the polluting process, based on monetary value. Yet another approach is to allocate emissions according to the share of value-added over the life cycle of the product in each step of the value chain (Lenzen et al., 2007; Pinero et al., 2018). The idea is to incentivise those who profit from emissions to then finance strategies and investments required to reduce emissions.

Fernandez-Amador et al. (2017) found that the emergence of global value chains weakened the linkages between national commitments on emissions and the incentives to control emissions globally. This was especially marked after the adoption of the Kyoto protocol, which lowered emissions generated in a high-income country but increased emissions derived from imports. They argue that there has been relative decoupling between carbon emissions and economic development, since both production-based and consumption-based emissions have declined in relation to gross domestic product (GDP) in the countries considered. However, carbon footprints (consumption-based emissions) show a larger income-elasticity than production-based inventories. This suggests that consumption patterns are in general more carbon-intensive than territorial-based production patterns.

The complexity of dealing with this gap is highlighted by Jakob et al. (2014) who identify several different channels of “emissions leakages” that could reduce the effectiveness of mitigation policies. For example, reduced demand for fossil fuels in one region could reduce their price and hence stimulate their consumption in other regions. Alternatively, higher prices of emission-intensive goods in one region could encourage imports from other regions. In other words, one region’s contribution to carbon mitigation could encourage free-riding by others in the absence of proper regulatory trade policies. Worse still, this sort of unilateral climate policy could even increase greenhouse gas emissions.

Clearly, the basic mechanism behind this difference between production-based and consumption-based carbon emissions is global trade. Jakob and Marschinski (2013) identified four determinants of the flow of embodied emissions in international trade: trade balance; trade specialisation; average energy intensity of production in the entire economy, compared with that of trading partners; and average carbon intensity of energy in the entire economy, compared with that of trading partners. Jiborn et al. (2018) found that even those countries that could use renewable energy for domestic production have shifted to carbon-intensive import-based consumption. For example, Sweden, with good access to hydropower and wind, and energy-efficient production, and the United Kingdom, with energy-efficient production, have been increasingly displacing carbon-intensive production to countries with fewer renewable resources.

In contrast, Franzen and Mader (2018) found no empirical evidence for carbon leakage from high-income to low- and middle-income countries. Their analysis concluded that, on average, countries experience a relative increase in imports of CO₂ if they become more energy efficient; and on average, members of the Organization for Economic Cooperation and Development (OECD) or countries with high levels of GDP per capita did not have larger CO₂ imports, nor had their imports increased over time. However, this result can and has been contested, including in our own assessment below. Zhang and Fang (2019) note that many such studies rely on the mixture of incompatible databases for production-based and consumption-based carbon accounting, which has resulted in unreliable and misleading estimates of carbon leakage among countries.

Interestingly, even if current trade flows contribute to greater carbon emissions, trade could also be part of the solution (Brenton and Chemutai, 2021). This could occur if trade causes production shifts to locations with cleaner production techniques – although, as we have just seen, there are unfortunate counterexamples such as the United Kingdom and Sweden. Similarly, trade could also promote the spread of cleaner production technologies to the relevant regions. However, this would require a much greater international diffusion of green technologies than

is currently occurring. Such technology transfer is inhibited by a global trade architecture that privileges private intellectual property rights, especially patents and industrial designs that are “owned” by large corporations based in high-income countries, an issue that is considered in our companion paper, “*Obstacles to climate change mitigation and adaptation in developing countries*” (Das et al., 2022).

To sum up this brief literature review: we have identified several issues in the pattern of global carbon emissions. First, there is the gap between production-based and consumption-based (or final demand-based) emissions and the associated role of cross-border trade. In this regard, we identified the often-perverse incentives created by more open and deregulated trade, to shift production beyond national borders so as to become “greener” in terms of production. These observations suggest that climate strategies need to take account of these features, and how they vary across advanced and low- and middle-income nations. Another important issue – that varies sharply between wealthy countries and the rest of the world – is that of historical carbon debt, which we consider in the following section.

The effects of climate change are being felt disproportionately by low- and middle-income countries, which are less able to deal with the consequences because of lower per capita incomes, less fiscal space, technological constraints and reduced access to international capital markets.

Historical carbon debt

Today’s rich countries are responsible for nearly 80% of all human-related carbon emissions from 1850–2011, as Figure 1 indicates. This historical accumulation of greenhouse gas emissions is the major contributor to the climate impacts the world is facing today. Fundamentally, these problems are a result of that over-exploitation and abuse of the planet by a small group of now-rich countries, which together account for only around 14% of today’s global population. Although some of these emissions occurred before the science of climate change was clear, it is worth noting that more than 50% of these historical emissions occurred in the last 30 years. Over the past three decades, the science of climate change has become increasingly evident and widely accepted, and the technologies for climate mitigation have developed significantly. Clearly, rich countries could have done more to avert the climate crisis we now face. Meanwhile, the effects of climate change are being felt disproportionately by low- and middle-income countries, which are less able to deal with the consequences because of lower per capita incomes, less fiscal space, technological constraints and reduced access to international capital markets.

For these reasons, there are concerns about existing climate debt, which needs to be addressed in any conception of a “just transition”. The net-zero commitments made by rich countries do not explicitly mention this vast negative impact of their own past growth trajectories. If this climate debt were to be incorporated, it would mean a major revamp of existing proposals made by rich countries. For example, it has been estimated that the United States’ fair share of the global mitigation effort by 2030 is equivalent to a reduction of 195% below its 2005 emissions levels, reflecting a fair share range of 173–229% (US Climate Action Network, 2021).

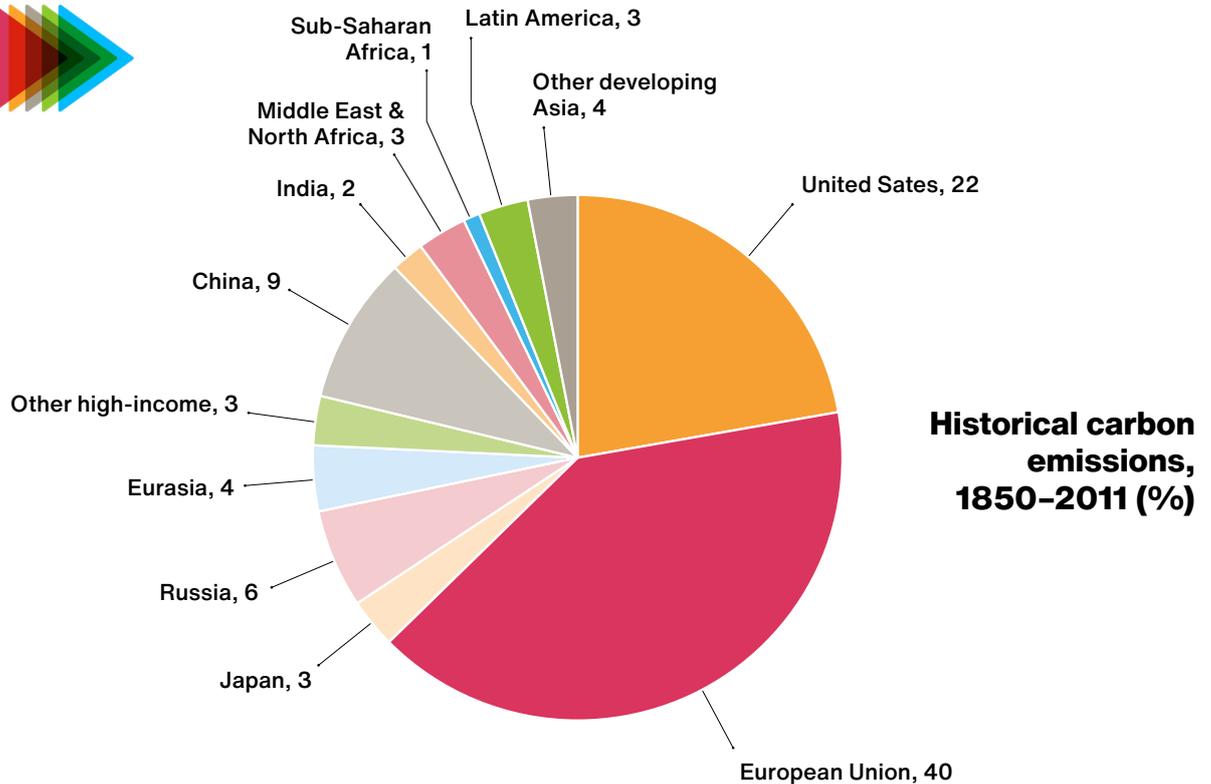


Figure 1. Source: [Climate Watch](#)

However, the advanced economies have succeeded in shifting the terms of negotiation away from perceptions of historical responsibility and climate debt, to address only current and future emissions. In addition, they present projections and commitments whereby they will continue to appropriate the vast bulk of the available “carbon budget” for the next three decades (see for example [Climate Equity Monitor](#)). Not only is this unjust, it also means that the climate debt of this small group of rich countries to the rest of the world will continue to grow. Yet, despite this issue being raised continuously by low- and middle-income countries in climate negotiations, it has simply been ignored by the rich countries, and often also by well-meaning climate activists based in those countries. This is not just ethically wrong, it is counterproductive. It reduces or even destroys the international solidarity and cooperation essential to ensuring that humanity can cope with the climate challenge. There will be no transition to a sustainable economy in a healthy planet – “just” or otherwise – if these legitimate concerns of low- and middle-income countries are not taken into account.

Problems with the use of Purchasing Power Parity exchange rates to compare incomes and paying capacity across countries

The use of Purchasing Power Parity (PPP) exchange rates, rather than actual or market exchange rates (MER), has now become quite standard in comparing both aggregate and per capita incomes between countries. PPP is also used when estimating carbon intensity or for national carbon reduction commitments. Proponents of this approach observe that different currencies can command varying baskets of goods and services in different countries, relative to what is suggested by prevailing MER. Typically, lower-income countries have lower-priced goods and services, and therefore lower aggregate price levels, which enable their currencies to have greater purchasing power within the domestic economies. This in turn has been used to argue that comparative assessments of real per capita incomes in lower-income economies that are

based on MER consistently undervalue the non-traded goods sector, especially labour-intensive and relatively cheap services, relative to higher-income countries. Accordingly, they lead to real incomes being underestimated in these lower-income economies, even to the point that inter-country per capita income comparisons based on MER may be misleading.

While PPP exchange rates appear to control for differences in price levels and standards of living in different countries, they are ridden with conceptual, methodological and empirical problems (Deaton 2010; Reddy and Pogge, 2010; Atkinson, 2015). The use of PPP also assumes that the economic structure of each country is similar to that of the benchmark country (the United States) and changes in the same way over time. The convoluted weighting procedure for goods can result in the use of high-priced unrepresentative goods that are rarely consumed in some countries. Angus Deaton (2010) provided the example of packaged cornflakes, which are available in poor countries, but only accessed by a relatively small minority of rich people. As a result, expenditure weights from the national accounts do not reflect the consumption patterns of people who are poor by global standards.

There is a further, and possibly even more damning, conceptual issue. In general, countries that have high PPP, that is where the actual purchasing power of the currency is deemed to be much higher than the nominal value, are typically low-income countries with low average wages (Ghosh, 2018). This occurs precisely because there is a significant section of the workforce that receives very low remuneration, which then means that goods and services are available more cheaply than in countries where the majority of workers receive higher wages. Widespread unpaid labour, as is typically the case in poor households in low-income countries, drives average costs even lower. The end result is that greater purchasing power of that currency is in fact a sign of indigence. A low currency economy is a low wage economy, and as wages (and therefore prices) increase over time, the PPP gap tends to be progressively reduced. This makes inter-country comparisons of per capita income based on PPP potentially misleading because they do not properly reflect the actual material conditions for most people in low-income nations.

Purchasing Power Parity (PPP) income estimates overstate incomes of poorer countries when it comes to comparing incomes across rich and poor countries.

In effect, PPP income estimates overstate incomes of poorer countries when it comes to comparing incomes across rich and poor countries. This is a serious concern when PPP estimates of national income and per capita income are used in international climate negotiations. Related to this, Semieniuk (2022) argues that evidence for decoupling depends on how GDP estimates are revised over time, and such variations can increase with periodic changes in PPP estimates. This raises further concern about using PPP GDP numbers to ascribe either tendencies for carbon intensity or obligations of carbon responsibility by country.

We believe that MER rather than the imaginary PPP exchange rates should be used for cross-country comparisons, for assigning climate responsibility and for trade and climate-related negotiations.

Recent trends in national carbon emissions

Changes in economic growth patterns since the 1990s – most of all, the rapid output growth exhibited by China – meant that by 2019, low- and middle-income countries were responsible for 63% of annual emissions. The three largest emitters of CO₂ today are China, the United States and India, which together account for more than half of global CO₂ emissions. This is what made the recent COP26 Summit so intense, especially in terms of finger-pointing at China and India. Both countries, particularly China (which entered the World Trade Organization (WTO) in 2001), have dramatically increased emissions, especially since the turn of the century. In contrast, the largest carbon-emitting advanced economies have shown lower increases and, in some cases, slight declines.

However, a closer look at the data suggests that, even in current terms, the inequalities in carbon emissions remain very significant. The standard indicator used by the UNFCCC and in climate negotiations, of carbon emissions produced within that country, may not be the most relevant.

Figure 2 shows the change in total emissions by the biggest emitters from 2000–2019. While the top 15 largest emitters have remained the same, their ranking has changed considerably over this period, with the previously largest emitter the United States falling into second position below China, and India moving up from fifth to third position. Developing countries showed much faster rates of increase of carbon emissions in this period: in China they went up by more than 3 times, in India by 2.7 times, in Indonesia by 4.7 times and in Saudi Arabia they nearly doubled.

Meanwhile, in the United States and Japan, total national production-based emissions actually declined by around 12% over these two decades – and in Germany the decline was nearly 22%. These declines reflect a combination of forces. Changes in trade patterns have enabled these countries to shift the more carbon-intensive production to other (mostly low-income) countries and thereby effectively “export” their carbon emissions. Economic structures in these nations have moved towards services that rely less on energy use. Meanwhile, there have been changes in the supply of energy away from the most-polluting sources (like coal and oil) to less-polluting sources such as nuclear and renewable energy. These factors are considered in the next section.

Total CO₂ emissions (million metric tons)

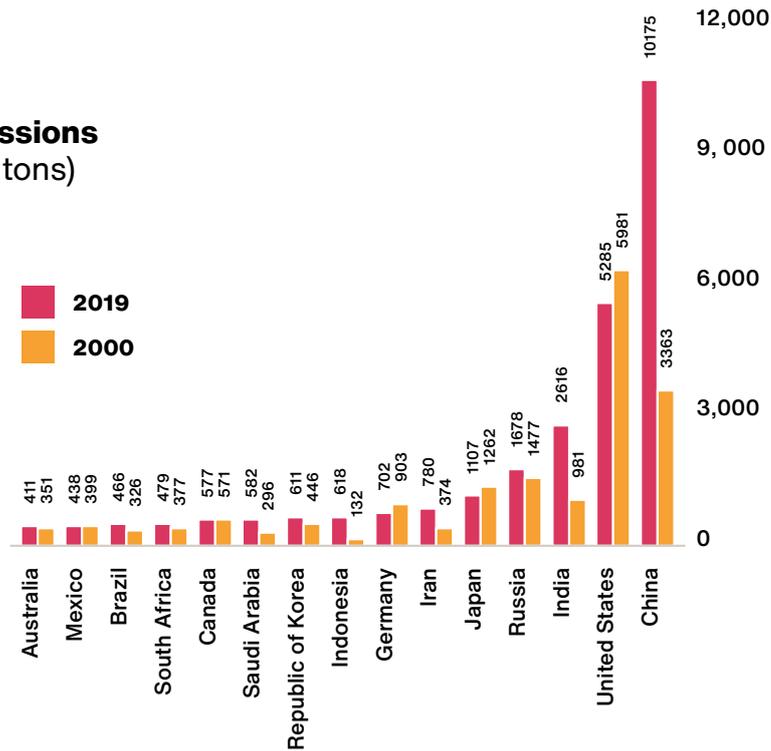


Figure 2. Source: [UNCTAD](#), based on data from the Global Carbon Project.

Despite these changes, in per capita terms, the advanced economies still remained by far the greatest emitters. It is extremely unfortunate that most climate discourse is couched in terms of GDP, rather than per person, as this obscures the deeper inequalities that pervade the current patterns. Figure 3 shows that in per capita terms, the United States and Australia showed eight times more carbon emissions than low- and middle-income countries such as India, Indonesia and Brazil, which are nevertheless castigated for allowing emissions to increase. Even China, despite recent increases, still shows less than half the level of per capita carbon emissions of the United States.

Per capita CO₂ emissions in 2019 (tonnes per capita)

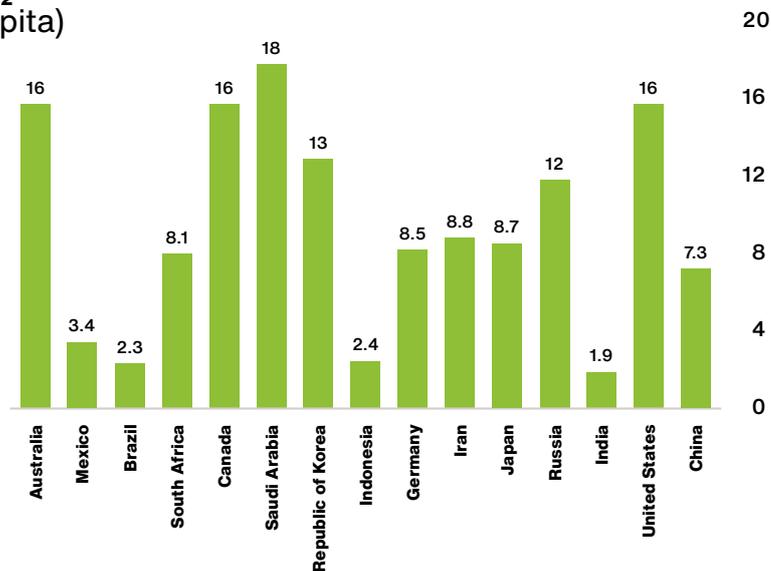


Figure 3. Source: Global Carbon Atlas

Carbon balance by production and final demand, mmt 2015

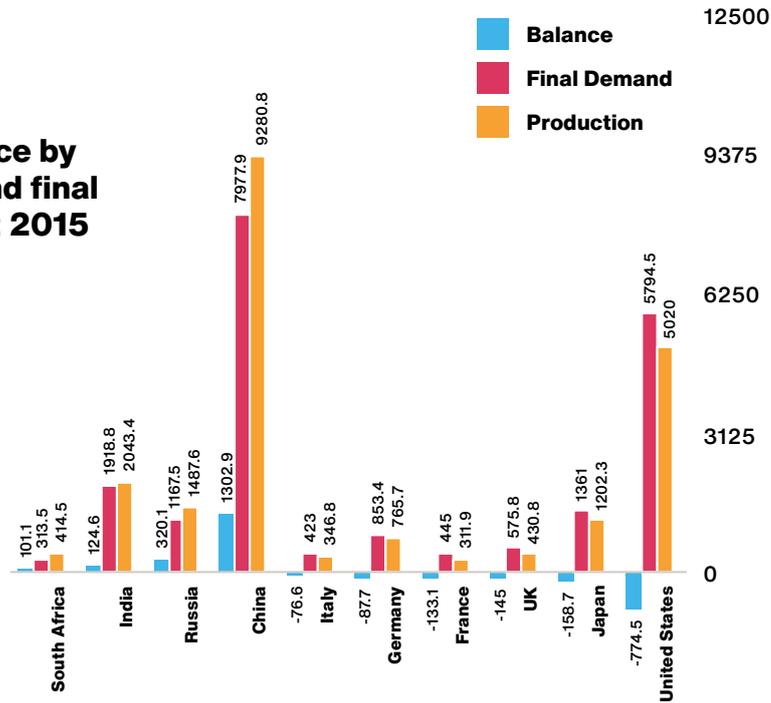


Figure 4. Source: OECD, Trade in Embodied CO₂ Database (TECO₂)

However, even per capita carbon emission comparisons based on national production are inadequate and do not reveal the full extent of current inequalities. As noted in the previous section, final demand (or consumption-based, as they are often described) emissions expose the problems with looking at carbon emissions only from the producer perspective. It highlights that it should not be only the producer but also the user who pays for the cost of such emissions. Recent changes in trade patterns reflect how economies followed the now-infamous strategy proposed by former US secretary of the treasury Larry Summers, of exporting polluting industries to lower-income countries – while adding carbon-emitting industries and production processes to this list. Several high-income economies have been outsourcing carbon-intensive industries, importing the related products, and shifting to emphasising value-added creation in less-polluting activities.

The OECD calculations of this process are based on Global Multi-Regional Input Output (GMRIO) tables with environmental extensions. They provide assessments of carbon emissions based on final demand (consumption plus investment) and the carbon balance achieved through trade, which includes carbon emissions during production (including export production) minus those in the imports. These calculations suggest that exported emissions by OECD countries increased rapidly from 2002 (notably, after China joined the WTO) and peaked in 2006 at a negative carbon balance of 2,278 million metric tons (mmt), which was 17% of the OECD’s production-based emissions. They have been declining thereafter, but still remain at around 1,577 mmt. Figure 5 provides some indication of the extent of this carbon balance in 2015 for 10 major economies.

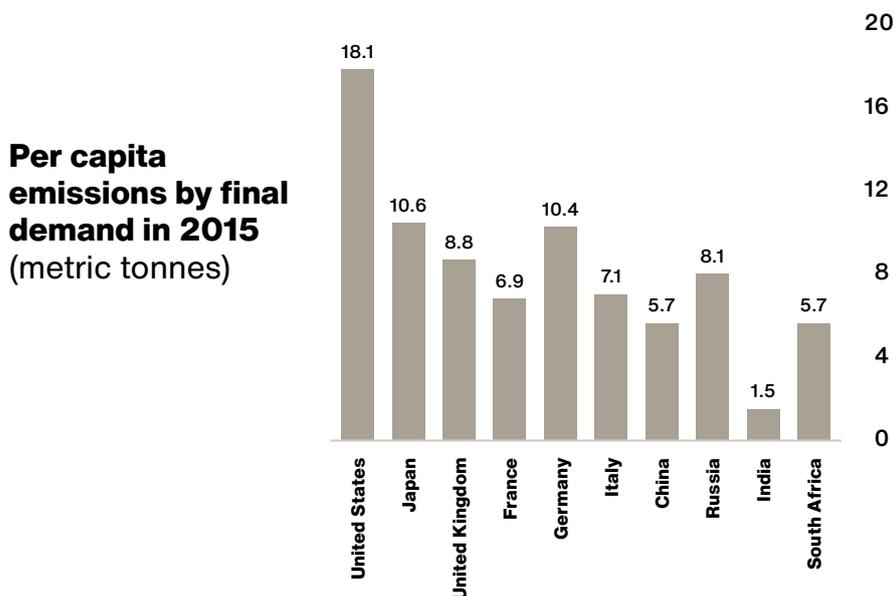


Figure 5. Source: OECD, Trade in Embodied CO₂ Database (TECO₂)

Once final demand emissions are taken into account, the per capita differences across countries are even more pronounced. The United States showed 8 times the per capita carbon emissions of India in production terms in 2015, and this difference increases to 12 times once final demand emissions are calculated. Even with respect to China, US per capita emissions based on final demand were more than three times greater, despite China being seen today as the world’s largest emitter in aggregate production-based terms. But these differences in per capita emissions across countries, extreme as they are, still mask the full extent of inequality in carbon emissions. National averages aggregate across significant degrees of internal inequality within a country, determined by levels of income, location and occupation among other factors. According to data in the World Inequality Report 2021, global carbon inequalities are now mainly due to inequalities *within* countries. Inequalities within nations now accounts for nearly two thirds of global carbon inequality, having nearly doubled in share from slightly more than one third in 1990 (Chance, 2021). There are globally high emitters in low- and middle-income countries and globally low emitters in rich countries, as Table 1 indicates. Predictably, the richest decile in North America are the most extravagant carbon emitters in the world with an average of 73 tonnes of carbon emissions per capita each year, which is 73 times the per capita emissions of the poorest half of the population of South and South East Asia. The rich in East Asia also emit very high levels, though still significantly less than in North America. The surprise, however, is in the relatively low emissions of the bottom half in the rich regions. In Europe, the lowest-emitting 50% of the population emits around 5 tonnes per year per person; the bottom 50% in North America around 10 tonnes and the bottom 50% in East Asia around 3 tonnes. These relatively small carbon footprints contrast sharply with those of the top 10% of emitters in their own countries, but also with emissions by the richest in relatively poor regions. The top decile in South and South East Asia, for example, emits more than double the amount of carbon than the bottom half of the population in Europe, and even the top decile in sub-Saharan Africa emits more than the poorest in Europe.

	Bottom 50%	Middle 40%	Top 10%
East Asia	3.1	7.9	38.9
Europe	5.1	10.6	29.2
North America	9.7	21.7	73.0
South & South East Asia	1.2	2.5	10.6
Russia & Central Asia	4.6	10.2	35.1
Middle East & North Africa	2.3	7.3	33.6
Latin America	2.0	4.7	19.2
Sub-Saharan Africa	0.5	1.7	7.3

Table 1. Per capita emissions by income shares, tonnes per annum. Source: Lucas Chancel (2021)

Note: In this calculation, personal carbon footprints include emissions from domestic consumption and public and private investments, as well as imports and exports of carbon embedded in goods and services traded with the rest of the world. Modelled estimates are based on the systematic combination of tax data, household surveys and input-output tables, with emissions split equally within households.

These figures are indicative of the extreme and growing inequalities in carbon use within countries. What is more, growing inequality also seems to drive up carbon emissions overall. While the bottom half of income groups in the United States and Europe reduced per capita emissions by 15–20% between 1990–2019, the richest 1% increased their emissions quite significantly, everywhere. Today, the richest 10% of people on the planet are responsible for nearly half of all carbon emissions.

Measures to reduce these growing disparities need to be more explicitly integrated into mitigation policies. Large inequalities in emissions suggest that climate policies should target wealthy polluters more. However, in general, the opposite seems to be the rule: carbon taxes alone usually have a disproportionate impact on low- and middle-income groups and have had relatively little impact on consumption patterns of the wealthiest groups, both in rich and in poor regions. Clearly, the strategies to reduce carbon emissions need to start focusing on containing consumption of the rich, both within countries and globally. It is unlikely that a simple carbon tax and dividend – even one conceived of at the global level – would solve this problem. Instead, more targeted efforts at reducing income and asset inequality could well prove to be more effective.

The determinants of changes in carbon emissions

In the *Historical carbon debt* section we noted that reductions in carbon emissions as measured in terms of production or GDP can be deconstructed into different factors. Three of them are internal or domestic factors that reduce emissions in production processes. First, a reduction in energy use per unit of GDP, typically resulting from changes in the sectoral composition of the economy – particularly a shift away from material-producing sectors to services, which tend to rely less on energy use (though that is not true of all services, especially transportation and utilities). Second, technological changes within sectors can reduce energy consumption per unit

of output. Third, within sectors and in the economy as a whole, changes in the type of energy used – with shifts away from the more carbon-emitting sources, particularly coal and oil, to the less carbon-emitting sources, such as renewable energy. Among these various sources of energy, renewable energy (solar/wind) is clearly the most desirable option and coal (followed by oil) the least desirable.

Region/Country	CO2 emissions/ population (tonnes per capita)	GDP/population (constant 2015 US\$)	Energy Intensity ratio: (QBTUs/ trillion \$ GDP)	Emissions/Q- BTU (mmtCO ₂ / quads of energy)
World	4.5	10,829	7.3	61.6
China	7.4	9,619	10.9	72.9
United States	15.2	59,822	5.2	52.1
France	4.6	38,276	4.0	36.3
Germany	8.6	42,956	3.9	62.4
Italy	5.4	31,586	3.6	56.2
Japan	8.7	36,189	4.2	70.6
Russia	11.1	9,899	23.3	54.7
United Kingdom	5.4	46,242	2.7	52.0
India	1.8	1,915	12.1	74.3
South Africa	7.5	5,640	16.9	82.8

Table 2. Components of per capita carbon emissions in selected countries, 2018. Source: Calculated from World Bank, World Development Indicators, and OECD, Trade in Embodied CO₂ Database (TECO₂).

Region/Country	CO2 emissions/ population	GDP/population	Energy Intensity ratio:	Emissions /Q-BTU
World	18.0%	37.8%	-12.9%	-1.5%
China	184.8%	338.5%	-28.9%	-11.1%
United States	-25.9%	22.9%	-27.6%	-12.4%
France	-24.9%	14.0%	-24.9%	-15.9%
Germany	-14.8%	24.6%	-23.4%	-9.8%
Italy	-29.5%	-2.3%	-13.2%	-13.7%
Japan	-6.7%	15.1%	-25.7%	6.4%
Russia	9.2%	85.9%	-32.1%	-5.0%
United Kingdom	-40.0%	20.3%	-38.4%	-14.6%
India	100.0%	152.8%	-20.6%	2.4%
South Africa	19.0%	25.2%	-25.6%	-3.0%

Table 3. Change in carbon emission intensity of GDP by components, 2000–2018. Source: Calculated from World Bank, World Development Indicators, and OECD, Trade in Embodied CO₂ Database (TECO₂).

Table 2 shows the absolute levels of per capita emissions and their various components in 2018, while Table 3 indicates the pattern of change from 2000–2018 in 10 countries that currently account for around two thirds of global carbon emissions. It is important to bear in mind the effect of levels of development when comparing across these countries. Thus, while India shows the lowest reduction in emissions intensity in the group, it had and continues to have the lowest absolute levels of both per capita emissions and per capita income. Poorer countries (India, South Africa, China) tend to have higher absolute levels of emission intensity, along with those relying heavily on hydrocarbon exports (Russia), and the possibilities of reduction tend to be constrained by insufficient access to the frontline technologies for energy-saving and emission-reducing production. Even so, the table highlights the wide variation in mitigation trajectories in low-, middle- and high-income nations. Most countries showed substantial declines in energy intensity of GDP over this period, reflecting both structural changes and technological changes. But the extent of decline varied from only 13% in Italy to nearly 40% in the United Kingdom. France, Italy, the United Kingdom and the United States made notable changes in their energy mix to reduce their share of the more carbon-emitting energy sources; by contrast, Japan and India increased their reliance on “brown” energy sources.

But these changes, while significant, account for only a part of the overall reduction in carbon emission intensity for the advanced nations. International trade also plays a role, as noted in our discussion of carbon balances. In this respect, the most significant factor has been the emergence of China as a major manufacturing exporter, especially to high-income countries. Between 2000–2019, manufacturing exports of China increased more than tenfold in terms of

By 2015, imports from China alone accounted for more than half (51%) of the carbon emissions balance of the United States

dollar values, and even more in volume terms (as unit prices fell over this period). Much of this was in the form of those imports requiring more carbon-intensive production. For example, US imports of non-electrical machinery (such as engines, agricultural machinery, metal-working machine tools and mechanical handling equipment) increased more than seven-fold from US\$16.8 billion in 2000 to US\$124.5 billion in 2019, while imports of transport equipment increased by nearly eight times. By 2015, imports from China alone accounted for more than half (51%) of the carbon emissions balance (final demand minus domestic production) of the United States. The corresponding shares were 63% for Japan, 49% for Germany, 38% for the United Kingdom, 34% for Italy and 29% for France (OECD data).

Advanced economies and their multinational companies drove this process. That is evident from the fact that China’s share in the carbon emissions balance was either much smaller or in the opposite direction for non-OECD countries: only 3% of Russia’s balance, for example, and significantly negative for India and South Africa. Indeed, these countries were also net exporters of carbon-emitting production to advanced economies, which thereby benefited from the consumption of such goods without showing equivalent increases in carbon emissions. The catalyst for this process was the entry of China into the WTO, which further facilitated the development of global value chains established in the 1990s, relocating certain parts of the production process (typically the more polluting, carbon-intensive and labour-intensive processes) to low- and middle-income countries.

As it happens, the significance of such cross-border trade in changing the pattern of carbon emission grew dramatically in the decade preceding the financial crisis of 2007–2008 but peaked just before then. As a result, the carbon emissions balance declined from 2,203 million tonnes in 2007 to 1,577 million tonnes in 2015. There have been further declines since then, also because many imports from low- and middle-income countries (and especially China) are now produced using greener techniques. Even so, the discrepancy remains significant.

The way forward

What is the best way of dealing with these issues? Two major concerns have been highlighted in this paper: the severe inequalities in carbon use both across and within countries; and the problems associated with assigning national climate responsibility. It is glaringly obvious that changes to production and consumption structures within all countries are urgent and essential

for the global climate transition. Moreover, for such a transition to have any chance of success it must be just and equitable, and seen to be so by all parties. The “losers” both across and within countries should be compensated at all points and with all strategies. In particular, providing sufficient incentives for low- and middle-income countries that would be affected differentially, the workers who stand to lose their jobs, the small subsistence producers who stand to lose their material conditions, and the mass of people for whom consumption patterns must change. This requires changes in both the global architecture and in national policies.

To consider the national policies first, the most essential changes are those that would make economies more energy efficient. We must shift patterns of investment, production and consumption towards activities requiring less energy. Then, within energy sources, reduce the share of the most carbon-intensive sources –

thereby moving away from coal and petroleum-based energy to low- and zero-carbon sources. Obviously, this will require significantly more investment. Chomsky and Pollin (2020), as well as the United Nations Industrial Development Organization (2015), argue that COP targets could be achieved if most countries, particularly countries with large economies or populations, devote just 1.5% of their GDP each year to such investments. Such a move, they say, would also create a significant number of jobs.

However, to make such investments viable requires major shifts in current international economic arrangements. To begin with, the calculation of carbon intensities and coupling/decoupling must be based on actual market exchange rates, which are those that operate in practice. This will involve a redistribution of current duties and obligations towards a more just and fair allocation. Additional changes must take place in international finance, in cross-border trade patterns, and in the regime of intellectual property rights that have created private knowledge monopolies.

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Massively increased climate finance should be urgently directed towards low- and middle-income countries for both mitigation and adaptation. There is no excuse for the rich countries repeatedly breaking their promise of US\$100 billion per year in climate finance, which should now be paid in full covering all the shortfall since 2012. But there are other ways of providing finance for such investments.

One immediate and costless means is to issue significantly more special drawing rights (SDRs), the international liquidity created by the International Monetary Fund (IMF). Currently, SDRs are unequally distributed and have accrued mostly among advanced economies with larger IMF quotas. They can provide significant relief and additional (and non-conditional, non-interest bearing) finance to low-income countries. The IMF's recent issuance of US\$650 billion into the global economy to temper the effects of the COVID-19 pandemic should be seen as just the start. Eventually we hope to see a much larger issuance of at least US\$2–3 trillion intended essentially to support climate alleviation investments. There could also be a policy of automatically providing

more SDRs every year, especially to countries engaged in more difficult and demanding investment increases. In addition, there is a strong case for advanced nations to reallocate their allocated SDRs (which they are unlikely to use at all for their own national purposes) to the United Nations' Adaptation Fund and Green Climate Fund, as well as to regional multilateral development banks and other such agencies' similar investments.

Other changes are required in the global financial architecture. There must be an internationally agreed framework for sovereign debt resolution that dramatically reduces the current unpayable debt burdens that are constraining many low- and middle-income countries. This debt restructuring mechanism should necessarily include not just bilateral and multilateral lenders, but also private lenders – enforced through regulatory and legal changes. In addition, there needs to be stricter regulation on private financial markets to prevent “brown” and carbon-intensive investments by private lenders and bondholders and to incentivise green investment primarily through regulatory mechanisms, not public subsidies.

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One major concern is the concentration of the necessary knowledge and technology in high-income countries, and particularly in a few private companies. This is not just foolish and counterproductive, it is deeply dangerous, because it prevents the dissemination of critical technologies that are essential for the green transition. The global system of intellectual property rights, established through the Marrakesh Agreement (signed in 1994) that created the WTO, must now end. Far from encouraging more invention and innovation, it has led to monopolies of knowledge and private profiteering at the cost of the public good, and is now preventing many countries from accessing the technologies needed for changes in production and consumption. Governments in advanced economies have enabled knowledge monopolies of large private corporations that make access to crucial technologies too expensive and unaffordable in lower-income countries. When low- and middle-income countries try to stimulate renewable energy

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innovations through subsidies to their own producers, they face cases in the WTO brought by the United States and others.

Avoiding the destruction of the planet or preserving the viability of human life should not depend on the whims and profit-orientation of a few large companies that control knowledge even though such knowledge was largely created by public research and public subsidies. Yet that is precisely what is currently happening. What is needed is a waiver of Trade-Related Aspects of Intellectual Property Rights, or TRIPS, not only to end the ongoing COVID-19 pandemic, but for humanity to cope with the even greater threat posed by climate change.

One feature that has been highlighted in this paper is the gap between emissions based on production and consumption, as many rich countries have effectively “exported” their emissions to low- and middle-income countries. Governments in advanced countries have begun to recognise this gap. However, the current proposals to address this through trade measures are deeply

problematic. We are seeing higher cross-border taxation of carbon-emitting goods and moving towards a global carbon price that would deter certain kinds of carbon-intensive investment and production. In its current form, this strategy is protectionist and counterproductive, in that it is likely to penalise low- and middle-income countries without enabling or assisting alternative green economy trajectories.

Most critically, such proposals are not accompanied – as they necessarily must be – by much greater levels of climate finance that would enable the required shifts in production capacities in low- and middle-income countries. They are not accompanied by measures that would regulate the way private finance (mostly from institutions in rich countries) continues to prioritise “brown” investments in low- and middle-income countries. Furthermore, the constraints to green investment in low- and middle-income countries posed by the WTO’s intellectual property rights regime is not recognised nor sought to be addressed. Instead, the proposed solution is much more limited and siloed: a border tax on carbon-intensive products.

Would a global carbon tax and dividend policy help to resolve this problem? In theory, certainly – but there are many reasons to be wary of such a policy in the current global geopolitical context. Crucially, who or which international institutions could monitor the administration of such a tax and then ensure that the revenues are fairly distributed? The unwillingness of rich countries to provide even the minimum necessary tax cooperation to ensure that multinational corporations pay their fair share of taxes does not augur well for the prospect of a global tax. Meanwhile, the issue of fair distribution of revenues is fraught. It must be based on equitable principles that take account of carbon debt, existing carbon use and the specific needs of low- and middle-income countries, but this is unlikely to occur in the current political economy. Advanced countries have been unwilling to provide even the pitifully small sum of US\$100 billion per year in climate finance as promised more than a decade ago. It appears unlikely that they will suddenly exhibit greater generosity in sharing any additional tax revenues that could accrue from carbon taxation. In

such a context, bringing in trade policies that sound environmentally sensitive but are essentially protectionist in nature would contribute little to the larger aim of climate mitigation. It will also add to the pervasive lack of trust created by recent actions of rich countries, as a result of vaccine monopolies and renegeing on earlier promises of climate finance.

This paper, therefore, argues in favour of a more holistic approach. Appropriate finance mechanisms and technology transfer are imperative for the international cooperation the world needs right now. It is essential to recognise that without addressing deep, systemic and pervasive global inequalities, there can be no solution to the climate crisis. Instead, climate catastrophe will be almost inevitable.

Our companion paper (Das et al., 2022) considers the elements of the international economic and financial architecture that need urgent and drastic reform, in order to address our current challenges.

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