From Global Policies to Phase Out Fossil Fuels To a Sustainable Union

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Abstract

In this paper, I show that there is a distributional equivalence between a system of carbon prices differentiated by country and a uniform carbon price with differentiated emission rights involving international transfers. I introduce a policy proposal based on a uniform price and international transfers, with emissions rights close to an equal per capita allocation, and show how it compares to existing proposals. Using the model NICE, I simulate prominent international climate policy proposals and compare their welfare effects at the year-country-decile level. This paper is divided in four sections. First, I take stock of the current international climate policy regime. After showing that the current regime falls short of ensuring decarbonization aligned with the Paris Agreement's target and providing sufficient resources for sustainable development in the Global South, I delineate the objectives that a new regime should meet. Second, I propose that voluntary countries form a *Fossil-Free Union* whereby they would establish an international emissions trading system to guarantee that their emissions are in line with the target, and where the allocation of emissions rights would ensure North-to-South transfers in a way that would make most countries willing to join. I provide precise estimates of the distributive effects of the Fossil-Free Union. Third, I propose a *Sustainable Union*, where voluntary countries would commit to reallocate one percent of their GNI to all participating countries in proportion to their population, financed by global solidarity levies on the wealthiest. These proposals are complementary and would put the world on track for the climate and sustainable development targets. Furthermore, they garner majority support among the population in every country. Fourth, I provide a comparative analysis of alternative international climate policies.

Keywords: Climate policy; carbon price; SDGs; poverty; international taxation.
JEL: Q56; F38; H23; Q54; H87; F64; Q58; F53; F35.

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1 Where do we stand? What do we need?

1.1 A critical assessment of the current regime

The international climate policy regime is laid down in the United Nations Framework Convention on Climate Change (UNFCCC), and its offshoot, the Paris Agreement. The consensus of the international community in favor of this regime and its common temperature target is an immense success: The UNFCCC has been universally adopted, and the Paris Agreement had been ratified by all countries but three (Iran, Libya, and Yemen) before the U.S. withdrawal. However, reliance on consensus for decision-making at the UNFCCC also results in major limitations: agreements rest on the lowest common denominator and fall short of achieving any substantial progress on international climate action. In this section, we review the current regime and its most likely developments.

1.1.1 Developed nations taking the lead

The UNFCCC introduces the distinction between developed and developing nations: the former shall provide financial resources to the latter to promote their sustainable development and climate action. While aimed at sharing fairly the costs of climate action, this classification dates from 1992 and is now outdated. For example, **while Singapore, South Korea, Saudi Arabia and Slovenia are all richer than Greece, only the latter is considered by the UNFCCC to be a developed country with financial obligations**. This outdated classification is stalling progress in critical negotiations, as newly high-income countries resist being considered developed, and historically developed countries are reluctant to increase their contributions unless all high-income countries do so.

While high-income countries should indeed provide resources to foster climate action in lower-income countries, the determination of required transfers should not rest on an outdated, binary classification; it should be defined using up-to-date, continuous indicators such as the GNI per capita. **A simple yet fair rule would be that a country's contributions are to be made in proportion to GNI and entitlements in proportion to population**.

1.1.2 CBDR

In its Article 1, the UNFCCC states what is now known as the *CBDR* principle: "Parties should protect the climate system (...) on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities." This Article is commendable in its objective to guide the allocation of the burden of climate action between countries and reconcile different burden-sharing principles: common action, equity, historical responsibility, ability to pay, etc. Unfortunately, the CBDR principle only offers vague and inconsistent guidance. For example, does equity refer to equal per capita emissions rights or to something else (equal cost share of emissions reductions, equal access to development)? How should we balance rules that result in different allocations of

emissions rights, such as common action, equal per capita, historical responsibilities and ability to pay? **As the key question of the burden-sharing rule was left unresolved by the CBDR principle and its multiple possible interpretations, countries are not able to agree** on binding targets of emissions reductions and financial transfers by country.

1.1.3 NDCs

This absence of consensus on burden-sharing led to the system of Nationally Determined Contributions (NDCs), where each country sets its own targets. Countries are not sanctioned if they miss their targets. Countries do not even have to define their target using a common indicator (such as their future cumulative emissions). As NDCs rarely specify a cumulative emissions target, researchers need to formulate hypotheses to assess whether NDCs are jointly consistent with the universally agreed temperature target.[a] Even in the most optimistic hypotheses, NDCs are insufficient to meet the temperature target. If all countries respect their NDCs, global GHG emissions should be 51 $GtCO_2e$ in 2030, while 41 Gt would be needed to meet the 2 °C target with a 66% chance.[21] According to the Climate Action Tracker, **current policies and actions correspond to a global warming of +2.7 °C** by 2100, and warming may continue to rise beyond that date.

1.1.4 ITMOs

The article 6.2 of the Paris Agreement allows Parties to exchange Internationally Transferred Mitigation Outcomes (ITMOs). This enables a country to nominally reduce its emissions (the emissions as counted to assess its NDC) by purchasing verified emissions reduction to another country. The latter country will then be credited with the buyer's ITMO emissions. As any bilateral agreement on ITMO is permitted, the use of ITMOs risks reducing buyers' domestic decarbonization efforts. Indeed, to the extent that the NDCs do not add up to the global emissions reductions objective, there will be "hot air" (i.e. excess emission rights): ITMOs will not reflect the required mitigation constraint, and their price will be too low. As a result, ITMOs may propagate a global lack of ambition to countries with otherwise ambitious NDCs, offering a cheap (and less effective) alternative to domestic decarbonization.

To illustrate this, let us use a fictive example with two world regions, Rich and Poor, each containing half of the world population. Say that the carbon budget is 1,000 Gt and that in a business-as-usual scenario without climate action, both regions would emit 750 Gt. Imagine that region Rich has an ambitious NDC of 500 Gt while Poor has a low

[a] Note that the temperature target is itself vague. Article 2 of the Paris Agreement aims at "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels." Yet, given the uncertainty around the climate system, this (double) target is not precisely defined: does it mean a 83% chance to limit global warming to 2 °C? A 67% chance? A 50% chance? Each probability is associated with a different carbon budget – respectively 900, 1,150, and 1,350 $GtCO_2$ starting in 2020, according to the IPCC (AR6, WGI, p. 39).

ambition NDC of 1,000 Gt. In absence of international carbon trading, we can expect region Rich to emit 500 Gt (in line with its NDC) and region Poor to emit 750 Gt (as no climate action is required to fulfill its NDC). In this fictive example, region Poor may be willing to sell 250 Gt of ITMOs to region Rich at a very low price. Region Rich could then meet its NDCs with 750 Gt of emissions, resulting in world emissions of 1,500 Gt, higher than the 1,250 Gt that would have occurred in absence of ITMOs.

To prevent ITMOs from weakening domestic action, countries that use them should commit to extra rules, beyond verifying the environmental integrity of the ITMO they buy. In case of linkages between domestic carbon markets, the same rules would be required to the cross-border (or rather, cross-market) purchase of emissions allowances. Let us call *sellers* the countries that are willing to sell ITMOs, and *buyers* the countries they agree to sell them to. The extra rules to prevent hot air could be as follows:

- **Sellers and buyers should include a cumulative emissions target (i.e. a national carbon budget) in their NDC, decomposed in yearly targets**.
- **The joint carbon budget of sellers and buyers should be compatible with the Paris temperature target**. If the group of sellers and buyers does not include all countries, their joint carbon budget should correspond to their population share of the world's budget.
- **The joint target** (of sellers and buyers) **in a given year should be lower than their preceding year's joint emissions, by at least (say) 2%.** Note that if countries propose a credible emissions trajectory (as per the first rule), this last rule would not be necessary. This last rule is added just to make sure that sellers and buyers propose ambitious emissions reductions even in the first years.

If a group of sellers and buyers agrees to these rules, they would effectively impose the principle of an equal per capita allocation of emissions rights, at least to govern the allocation between their group and the rest of the world. While alternative allocation principles are possible, the operationalization of cross-border trading of emissions allowances (or ITMOs) needs to rely on an allocation principle. The inadequacy of NDCs (taken jointly) proves that the global climate regime cannot rely on diverse and self-serving allocation rules to divide the global carbon budget into consistent national targets.

1.1.5 Climate finance

An equal per capita allocation of emissions rights corresponding to the remaining carbon budget would entail transfers of 0.3% of the world's GDP from high to low emitters (on average between 2030 and 2080). North-to-South transfers would be over $800 billion in 2035 and would exceed $1 trillion between 2040 and 2060. Taking into account historical responsibilities for emissions, an equal per capita allocation of cumulative (past and future) emissions rights would entail even more transfers (the carbon debt that the North owes to the South is estimated at $26 trillion[27,30]).

At COP29, the international community reached a compromise concerning the New Collective Quantified Goal (NCQG): Developed countries committed to mobilize $300 billion per year by 2035 for developing countries for climate action (and countries "call on all actors" to mobilize $1.3 trillion, which would be in line with experts' recommendations[59,64]). **Although the quantum of $300 billion represents a tripling of the previous climate finance goal, it can be reached through loans** (including from the private sector), and does not specify what share should be provided as grants (or grant-equivalent concessional loans). In fact, the current goal of $100 billion is met with only $26 billion provided in the form of grants.[51] In theory, the NCQG could be met with the same amount of grants (i.e. North-to-South transfers), or even less.

In contrast, at COP29, "**India specified that the NCQG should mobilize $1.3 trillion, of which at least $600 billion should come in the form of grants** and equivalent resources."[12] India, voicing Global South concerns, stated it was "disappointed in the outcome which clearly brings out the unwillingness of the developed country parties to fulfill their responsibilities. We cannot accept it." Transfers aligned with Global South's demands would allow enormous progress towards the Sustainable Development Goals, including climate action but also the deployment of public services and poverty reduction programs. Conversely, an insufficient provision of climate finance does not only infringe on climate justice, it also jeopardizes decarbonization in the Global South, as **many countries make their NDC conditional on the adequate provision of climate finance**.

Together with more North-to-South transfers, reforms to the international financial systems are needed to reorient financial resources towards climate action. These reforms are multifaceted and are more likely to be accepted by governments in the Global North than direct transfers, since they rely on mostly painless, growth-enhancing accounting operations. The government of Barbados (supported by the UN Secretary-General) leads the movement in favor of these reforms. Their "Bridgetown Initiative" calls for debt relief for low-income countries, for a new issuance of at least $650 billion in Special Drawing Rights by the IMF to expand the loans of Multilateral Development Banks (MDBs) to at least $500 billion per year, and for public guarantees to lower interest rates on sustainable projects in the Global South.[11] Note that although the Bridgetown Initiative is most famous for its climate finance proposals, it also calls for other reforms, such as a universal carbon price and international taxes on the super-rich to finance global public goods.

While a scaling up of climate finance is crucial, it is not sufficient to decarbonize the world as it does not cap (or directly reduce) **emissions**. In the worst case scenario, the expansion of low-emissions projects would mostly add up low-carbon infrastructures on top of fossil ones, failing to meaningfully reduce emissions.

1.1.6 JETPs

The last pieces of the climate regime worth mentioning are the Just Energy Transition Partnerships (JETPs). **JETPs are mechanisms where one developing country essentially commits to emissions reductions through the deployment of renewable energy in exchange for concessional terms on the required loans by a group of developed countries**.

Four JETPs have been signed so far, involving Indonesia, Vietnam, South Africa, and Senegal.[37] In existing JETPs, the groups of developed countries pledged to offer loans ranging from $2.5 billion (for Senegal) to $20 billion (for Indonesia).

While JETPs offer a promising way to deliver climate finance in a way that guarantees emissions reductions, they currently suffer from several shortcomings. First, **their coverage is limited (in terms of sectors and countries)**. To improve the sectoral coverage and efficiency of JETPs, researchers have proposed to design them as a financial transfer in exchange for a national carbon price.[60] Second, as they focus on emissions reductions rather than sustainable development, **JETPs do not contribute to poverty reduction**. This concern could be mitigated by JETPs with a higher reliance on grants.[10] However, a higher provision of grants is difficult to achieve absent a dedicated source of revenue (such as an international tax).

Lastly, even if **JETPs** were improved along the previous lines, they would still **fail to guarantee that the decarbonization of big emitters like China or the European Union is consistent with required global efforts**.

1.2 Objectives for a truly sustainable regime

Now that we have a critical understanding of the current international climate regime, let us sketch the properties we desire for a new (or improved) regime. We will then be able to assess different proposals in light of these objectives. Here they are:

- **Temperature**. An effective climate regime should achieve the Paris Agreement's temperature target. It should do so by a stabilization of the concentration of each GHG in the atmosphere and abstain from the risky bets of climate engineering such as Solar Radiation Management. This objective would translate into a **global carbon budget**. For example, the carbon budget could be set at 1,000 $GtCO_2$ starting in 2025, which corresponds to most likely warming of +1.8°C and a 67% chance to keep global warming below +2°C.

- **SDGs**. A holistic approach requires solving all humanity's greatest challenges, not just climate change. As explained above, justice requires sufficient **North-to-South transfers** to fund sustainable development (not just climate action). Even though the Sustainable Development Goals (SDGs) and the planetary boundaries would require additional policies and transfers, one important feature of the climate regime is how much climate finance it delivers in the form of transfers to the poorest and improved market conditions. This can be measured through SDGs indicators or the catch-up of GDP per capita in low- and lower-middle-income countries.

- **Efficiency**. As stated by the UNFCCC since 1992,[63] "measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost." Economists have argued that ensuring cost-effectiveness require an **economy-wide carbon price, uniform** across sectors and countries. This fundamentally results from the fact the social cost of emissions is independent from their

source or location, therefore emissions should be priced uniformly. Note that this argument in favor of carbon pricing does not preclude other, complementary policies: these have also been shown to be optimal by economic analysis.[61]

- **Acceptability**. A promising proposal is one that has good chances to be accepted by most countries. To measure the success of a proposal, we can use the share of global emissions that are covered by participating jurisdictions. Different elements contribute to acceptability:
  - *Progressivity at the top*. If costs are concentrated on the richest households, the regime can benefit the majority in each country while addressing the excessive level of inequality.
  - *No loss in middle-income countries*. Countries whose population is not rich should not lose from an international climate policy. To assess whether a country loses or not, we should compare its situation in the new regime compared to the status quo. If we synthesize a country's situation by the carbon budget it is granted, a country would lose if its carbon budget is lower than their unconditional NDC completed by the ambitious emissions trajectory that the country currently envisions.
  - *Win-win*. While (per the SDG objective) transfers would be required from high-income countries, this does not necessarily mean that these countries' population would lose out. First, because (as stated above), redistributive policies can concentrate the costs on the richest households in their country. Second, everyone would benefit from a stabilized climate and from a world where SDGs are met. For example, sustainable development would spur global demand, including for advanced technology and low-carbon exports from industrialized economies. Third, while transfers imply a loss compared to the situation with the same worldwide decarbonization efforts and without international transfers, the latter situation is unlikely (as transfers are necessary to promote decarbonization in the Global South). As proposed above, the situation that should be used as a point of comparison is the status quo where the country's carbon budget corresponds to its unilaterally planned emissions trajectory and where there is no international trade in emissions allowances. **To the extent that transfers are the counterpart of the purchase of emissions allowances, a new climate regime could be a *win-win* for all participating countries, as they would all reap the efficiency gains** of an optimal location of emissions reductions.

Coalition of the willing. International negotiations have shown that it is illusory to seek universal agreement for an ambitious agreement. Therefore, political realism requires pushing for proposals that do not get accepted by all countries, and thus, that may also fail to deliver on the climate target, as countries outside the coalition would not fulfill their

part of the temperature objective. If oil exporting countries, representing 25% of current emissions, do not join the coalition, temperature in 2100 would be about 0.3°C higher than with a universal participation to decarbonization efforts. While this outcome would be a partial renouncement to some objectives (full acceptability, strict temperature target), it is probably the only type of outcomes that is accessible given the political balance of power.

2 A Fossil-Free Union

Having in mind the shortcomings of the current regime as well as the objectives of a new regime, we are now equipped to propose an international agreement to phase out fossil fuels in a way that is cost-effective, acceptable to most countries, and promotes sustainable development.

2.1 The principles for a Fossil-Free Union

The Union would be open to any country, as well as subnational entities (such as U.S. states).

Emissions Trading System. The Union would put in place **an international Emissions Trading System (ETS)**, **that would add up to existing ones** (to not dilute the stringency of existing ETSs). All sectors except agriculture and land-use (LULUCF) would be covered. In particular, the ETS would cover (domestic and international) aviation. International shipping could also be covered, replacing the system established by the International Maritime Organisation. The ETS would cover all gases emitted in industrial or energy processes, as in the Korean ETS. Namely, the ETS would cover CO_2, N_2O, PFCs, SF_6, HFCs, as well as methane emissions from industrial processes, fossil fuel extraction, and waste management (but not methane emissions from agriculture).

Complementary policies such as the Tropical Forest Forever Fund would be needed to cover LULUCF sectors. This is important to avoid carbon leakage that would substitute fossil fuels with biomass obtained through deforestation.[4]

Emissions allowances would be fully auctioned by an *ad hoc* international authority to polluting companies upstream of the supply chain.

The ETS will be completed by a **carbon border adjustment** to prevent carbon leakage and ensure that the Union's carbon footprint (rather than its territorial emissions) is capped. Importers into the Union would have to purchase emissions allowances corresponding to the carbon embedded in the imported goods. Exporters out of the Union would receive a rebate for the carbon embedded in their exports, and extra allowances would be auctioned to finance the rebates.

In some federal countries like the U.S., some States may be willing to join the Fossil-Free Union (FFU) while the federal level would not. To help such States to join the Union despite their belonging to a national customs union, they would be exempted from the carbon border adjustment. In this way, **a State like California could join**. It could also use its share of the revenues to subsidize manufacturing firms, perpetuating its way of recycling ETS revenues and preventing carbon leakage.

Once export rebates are paid, the remainder of **carbon pricing revenues would be returned to countries based on their yearly quota**.

National carbon budgets. Each country would be granted a carbon budget between the starting year (say 2030) and net-zero (say in 2080).

Each country would then describe how they would divide their carbon budget intertemporally into yearly quotas. As such, the yearly trajectory of the Union's emissions over the next fifty years would be known at the starting year. Each country would be relatively free on the intertemporal breakdown of their carbon budget, though this choice would have to respect some constraints, developed in Section 2.6, and related to the **rules to avoid hot air** proposed in Section 1.1.4.

Adjusted per capita allocation. By default, each country would be granted a carbon budget corresponding to an equal per capita share of the remaining global carbon budget. This allocation can be understood as an equal right to pollute for each human, irrespective of their country. Such an allocation would induce international transfers from agents (people or countries) with a carbon footprint higher than the world average, to agents with a lower carbon footprint.

As future population is unknown (and can be affected by policy choices), the benchmark per capita carbon budget would be based on the population share taken at the starting year.

Then, **some departures from the benchmark would allow adjusting to special circumstances**. To prevent transfers flowing from lower-income countries to high-income countries, high-income countries would be granted a carbon budget corresponding to their ambitious decarbonization pathway. In particular, **the European Union would be granted emissions allowances in line with its NDC**, with 90% emissions reductions in 2040 (compared to 1990), and net-zero in 2050. This represents **less than** half of EU's benchmark **equal per capita share**.

To prevent middle-income countries from losing, **countries would be allowed to propose further departures from the benchmark** allocation, to the extent that the Union's carbon budget is respected. These departures from the benchmark **need to be agreed by a majority** of participating countries, weighted by their GHG emissions.

In particular, **middle-income countries with emissions per capita above the world average, such as China, Iran, or Turkmenistan, could be granted** a carbon budget equal to the cumulative carbon footprint corresponding to **their own ambitious decarbonization pathway**.

Universal cash transfer. The Union would **encourage countries to return the ETS revenue to the population through an equal cash transfer**. In particular, the Union would develop standards and provide technological resources to distribute the cash transfer. Despite the difficulty to reach people who lack civil status or live in remote areas, solutions exist. For example, the Indian system Aadhaar has provided a unique biometric identifier to 99% of the country's population in less than seven years. In Africa, the World Bank's ID for Development program is financing the deployment of universal legal identity, in line with SDG Target 16.9. Besides, with phone-based payments and biometric identifica-

tion, satellite Internet, and off-grid solar panels, the technology is mature and affordable to distribute cash transfers in a way that is fraud-resistant and leaves no one behind.

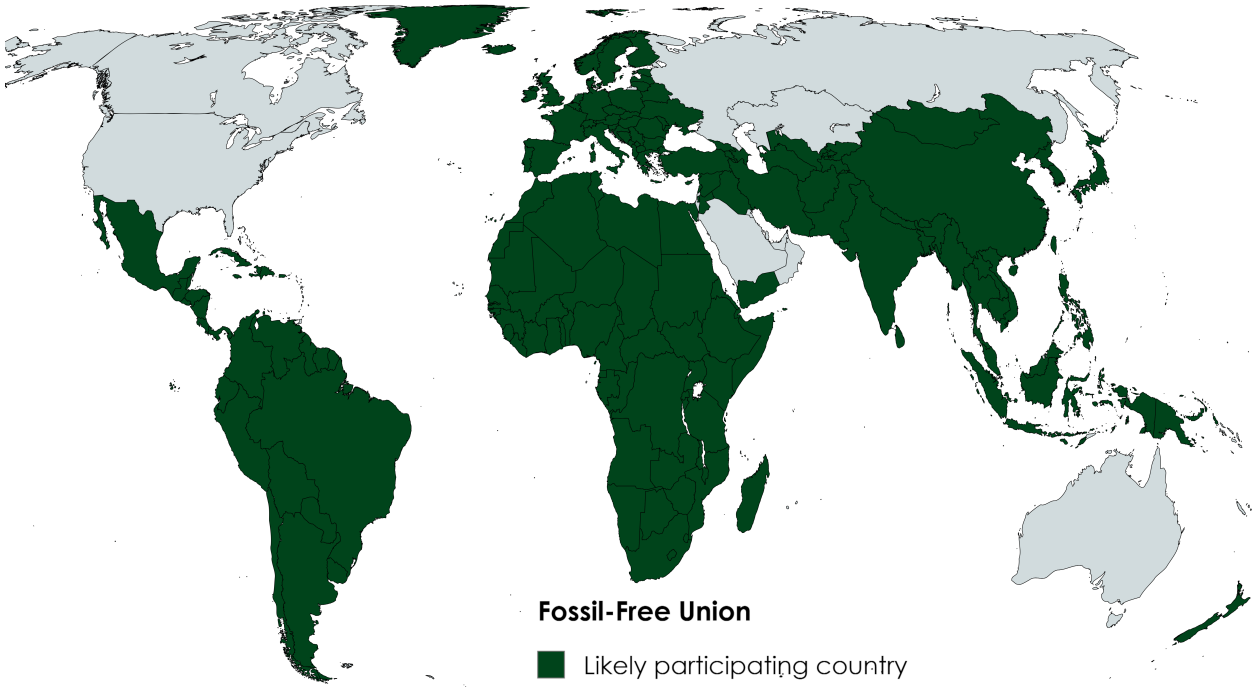
The equal cash transfer would compensate people for the rise in fossil fuel prices. The transfer would reflect each person's equal right to pollute, as it would work as if the person would have sold this right at the carbon price to polluting companies.

Countries that choose not to distribute all revenue through a cash transfer would have to prove that they spend it in a way that leaves no one behind.

2.2 Likely participating countries

Countries that would not lose from the policy are expected to join: these include all low- and middle-income countries, as well as high-income countries with a strong climate ambition. The map in Figure 1 shows which countries are likely to join the Union. These countries represent 74% of current emissions.

Figure 1: Countries likely to participate in the Fossil-Free Union.



2.3 Allocation of emissions rights

If decarbonization continues on its current trend, emissions of the prospective Union would total 924 $GtCO_2$ over 2030–2080, while current NDCs (without accounting for long-term targets) would imply 788 $GtCO_2$. In both cases, emissions are expected to continue after that date: Union's emissions would reach 1,134 $GtCO_2$ over 2030–2100

under the current trend.[b] In contrast, enforcing an equal per capita share of the remaining 1.8°C carbon budget would **limit Union's emissions to 691 $GtCO_2$** over 2030–2080, with **net-zero emissions by 2080**, and negative emissions beyond that date (cf. Section 2.7).[c]

To determine the **"non-losing" carbon budget, below which a country could be considered losing**, we proceed as follows. For countries in the Global South, we use a Contraction & Convergence benchmark, where emissions rights per capita start at their current trend value in 2030 and linearly converge to the equal per capita share in 2050. This benchmark implicitly assumes that countries with relatively low emissions would consider as beneficial to their development the pathway that starts with the current trend, gradually grants them extra resources for sustainable development (in the form of emissions rights converging to an equal per capita share of the global sum), and then follows the world decarbonization trend. For high-income countries and for China, we use the cumulative emissions implied by their NDCs and long-term targets.[d] Doing so implicitly assumes that these countries have the domestic capacity to deliver their long-term targets on their own. These non-losing carbon budgets imply slightly more rights than the equal per capita share for China, and less for high-income countries.

Table 1 present the cumulative emissions implied by the current trend, *non-losing* budgets, equal per capita ones, and the proposed allocation.

The proposed allocation departs from the equal per capita one for China and Western Europe only, which are both allocated a carbon budget corresponding to their NDCs and long-term targets. It is worth noting that **the proposed allocation grants Eastern Europe, Japan, and South Korea with their equal per capita share**. Indeed, either these countries have significantly higher emissions per capita than the world average, in which case there is little risk that they turn net recipient from international transfers, or they are not as rich as Western Europe, in which case there is little concern if they turn net recipient. In both cases, there is no need to apply to them the same exception as for Western Europe. Note that I will soon update the proposal to match the European Union's NDC and Effort Sharing Regulation (that defines intra-EU solidarity in burden-sharing). For the moment, the regional grouping of the model I use divides Europe along West vs. East (rather than EU vs. non-EU).

Taking into account departures from the benchmark budget for China and Western Europe, emissions rights amounting 11 $GtCO_2$ remained to be allocated to match the Union's equal per capita share of the world's carbon budget. These extra emissions rights

[b] The data on emissions by region from the current trend and NDCs (with and without long-term targets) is given by the TIAM model in van de Ven et al. (2023)[65]. They model post-2030 action by extending the average rate of change in emissions intensity of GDP from 2020 to 2030. These estimates are more rudimentary and more optimistic than the ones by Climate Action Tracker (CAT). For example, the *current trend* scenario leads to a warming of +2.3°C in 2100 (vs. 2.7°C for CAT's current policies). Therefore, our comparison provides a conservative estimate of the ratchet-up in ambition brought by the Fossil-Free Union.

[c] The global carbon budget (and associated equal per capita rights) follows from non-LULUCF CO_2 emissions in the scenario SSP226MESGB of Gütschow et al. (2021).[36]

[d] For China, the value is in line with the domestic 2°C target scenario developed at Tsinghua University.[38]

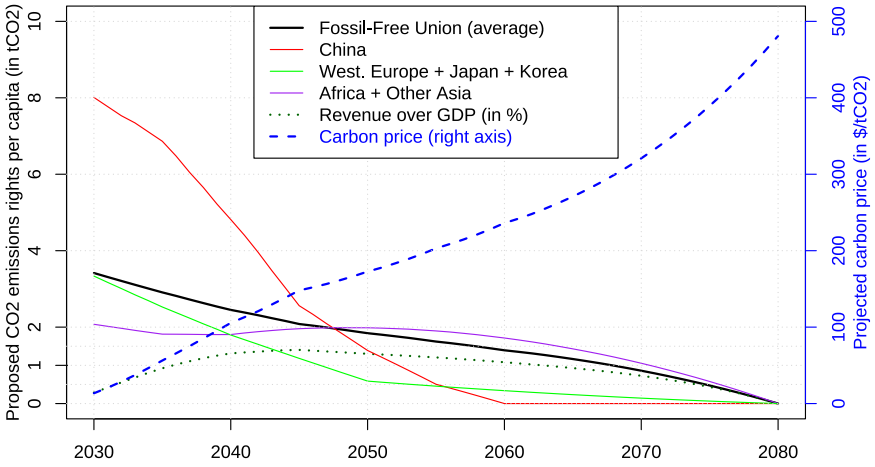
Table 1: Carbon budgets over 2030–2080 for a 1.8°C trajectory (in $GtCO_2$).

	Africa	China	Latin America	India	Europe	Japan & South Korea	Other Asia	*Fossil-Free Union*	*World*
Current trend	90	250	81	145	32	46	182	*924*	*1,240*
Non-losing	115	147	58	133	19	11	110	*640*	*800*
Equal p.c.	144	**131**	64	140	**51**	16	118	*691*	*770*
Proposal	147	**147**	64	140	**24**	16	125	*691*	*770*

were used to grant some extra carbon budget to 19 countries that would otherwise lose (in the sense that their welfare would be lower than in the case with non-losing rights). These countries include oil exporters such as Iran, Libya, and Turkmenistan, but also middle-income countries such as Egypt, Indonesia, Malaysia, and Thailand.

Finally, **we propose yearly quotas by country that respect the different constraints** (Figure 2 shows trajectories for broad regions). In particular, proposed allowances sum up to national carbon budgets for each country, and low-income countries receive more allowances than their current trend's emissions. Figure 2 also shows the carbon price that should result from this emission trajectory. The steadily increasing price would ensure sustained North-to-South transfers, paid by the efficiency gains from trade.

Figure 2: CO_2 emissions allowances for selected regions (in tCO_2 p.c.).

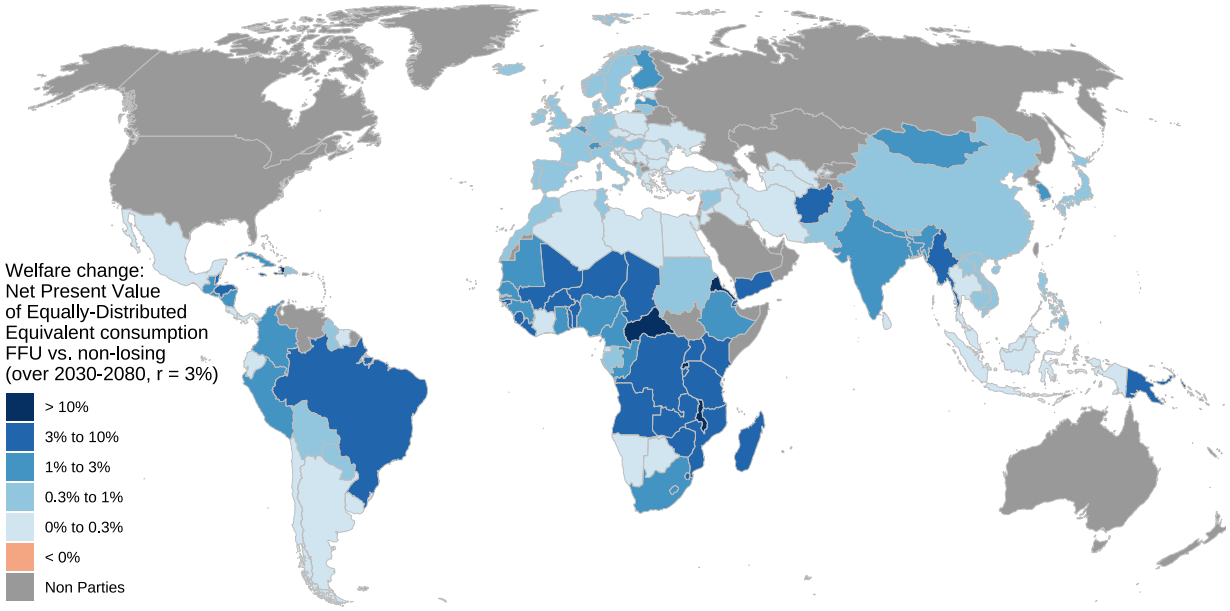


2.4 A win-win deal

Each country colored in Figure 1 would have an interest to join the Union:

- Every country would benefit from a stabilized climate, and from the guarantee that all countries in the Union decarbonize.

Figure 3: Variation in welfare[e] in the Fossil-Free Union, compared to a world with countries' emissions given by "non-losing rights" and without international carbon trading.



- Most countries would be granted a carbon budget sufficient to avoid a loss from the status quo. In particular, Figure 3 shows that all countries likely to join would enjoy increased welfare thanks to the Fossil-Free Union.[e]
- Lower-income countries would receive transfers from the rest of the world, spurring their sustainable development.
- Countries with an important low-carbon industry, such as East Asian countries, would gain from the stronger demand for these goods.
- High-income countries would benefit from the efficiency gains allowed by international carbon trading.[f]
- **Large representative surveys show strong public support in favor of the Fossil-Free Union, even in high-income countries** when transfers are presented as a loss and their magnitude is specified. For example, there is **54% support in the U.S. and 76% in Western Europe** (cf. Section 4.2).[29] Moreover, academic research shows that political programs containing the Fossil-Free Union are preferred by 58% to 60% of

[e]Simulations take into account international transfers, abatement costs, consumption-based emissions, and local climate damages. I used the model NICE,[68] which allows disaggregation at the country-decile-year level. To measure welfare, consumption is aggregated across deciles using the concept of Equally-Distributed Equivalent consumption, corresponding to the consumption level under perfect equality that would result in the same isoelastic utility (with a standard inequality aversion parameter $\eta = 1.5$).

[f]Note, however, that such benefit can disappear for countries with internal climate policy more stringent than the FFU's carbon price.

citizens in Western countries to similar programs without it, suggesting that **candidates at an election may win vote intentions by campaigning on the proposal**.[29]

2.5 A ratcheted-up ambition

Global temperature reduced by more than half a degree. According to the climate-economy model NICE that I use, the business-as-usual scenario without additional climate policies would lead to a global temperature increase of +2.6°C in 2100.

While the carbon budgets proposed in Section 2.3 are based on a +1.8°C trajectory, to the extent that the Union is not universal, they would imply a higher temperature trajectory. The higher temperature achieved is **not only due to countries outside the Union not pricing carbon at the same level as the Union**. It is **also due to a lower carbon price (and higher emissions) within the Union than the efficicent level that universal participation would entail**. Indeed, as non-participating countries are those with the largest emissions per capita, their absence from the Union decreases the Union's carbon price below its cost-effective level to achieve +1.8°C. In other words, the non-participation of the largest emitters (in per capita terms) prevents the efficiency gains that would occur should they participate: in this case, they would buy emissions allowances to the rest of the world, raising the demand for allowances and hence the carbon price, and the rest of the world would decarbonize faster (in exchange for transfers).

If the whole world decarbonized at the same rate as the Union, the temperature would reach +1.9°C in 2100. Assuming that emissions in non-participating countries would follow business-as-usual policies, the **temperature increase expected in 2100 is +2.0°C**.

Therefore, **the Fossil-Free Union** studied here **would bring a reduction of global temperature in 2100 of 0.6°C**. Of course, a lower temperature target could be reached by choosing a smaller carbon budget: the Union's decarbonization trajectory is a policy choice.

A sufficiently high carbon price. It is important that the Union's carbon price be sufficiently high, for different reasons. First, as transfers are proportional to the carbon price, a substantial carbon price is required to deliver meaningful transfers, finance sustainable development, and convince lower-income countries to join. Second, a low carbon price would entail few decarbonization incentives and indicate that the carbon budget is too large, i.e. the ambition too low. Third, a low price could result in a price hike if a large emitter (like the U.S.) decided to join the Union. This, in turn, would hinder the interest that high-income countries would have in favor of expanding the Union to new countries, as their contributions would increase along with the price.

To make sure that the price is sufficiently high, the Union could implement a (steadily increasing) carbon price floor. However, this is not our favorite option. Indeed, **adding a price floor would redefine and obscure the distributive effects** implied by the carbon budgets. By inducing a price higher than the equilibrium market price, **the price floor would** entail emissions lower than the yearly allowances and **be equivalent to a**

reduction of each country's emissions allowances. While countries recipient of transfers would be cushioned against these lower allowances through larger transfers, contributing countries would lose out compared to the situation without a binding price floor. This could jeopardize an agreement on the proposed allocation, that has been designed so that industrialized countries neither gain nor lose from the policy. Furthermore, given that we can hardly predict whether the price floor would be binding or whether the equilibrium price would be higher than the price floor, we can hardly redefine the proposed allocation to mitigate the effects of the price floor.

Instead of a carbon price floor, we propose rules to ensure that there is no excess allowances and that the carbon price increases sufficiently overtime. These rules correspond to the rules sketched in Section 1.1.4 and apply to the intertemporal allocation of national budgets. These rules are that the **Union's allowances should not exceed its joint emissions at the starting year, and that they have to decrease every year at a minimum rate of, say, 2%**. The intertemporal allocation proposed in Figure 2 respects these constraints: allowances are never above the *current trend* scenario and they decrease by at least 2% per year at every period.[g]

If countries cannot agree on an intertemporal allocation of their emissions allowances that respect these rules, the Union's scientific council would propose how to allocate allowances intertemporally in a way that maximizes welfare, thereby preserving the interests of all countries. **In case the Union rejects the proposal of the scientific council, a price floor would be implemented** (say, starting at \$10/tCO_2 and increasing by \$10 each year). The threat of a strong price floor should help countries find an agreement.

2.6 Timeline and governance

Initial stages. To build up the administrative capacity, the ETS could be preceded for a few years by a small carbon tax (say \$10/tCO_2), instead of an ETS. The revenues would be returned to countries using a pre-agreed allocation, for example proportional to the ETS starting year's national carbon budgets.

The ETS could also gradually expand its sectoral coverage. In particular, emissions from the aviation and/or manufacturing sectors (the ones covered by the European CBAM) could be covered before the ETS is extended to all intended sectors.

In any case, what should occur upfront is negotiation and agreement about the carbon budget and how it is allocated between countries and over time.

Expansion of the Union. The Union can expand to a new member by approving a participation request, which should include a proposed national carbon budget and its intertemporal allocation. **When a new member joins, its entry into the ETS can be phased in** gradually, say over five years. Initially, allowances owed by the new member's companies would correspond to a fraction of their emissions, and the new member would

[g] In the proposed allocation, the decrease is slightly below 2% in 2046, 2047, and 2051, with a minimum at 1.77%, but the average decrease evaluated over any five-year period is always larger than 2% per year.

only receive that fraction of its normal ETS revenue, with the fraction linearly increasing during the phase-in period.

Renegotiation of carbon budgets. At any time, a country can propose a new global carbon budget, a new allocation of the global carbon budget across countries, or a new intertemporal allocation of national carbon budgets. A prospective new member can also make such a* "reallocation proposal". A reallocation proposal is submitted to the governing body at the condition that the scientific council deems it compatible with the objectives of Section 1.2. In particular, the scientific council would deem the proposal unfit if it is expected to increase the global temperature in 2100, taking into account the changes in membership (entries or exits) that an agreement on the proposal may entail.

Monitoring. GHG emissions must be monitored, reported and verified by the Union's administrative authority. The Union would make countries work together and assist countries lacking administrative experience. Besides, transfers would provide resources to low-income countries, which they can use to build up administrative capacity.

Governing body. In the Union, voting rights could be proportional to countries' emissions.[h] During operation of the ETS, the governing body would define the market design and possible sanctions against non-compliant or non-participating countries. Before the starting year, the governing body would discuss and vote on the agreement. In particular, it would choose the global carbon budget, its allocation into national budgets, and the intertemporal allocation of national budgets.

Beyond its mandate, the governing body would offer a space for discussion on climate-related matters. For example, it could be used to coordinate complementary policies, such as a ban on the production or import of combustion-engine cars by 2035.

Scientific council. Each participating country would be allowed to designate a team of scientists to represent them in a scientific council. Appointed scientists could be designated by several countries at the same time. The scientific council would assist the governing body by modelling the climate, economic, and distributive effects of the policy, by providing analyses upon request, and by proposing an intertemporal allocation of national budgets. In case of disagreement in the scientific council, each team of scientists would have a voting right proportional to the population of the country (or countries) that designated them.

Market design. The compliance period to surrender emissions permits should be one calendar year, and the auctioning of emissions allowances should occur once a year. Car-

[h]The ETS would directly affect participating countries according to their emissions. It thus seems legitimate to grant each country a voting right proportional to its carbon emissions, at least for decisions pertaining to the ETS or sanctions.

bon offsets should not be allowed as a substitute to surrender emissions allowances. Borrowing and banking emissions permits should be limited in time and quantity to avoid speculation.

Sanctions. Countries that do not correctly apply carbon pricing on their territory could be excluded from the Union by a vote of the governing body. Besides, **if the governing body deems it appropriate to encourage participation, it could vote sanctions against non-participating countries, such as tariffs (beyond the carbon border adjustment)**, assets forfeiture, or travel restrictions (especially targeting elites).

2.7 Negative emissions

In this proposal, we interpret the Paris Agreement as allowing for a temporary overshoot of the 1.5°C target, provided that warming never exceeds 2°C. In other words, after a first phase with positive emissions, a second phase with net negative emissions will make it possible to get back down to 1.5°C, a threshold that will very likely already be crossed in 2040.[24] The positive emissions budget that we consider for the first phase (1,000 $GtCO_2$ from 2025) corresponds to a 67% probability of not exceeding 2°C of warming.

In the second phase, when net emissions will be negative, there would be two annual carbon budgets: a quota of residual positive emissions (for activities that are impossible to decarbonize), and a tender for negative emissions. An annual call for tenders would enable negative emissions to be purchased at the lowest cost. Carbon sequestration could be financed by taxes on the wealthiest, such as a global wealth tax. Only projects whose sequestration is indisputable would be financed. For example, sequestration through gains in forest biomass would only be financed if the emissions due to the loss of forest were also priced.

Carbon sequestration would also be financed from the first phase, where taxes on the wealthiest could already be used. Its value would then be set at the market carbon price, and the sequestration thus remunerated would swell the auctioned emissions quota by the same amount.[25]

After several decades of net negative emissions, we would reach the Paris Agreement climate target (1.5°C warming), and we could even continue to sequester carbon to achieve a milder climate and limit sea-level rise. In this article, we do not engage with negative emissions, which will only become significant in a few decades' time, and we focus on the first phase of the Plan.

2.8 Limitations of the proposal

Any proposal comes with downsides, as trade-offs between conflicting policy objectives are inevitable. The proposal for a Fossil-Free Union faces three main limitations.

First, as the between-country and intertemporal allocation of the global carbon budget would be determined in advance, the agreement is not adapting to changing circum-

stances (e.g. a middle-income country growing and decarbonizing faster than expected, or surprises concerning the pace at which the transition can occur). Section 5.4 argues that an alternative option with adaptive emissions rights causes bigger issues. Furthermore, the rigidity ensures that the Union is committed to meet the climate targets. In addition, the rigidity is mitigated by the possibility to renegotiate the carbon budgets, described in the previous section.

Second, to fully understand the distributive effects resulting from the carbon budget allocation (in particular the intertemporal one), one needs to know the equilibrium carbon price that would emerge at each period. Yet, the carbon price can only be estimated with uncertainty. To make sure that distributive effects are known in advance, the Fossil-Free Union can be complemented by the "Sustainable Union" proposed in Section 3, that would determine the transfers between countries based on their GDP per capita and finance them through new international taxes on the wealthiest.

Third, the North-to-South transfers involved in the Fossil-Free Union may be too low in view of the resources needed to achieve the SDGs or of the "climate debt" that high-income countries owe due to their past emissions. These concerns are also resolved in the "Sustainable Union" proposed in Section 3.

Finally, this carbon pricing proposal face challenges inherent to any international proposal to phase out fossil fuels. A challenge for carbon pricing is to monitor and verify emissions of companies or governments that could fail to comply. Although required to guarantee a Paris-aligned decarbonization, the application of a common carbon budget can be viewed as infringing on sovereignty. In absence of a mechanism to preserve forests, policies to phase out fossil fuels may cause some carbon leakage in the form of accrued deforestation. As in any international agreement, there is a risk that some countries leave after a few years (though this risk is mitigated for lower-income countries by granting them more rights around 2050 compared to 2030 or 2040). Lastly, a cartel of oil exporting countries could decide to cut supply in order to raise oil prices, thereby increasing their rents at the expense of the Union's carbon pricing revenues.

3 A Sustainable Union

While the previous section focused on the phase out of fossil fuels, we propose here a more comprehensive agreement towards sustainable development, financed by global solidarity levies. **We propose new taxes on wealth, polluting fuels, financial transactions, and corporate income, raising more than $3 trillion per year**. Part of the revenues from these taxes would finance international transfers. **One percent of each country's GNI would be reallocated to each country in proportion to their population**, addressing climate finance needs and fostering sustainable development.

3.1 The design of a Sustainable Union

A group of countries forming a Sustainable Union would have to agree on **three key elements**:

1. a target for **revenues from new levies** on the richest and on pollution, **say 2% of** their **GNI**;
2. a common **contribution to sustainable development, say 1% of GNI**; and
3. the Fossil-Free Union's **global carbon budget, say 1,000 $GtCO_2$** starting in 2025.

If participation is universal, the contributions would be returned to participating countries in proportion to their population. If some countries do not participate, the **rules guarantee that countries with per capita GNI above the global average would contribute financially to lower-income countries**, drawing on part of the new revenues. Net contributions (or transfers) per capita are proportional to the difference between the country's GNI per capita and the world average's.[i]

Global solidarity levies We propose to tax wealth at a rate of 2% above $5 million and 5% above $100 million (i.e. less than the return on capital for large fortunes). Thus, a couple with $10 million in wealth ($5 million each) would not be taxed, while a person with $150 million in wealth would be taxed at 3% per year.[j] Our proposal remains moderate; two or three times as much could be raised by adopting a more progressive tax schedule. The remaining revenues would come half from carbon pricing (with a higher rate on the aviation sector, currently exempt from taxes) and half from taxes on financial transactions and profits. We could also add a tax on inheritance, on the super-profits of fossil fuel companies and/or on digital advertising.[1]

We estimate the potential revenues from new taxes at global level.[28] These would amount to over 3% of global GDP (as shown in Table 2), the majority of which would come from a wealth tax.

[i] An alternative basis for the transfers could be the non-fossil GNI per capita. This would help economies dependent on the extraction of fossil fuels achieve their difficult transition.

[j] Indeed, 5% of $150 - 100 = 50$M and 2% of $100 - 5 = 95$M yield $2.5 + 1.9 = 4.4$M, that is 2.9% of 150M.

Table 2: Estimated revenues from new global taxes (in billions of dollars per year).

Financial Transaction Tax	Carbon price ($10/tCO$_2$)	Aviation tax ($300/tCO$_2$)	Corporate income tax (at 21%)	Tax on the ultra-rich ($3% above $100M)	Wealth tax ($2% above $5M)	**Total**
327	356	223	299	765	1,364	**3,334**

The participating countries would commit to applying a minimum rate of taxation on individual wealth, corporate income, carbon emissions from aviation fuel, and financial transactions, and to creating a global asset registry to list the assets held by each person. Thanks to the extraterritorial mechanism of "tax collector of last resort" proposed by economist Gabriel Zucman,[69] the Union would collect the "missing" tax due to the non-application by countries outside the Union of the minimum rate on multinational profits and individual wealth. In this case, the Union would demand payment of the "missing" tax, pro rata to the activities of the company (or companies controlled by the wealthy individual) that take place inside the Union, on pain of retaliatory measures against the company in question. These revenues would be used to increase transfers from the Union to the countries with per capita GNI below the world average.

The link with the Fossil-Free Union The countries of the Sustainable Union would commit to joining the Fossil-Free Union. The carbon price would thus be probably higher than the figure of $10/tCO$_2$ used in the simulation. Importantly, **the transfers entailed by the Fossil-Free Union would be counted as part of the contributions required by the Sustainable Union**. Therefore, if all countries from the Fossil-Free Union joined the Sustainable Union, the calculation of international transfers would be greatly simplified, as these would be determined by the simple formula of the Sustainable Union.

An issue with this arrangement is that transfers from or to a country would cease to depend on its carbon emissions, so incentives to implement national decarbonization legislation would be reduced. Two mechanisms would maintain incentives for a country to decarbonize. First, as the carbon price of the Fossil-Free Union would apply to companies rather than governments, even though costs for a country as whole would not depend on its emissions, consumers would still face the marginal cost of the carbon price and be incentivized to decarbonize accordingly. Second, to discourage countries from repealing existing climate legislation, any participating country would have to increase its net contribution to the Union if it reduces the climate ambition of its legislation. More precisely, any change in a country's legislation that is estimated to lead to increased emissions (or reduced emissions reductions) would be counted negatively in the country's contribution. Thereby, **a country renouncing to a decarbonization policy would have to compensate other countries by the induced extra emissions priced at the Union's carbon price**.

Monitoring A recurring concern on the part of contributors is that transfers could be diverted or misused, and could fail to contribute to the intended uses. Opinions also differ as to the best way to ensure that the poorest people benefit from transfers: should they be paid to governments, development agencies, NGOs, or households? In order to respect the plurality of solutions and the sovereignty of States, the treaty would leave the choice of programs to be financed to the beneficiary States, provided they are validated by **a multilateral agency** such as the World Bank. The agency in question **would ensure that funds are traceable, and that they finance only public services, social protection and sustainable infrastructure**. In the event of non-compliance with conditionalities, management of the funds would be entrusted to (another) multilateral agency, which would itself ensure that the population actually benefits.

Flexibility and conditional cooperation The Sustainable Union would be open to all countries. To encourage as many countries as possible to join, the treaty funding the Union would include elements of flexibility and conditional cooperation. In particular, **the contribution required of a high-income country could be reduced to the extent that other high-income countries did not participate**. Thus, if the European countries join the Union but the United States and Japan do not, Europe's contribution could be halved. Also, **a country could make its participation conditional on the participation of one or more specific countries, or on emissions covered by the Fossil-Free Union exceeding a threshold**, or on the GDP covered by the Sustainable Union exceeding a threshold. For example, the European Union could choose to participate on condition that 60% of global emissions are covered by the Fossil-Free Union, which would de facto make its participation conditional on that of China to international carbon pricing (as China accounts for 30% of global emissions).

3.2 The distributive effects of a Sustainable Union

Figures 4 and 5 estimate in each country the revenue collected from the new taxes as well as the transfers between countries. As one percent of each country's GNI is reallocated to each country in proportion to their population, with universal participation these mechanisms would entail **$766 billion in North-to-South transfers** (Figure 4), **mostly borne by the richest 1%**, and up to $1 trillion per year if one adds up existing Official Development Assistance. **The new taxes would collect $3.3 trillion globally** (Table 2), **enough for all developed countries to finance their net international contribution** (Figure 5). See Appendix B for details.

Figure 4: International transfers to be financed by new global taxes.

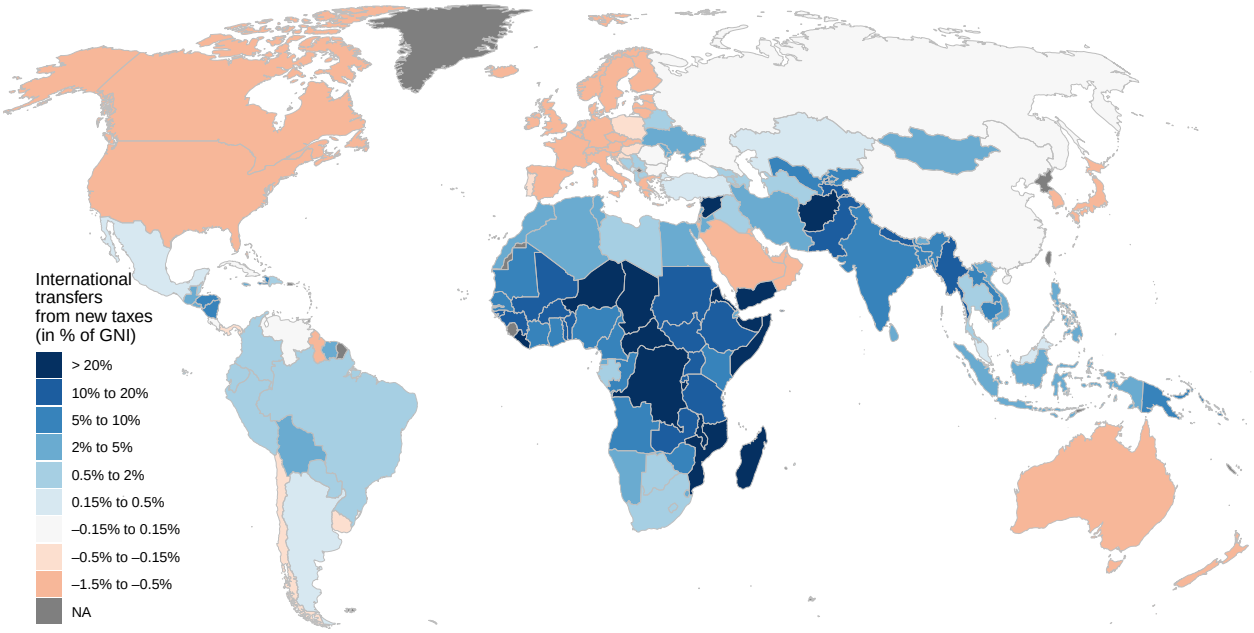
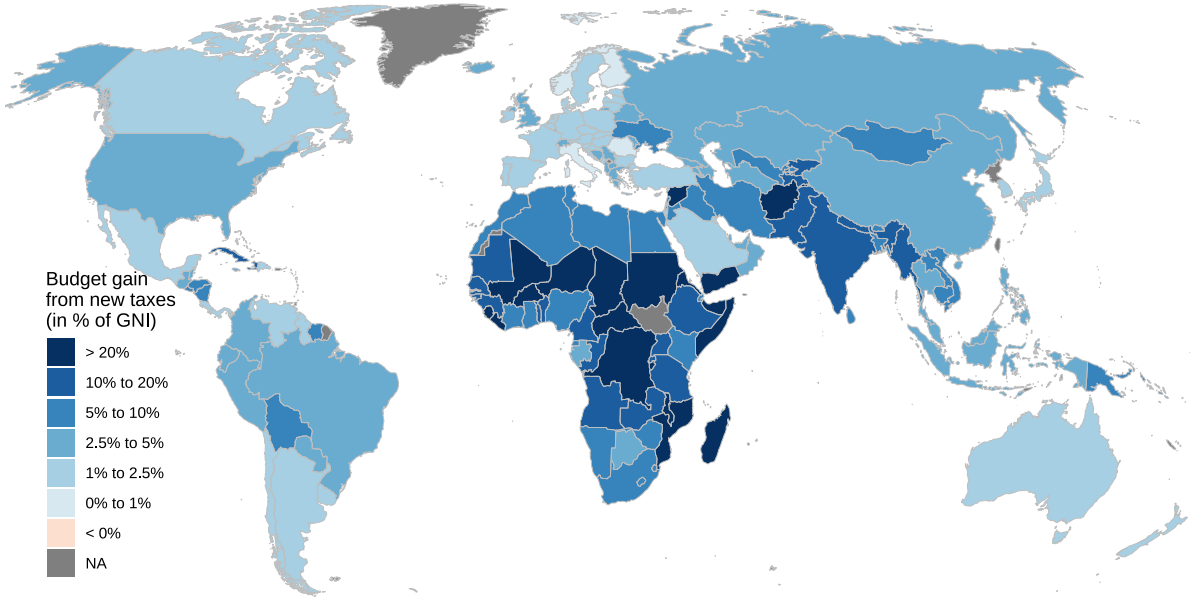


Figure 5: Net gain for state budgets from new taxes and international transfers (revenue plus net transfer).



4 Support for the proposals

4.1 Experts' support for the Fossil-Free Union

The FFU stems from three economic principles: the polluter-pay principle, welfare maximization, and the Pareto principle. The polluter-pay principle calls for carbon pricing, welfare maximization for a progressive distribution of carbon pricing revenues, and the Pareto principle constrains the distribution to allocations that make every participating country better-off. This last principle is what distinguishes the FFU from an *egalitarian cap-and-trade*, where revenues would be redistributed on a strictly equal per capita basis. As these two systems are very close, support for the egalitarian cap-and-trade can be understood as support for its more politically realistic variant: the FFU.

Given this theoretical backing, it is hardly surprising that the egalitarian cap-and-trade has emerged as the canonical solution to climate change. It seems that it was Michael Grubb, a professor at University College London, who first advocated this solution when the first IPCC report was being drafted in 1990.[35] In his article, Grubb writes that "by far the best combination of long-term effectiveness, feasibility, equity, and simplicity, is obtained from a system based upon tradable permits for carbon emission which are allocated on an adult per capita basis." Since then, many have expressed their support for such a solution.[3,6,8,17,43,66] For example, Blanchard & Tirole[9] (former IMF Chief Economist and "Nobel Prize" winner, respectively) write "The North should frankly acknowledge its responsibility for future climate damage, and consider the possibility of paying the South for the implementation of investments necessary to green its economy. This could be achieved by asking the countries of the South to join a market mechanism and offering them free permits in proportion to their population, which would at the same time increase incentives for mitigation in developing countries." Raghuram Rajan, former Governor of the Indian Central Bank and former IMF Chief Economist, also defends this system.[55] The IMF also recommends a uniform price with international transfers, though it also backs differentiated prices if international transfers are not feasible.[40]

Support for egalitarian cap-and-trade is not confined to *mainstream* economists: under the name *cap and share*, it is the first of six policies proposed in *the economics of degrowth*.[44] Similarly, heterodox economists such as Elinor Ostrom and Robert Costanza advocate a variant of global egalitarian carbon pricing, where half of the revenues would fund a basic income and the other half low-carbon projects.[7]

Finally, a coalition of NGOs called the *Cap And Share Climate Alliance* supports the FFU. Climate negotiators from Brazil, China, Kenya and Malawi have also expressed their support. The African Union calls for "a global carbon taxation regime",[2] and Ursula von der Leyen, President of the European Commission, also came out in favor of global carbon pricing Other prominent supporters include the government of Palau, political parties such as the French Greens or Renaissance (Emmanuel Macron's party), and scholars such as Gabriel Zucman, Julia Steinberger, and Christian Gollier.

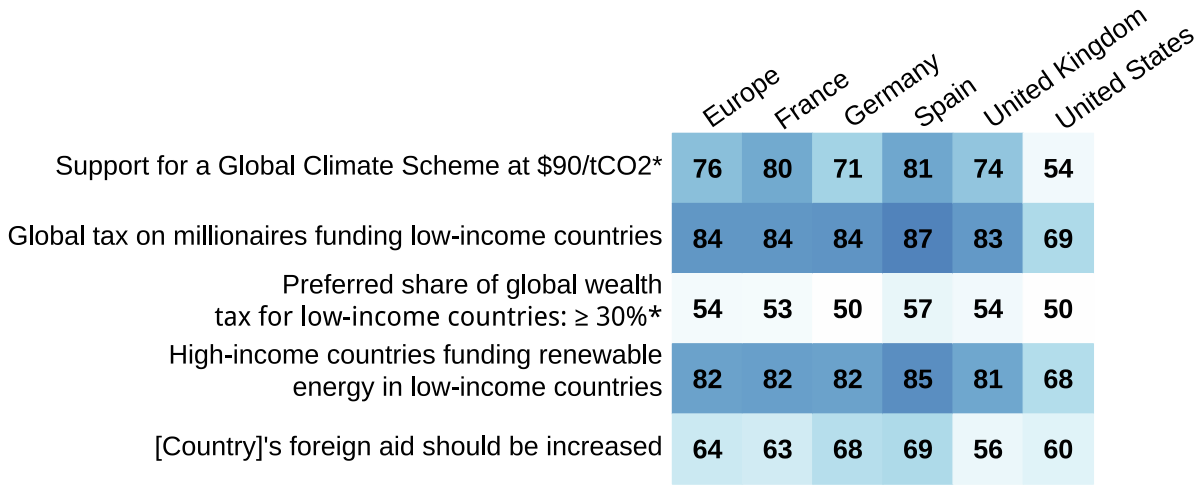
4.2 Public support for global climate and redistributive policies

International surveys have uncovered strong majority support for global redistribution. Over 29 countries, 78% agree and 5% disagree that "present economic differences between rich and poor countries are too large".[41] Recent representative surveys in 77 countries covering 87% of the world's population show that in all countries, a majority state that "rich countries should give more help to poorer countries to address climate change", with a global average of 79%.[62] Furthermore, 66% of Americans support providing "financial aid and technical support to developing countries that agree to limit their greenhouse gas emissions",[46] and 90% of Germans want some degree of global redistribution.[31]

Surveys of more than 40,000 people in 20 countries show that most people want climate action at the global (rather than the national) level.[20,29] These surveys show overwhelming support for a global emissions trading system that would keep emissions consistent with the 2°C target as well as for a global wealth tax that would finance low-income countries. Consistent with the literature,[14,18,48] there is a consensus for an equal per capita allocation of emissions rights, while grandfathering (allocating rights in proportion to countries' emissions) is the least preferred option in every country surveyed.

In surveys over 8,000 respondents in the U.S. and in four European countries,[29] my co-authors and I described a "Global Climate Scheme" similar to the FFU, consisting of a global price on carbon that would finance an equal cash transfer of $30 per month for every human, thereby alleviating extreme poverty. We explained that increased expenditures (from higher fossil fuel prices) would only be partially offset by the cash transfer, and informed the respondents of the cost to the average person in their country ($85 per month in the U.S., £20 per month in the UK). Even knowing the costs, 54% of Americans and 76% of Europeans supported the policy (Figure 6).

Figure 6: Support for global climate and redistributive policies (in percent).



We also found widespread support for a global tax on millionaires funding low-

income countries (69% in the U.S., 84% in Europe), similar to support for a domestic tax on millionaires funding domestic public services. We then asked to the respondents how they would prefer to allocate the revenue from a global wealth tax: The median respondent allocated 30% to low-income countries versus 70% to domestic health and education. Other questions in the survey consistently showed that most people care about global poverty. For example, more than 60% of respondents wanted to increase their country's foreign aid.

Finally, various experimental methods confirmed the sincerity of the support for global redistribution. For example, we found that a progressive candidate would not lose -– and could even gain — vote intentions by campaigning on global redistribution. This result is based on an experiment in which we presented respondents with two political platforms, corresponding to the conservative and progressive platforms of their country. For a random half of the sample, we added the Global Climate Scheme to the progressive platform. Preference for a platform never decreased when it included the Global Climate Scheme, and is sometimes increased, by up to 11 points in France.

5 Comparison of alternative proposals to phase out fossils

In Section 1.1, we have reviewed the pros and cons of ITMOs, climate finance, and JETPS, which represent the international initiatives to phase out fossil fuels with the greatest chance of implementation. While these approaches are acceptable to most countries, they generally fail to guarantee sufficient emissions reductions. In this section, we assess alternative proposals to expand carbon pricing or restrict fossil fuel extraction. We then provide three tables summarising the evaluation of each policy mentioned in this article. Table 3 presents each policy, Table 4 lists their pros and cons, and Table 5 attempts to grade the policies' properties in terms of the multiple desired objectives.

5.1 Linkages between carbon markets

Existing compliance carbon markets can be linked to each other, or linked to a voluntary carbon offset market.[42] With such linkages, either emissions allowances from a foreign country's carbon market, or carbon offsets (e.g. from forestation projects) are allowed for compliance in the domestic carbon market. The linkage can be partial, in which case there is a cap on the amount of external emission allowances/offsets that can be used for compliance.

Linkages are very similar to ITMOs; the main differences are that ITMOs are traded between countries (rather than firms) and always affect the accounting of NDCs (contrary to a link between two ETSs). By making carbon prices converge across borders, linkages achieve gains from trade. Yet, a linkage may induce hot air (and weaken domestic decarbonization efforts) if it is made with a system lacking ambition (cf. Section 1.1.4).

Furthermore, when a linkage connects ETSs, the difficult question of the allocation of emissions rights between countries arises (like in any international pricing agreement).

The connected countries have to either agree in advance on the trajectories of their respective emissions rights, or renegotiate the allocation at regular intervals. The EU was able to opt for the latter solution thanks to its centralized administration (the EU Commission). In absence of such authority, the former solution seems safer (to avoid later disputes), hence why it is the one chosen in the FFU proposal.

5.2 Differentiated carbon price floors

Many commentators argue that lower-income economies do not have the resources to adapt to a high carbon price and require a lower price than high-income countries. However, this claim is misguided and is not a sound argument in favor of differentiated carbon prices.[5] Indeed, a uniform price is more efficient, and in a redistributive system like the FFU, lower-income countries would actually *gain* purchasing power from the policy, meaning that they would obtain the required resources to adapt their economies. As long as they benefit from more emissions rights than emissions needs, they could in principle choose to keep their emissions stable and still pocket a financial transfer. Yet, the high carbon price would provide incentives to decarbonize and benefit from larger transfers.

A more reasonable argument in favor of coordinated carbon prices that would be differentiated depending on the country's income level[52] is the claim that international transfers are not feasible. In this case, differentiated prices offer a second-best solution.

Note, however, that there is an economic equivalence between differentiated carbon prices and a uniform price with differentiated emissions rights (see Appendix A for the mathematical derivation). More precisely, for a given agreement on differentiated prices, the same global emission reductions and the same costs and benefits by country can be achieved with a uniform price, by appropriately calibrating the price and the emissions rights, at least when efficiency gains are assumed away. This observation should invite us to question the claim that one option is not politically feasible, given that it has the same distributive effects as the other. Besides, because a uniform price offers efficiency gains from trade but differentiated prices do not, the latter is an inferior solution.

5.3 Supply-side policies such as *fossil fuel non-proliferation*

The *Fossil-fuel non-proliferation treaty* emerged as a prominent campaign to phase out fossil fuels. The call for a treaty (which does not refer to a specific treaty proposal) has been endorsed by over one million individuals, four thousands organizations (including Greenpeace and Climate Action Network International), and 101 Nobel prizes. While the petition only alludes to a consensual call for a "binding plan to end the expansion of new coal, oil and gas projects and manage a global transition away from fossil fuels"; campaign briefings and related academic research sketch out a more detailed plan.[13,32,57,58]

The campaign refers to a plan called to *Fair Shares Phase Out*, which involves setting country-specific end dates for fossil fuel extraction,[13,58] allowing a later phase out for

countries with lower income or higher dependence to fossil fuel extraction. For example, the U.S. would have to fully phase out oil extraction in 2031, Russia in 2037, Saudi Arabia in 2041, and Iraq in 2050.

This plan is problematic for at least two reasons. First, it requires the participation of all countries that export fossil fuels, yet these countries are the least likely to take action on climate change. Second, by cutting supply rather than demand for fossil fuels, this plan would increase fossil fuel rents instead of carbon price revenue. Therefore, despite the plan being touted as fair, it would probably widen inequality, as (predominantly rich) owners of fossil fuel resources would benefit while it would be difficult to compensate low-income consumers for higher fuel prices due to the lack of carbon pricing revenue. Admittedly, the plan also calls for North-to-South transfers to address the negative distributive effects, but it fails to include a specific proposal on how to fund these transfers, how to allocate them, let alone an assessment of overall distributive effects.

The aforementioned extraction end dates would also result in an inefficient location of fossil fuel extraction,[15] with e.g. cheap oil from Qatar being phased out 13 years before dirty oil from Venezuela. An alternative policy would exhibit similar properties without the inefficiency problem: a producer carbon price. Under this policy, producer countries would price carbon at the wellhead and retain the revenue from carbon pricing (or most of them). Some argue that producer countries would accept a producer carbon price as a compromise if climate-ambitious countries were willing to penalise them for refusing to cooperate. To achieve this, climate-ambitious countries would need to commit to decarbonising faster and imposing trade sanctions on fuel exporter countries (thereby reducing their revenues further) if they fail to price carbon.[54] However, this solution would lack fairness compared to an equal per capita allocation of carbon price revenues, as it would grant tax revenues to producer countries (most of which are wealthy). Furthermore, its proponents acknowledge that their proposal hinges on fuel-importing countries' ability to credibly commit to unilaterally stabilising the climate (compensating for producers' failure to decarbonise), whereas in reality, fossil-fuel exporters could doubt fuel-importing countries' willingness to make such sacrifices.

5.4 Opting-out from revenue sharing as in the *Global Climate Plan*

An earlier version of the Fossil-Free Union proposal was dubbed the *Global Climate Plan* (GCP).[26,27] The two proposals differ in how they prevent middle-income countries from losing and high-income countries from being net recipients of transfers. In the GCP, countries with a GNI per capita below 1.5 times the world average are authorized to fully opt-out from the mutualization of carbon pricing revenues and to retain the auction revenues collected on their territories (the waiver is phased out linearly for GNI p.c. between 1.5 and 2 times the world average). Thereby, middle-income countries with a higher-than-average carbon footprint, like China, would not be contributor to transfers, making them more likely to join the union. Conversely, emissions rights would be phased out for countries with high income and low emissions.

Compared to the FFU, which requires negotiating emission rights trajectories for each country, the GCP requires just a handful of parameters to be negotiated. However, the waiver entails other issues. First, as opting-out countries would obtain carbon pricing revenue corresponding to their territorial emissions, it gives an undue advantage to net exporters, whose territorial emissions are higher than their carbon footprint.[k] Second, countries benefiting from the waiver would have too little incentive to reduce their emissions, which could disproportionately shift the burden of decarbonization onto the rest of the world.

Acknowledging these issues, the GCP proposal envisages an alternative mechanism,[27] whereby the carbon budget of a middle-income country could be increased by a factor equal to the country's carbon footprint in 2025 divided by the average carbon footprint of the union at that date. Doing so introduces the same rigid carbon budget as in the FFU. But the FFU should be preferred, as its carbon budgets are based on official or scientific proposals concerning countries' decarbonization pathways, rather than on a crude approximation of their future needs.

[k] Note that the Carbon Border Adjustment Mechanism adopted by the EU grants exactly the same advantage on foreign exporting countries which pay an internal carbon price equal to the price on the European market: imports from such countries will be exempt from the carbon tariff, and these countries will benefit from carbon price revenues ultimately paid by European consumers.

Table 3: Description of possible international policies to phase out fossil fuels.

International policy	Description
(*Status quo*) Unregulated ITMOs	Countries trade Internationally Transferred Mitigation Outcomes, bringing flexibility to the location of NDCs' emission reductions.
Partial linkage of carbon markets[42]	Carbon markets such as the EU ETS would accept external ETS allowance or emission reduction certificates up to some limit.
ITMOs avoiding hot air	ITMOs with extra rules (described in Section 1.1.4) ensuring that countries trading ITMOs have joint NDCs in line with the Paris target.
ITMOs + country-level integrity	ITMOs with extra rules preventing countries lacking ambition to participate.
(*Status quo*) JETPs[37]	Just Energy Transition Partnerships where one developing country obtains concessional loans from a set of HICs conditional on the decarbonization of its power sector.
JETPs with more grants[10]	JETPs financed by grants more than loans, of $120 billion per year.
JETPs with wider scope[60]	JETPs with grants conditional on implementation of climate policy such as national carbon pricing.
Uniform price on CBAM sectors	International cap-and-trade on carbon-intensive manufacturing sectors, with little revenue sharing between countries.
Differentiated price floors[52]	Coordinated carbon price floors ($25/tCO$_2$ for LICs and lower-MICs, $50 for upper-MICs, $75 for HICs), with little revenue sharing between countries.
Diff. prices on CBAM sectors	Differentiated price floors limited to CBAM sectors, with little revenue sharing between countries.
Nordhaus-type club[16,50,67]	Uniform carbon price, with little revenue sharing between countries, with a CBAM, and dissuasive tariffs on imports from outside the club.
Fossil-Free Union (FFU)	International cap-and-trade, with revenue returned on a basis given by an equal per capita benchmark with some adjustments (cf. Section 2).
FFU + Sustainable Union (SU)	International cap-and-trade and new taxes (especially on wealth), where international transfers are proportional to the difference between a country's GNI per capita to the world average (cf. Section 3).
Uniform price floor + SU	Sustainable Union with a (negotiated) uniform carbon tax rather than a cap-and-trade.
Fossil non-proliferation treaty[13,49]	Coordinated phase out of fossil fuel extraction, with supply cuts starting in richest countries and ending with poorer, more fossil-dependent ones.
Producer carbon tax[54]	Uniform carbon tax applied on extraction or imports of fossil fuels, with part of the revenue shared with LICs and tariffs.
Expansion of climate finance[11,19,34,39,47,59]	Reforms to the financial system to orient investment towards sustainable projects in the Global South, through public multilateral guarantees on climate projects, expansion of Multilateral Development Banks' (MDBs) operations, rechannelling of Special Drawing Rights to MDBs' capital, debt-for-climate swaps, money creation, etc.
Standards and bans	Implementation of common sectoral norms, e.g. standards on the CO_2-emission intensity of cars, shipping or aviation fuel; bans of fossil-fuel exploration, or on the opening of new coal power plants; common taxonomy for climate finance.

Table 4: Pros and cons of possible international policies.

International policy	Pros	Cons
(*Status quo*) Unregulated ITMOs	Cross-border financing of efficient decarbonization projects.	*Hot air*, risks weakening domestic climate action.
Partial linkage of carbon markets	Same as ITMOs.	Same as ITMOs.
ITMOs avoiding hot air	ITMOs without hot air.	Trading between countries rather than firms, weakening enforcement.
ITMOs + country-level integrity	ITMOs with reduced hot air.	Either hot air or risks of unfair burden-sharing.
(*Status quo*) JETPs	Cross-border financing of electricity decarbonization.	Limited scope; few grants; no effect on high emitting countries.
JETPs with more grants	JETPs with North–South transfers.	Limited scope; no effect on high emitting countries.
JETPs with wider scope	Potentially full country decarbonization.	No effect on high emitting countries.
Uniform price on CBAM sectors	Efficient decarbonization of manufacturing, settling the CBAM issue.	Limited scope; no North–South transfer.
Differentiated price floors	Country-wide efficiency; ambition adapted to country circumstances.	Few North–South transfer; no gains from trade.
Diff. prices on CBAM sectors	Decarbonization of manufacturing.	Few North–South transfer; limited scope.
Nordhaus-type club	Efficient decarbonization.	Few North–South transfer; trade sanctions may fail to incentivize recalcitrant countries and will hurt the club.
Fossil-Free Union (FFU)	Efficient decarbonization with North–South transfers.	Ambition and burden-sharing rigid to changing circumstances.
FFU + Sustainable Union (SU)	Efficient decarbonization with large North–South transfers, spurring development.	Climate ambition rigid to changing circumstances; imperfect incentives for countries to implement complementary climate policies (as international transfers don't depend on the country's emissions).
Uniform price floor + SU	Efficient decarbonization with large North–South transfers, spurring development.	Climate ambition not guaranteed (price may be too low); imperfect incentives for countries to implement complementary climate policies.
Fossil non-proliferation treaty	Decarbonization.	Relies on the (unlikely) participation of fossil-fuel producing countries; would increase oil rents and hurt consumers, especially low-income ones; lacks efficiency.
Producer carbon tax	Efficient decarbonization.	Relies on the (unlikely) participation of fossil-fuel producing countries; would increase oil rents and hurt consumers, especially low-income ones.
Expansion of climate finance	Lower interest rates in LMICs, spurring sustainable development.	Does not cap emissions.
Standards and bans	Aligns one sector towards decarbonization.	Limited scope; no North–South transfer.

Table 5: Comparison summary of possible international policies.

International policy	Emission reductions	Least cost	Fair		Acceptable by				Flexible
			Rich pay	Poor gain	LICs	MICs	HICs	Oil countries	
(*Status quo*) Unregulated ITMOs	0	+	0	0	+++	+++	+++	+++	+++
Partial linkage of carbon markets	0	+	0	0	+++	+++	+++	+++	+++
ITMOs avoiding hot air	+++	+++	++	++	+++	++	+	−−	-
ITMOs + country-level integrity	+	+	+	+	+	+	++	++	+++
(*Status quo*) JETPs	+	0	0	+	+++	+++	+++	+++	+++
JETPs with more grants	+	0	++	++	+++	++	+	−−	+++
JETPs covering broad policy	++	+	++	++	+++	++	+	−−	+++
Uniform price on CBAM sectors	++	++	0	−−	-	+	+++	−−	+
Differentiated price floors	+	+	0	-	-	+	+++	-	+
Diff. prices on CBAM sectors	+	+	+	-	0	++	++	−−	+
Nordhaus-type club	+++	+++	0	-	+	+	+++	−−−	+
Fossil-Free Union (FFU)	++++	+++	++	++	+++	++	+	−−	−−
FFU + Sustainable Union (SU)	++++	+++	+++	+++	+++	++	0	−−−	−−
Uniform price floor + SU	++	++	+++	+++	+++	+++	0	−−	+
Fossil non-proliferation treaty	+	-	-	-	-	-	-	-	+
Producer carbon tax	++	++	−−	−−−	−−−	−−	-	-	+
Expansion of climate finance	++	+	+	+	+++	+++	++	+	+++
Standards and bans	++	0	0	0	+	+	++	+	0

Conclusion

Taking stock of the strong public support for global climate and redistributive policies,[29] we have proposed two complementary international agreements, dubbed the Fossil-Free Union and the Sustainable Union.

By establishing an international emissions trading system, the Fossil-Free Union would guarantee that emissions of participating countries are in line with the Paris Agreement's target. It would resolve the long-standing question of how to share the burden of climate action between countries, by setting a benchmark norm of equal per capita emissions allowances. Designed in a flexible way, it should be acceptable by all countries: first, it would allow departures from the benchmark allocation, for example to account for the needs of fossil-dependent countries; second, it would provide transfers to lower-income countries, paid by the efficiency gains resulting from carbon trading.

In addition, the Sustainable Union would ramp up global solidarity to finance sustainable development. A set of global solidarity taxes on the richest and polluters would finance both the budgets of each collecting country (two-thirds of revenues) and the budgets of low-income countries (one-third). The Sustainable Union would increase even further the incentives for lower-income countries to decarbonize, as their entry to the Sustainable Union would require them to join the Fossil-Free Union. Furthermore, the new levies would ensure that the richest are put to contribution during the sustainable transition and that they bear the costs of international transfers. Lastly, adding to the Fossil-Free Union the Sustainable Union would streamline the determination of international transfers, as these would be based exclusively on the capacity to pay or the needs, measured as the gap between a country's GNI per capita and the world average's.

As a next step, supportive organizations could launch a taskforce gathering scholars and diplomats to refine or rework these proposals. In particular, dialogue with diplomats or government officials will be key to understand what each country considers as a non-losing allocation, and update the analysis in that regard.

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A Correspondence between transfers in a cap-and-trade and differentiated carbon prices

A.1 The static case

Setting

Decarbonization is costly. When a country i faces a carbon price p_i, it curtails consumption by investing in low-carbon equipment and reorienting consumption to less preferred, less carbon-intensive products. These costs to consumption are called abatements costs and denoted a_i. Taking into account the possibility of transfers t_i from the rest of the world, expressing everything in per capita terms, and abstracting from exogenous investments, country i's consumption is related to its potential output y_i as follows:

$$c_i = y_i + t_i - a_i$$

Assume that the welfare of country i depends on its consumption c_i and global emissions $E = \sum_j e_j n_j$, where e_j is country's j per capita emissions and n_j its population size. For now, take global emissions as fixed at their optimal level E^*. Let p^* be the uniform carbon price required to attain E^*, i.e. $E^* = \sum_j e_j(p^*) n_j$. As shortcuts, we denote $e_i := e_i(p_i)$, $a_i := a_i(e_i)$, $e_i^* := e_i(p^*)$, and $a_i^* := a_i(e_i^*)$.

A situation is fully specified by the set of transfers $(t_j)_j$ and carbon prices $(p_j)_j$ for each country. For country i, given that global emissions are taken as fixed, the situation can be summarized as $s = (t_i, p_i)$, and (with a slight abuse of notation) we may express i's welfare accordingly: $u_i(c_i; E^*) = u_i(t_i, p_i)$.

Equivalent variation from the benchmark in the absence of transfers

To analyze an arbitrary situation s, it will be useful to relate it to two special cases. First, the coordinated situation $c* = (0, p^*)$ without transfer and with a uniform carbon price, which we take as a benchmark. Second, the autarchy situation $a = (0, p_i)$, without transfer and with differentiated prices, which will be a useful intermediary to analyze an arbitrary situation. We denote $V_i(p_i)$ the equivalent variation between situation a and $c*$, i.e. the transfer required at $c*$ to get a's welfare:

$$\begin{aligned}
u_i(V_i(p_i), p^*) &= u_i^a = u_i(0, p_i) \\
c_i^{c*} + V_i(p_i) &= c_i^a \\
V_i(p_i) &= c_i^a - c_i^{c*} \\
&= a_i(e_i^*) - a_i(e_i) \\
&\sim (e_i^* - e_i)\frac{da_i}{de}(e_i^*) = (e_i - e_i^*)p^*
\end{aligned}$$

as $\frac{da_i}{de}(p) = -p$. Denoting $\varepsilon^* = -\frac{de_i/e_i^*}{dp/p^*}$ the absolute price elasticity of emissions at p^*, we have

$$V_i(p_i) \sim (p^* - p_i)e_i^*\varepsilon^*$$

V_i is positive iff $p^* > p_i$, as country i "needs" a positive compensation to get the same welfare as in a compared to $c*$ with a higher price p^* (and lower emissions).

Equivalent transfer for an arbitrary situation

Let g_i^s be country i's net gain (or "equivalent transfer") in a situation $s = (t_i, p_i)$ compared to the benchmark situation $c* = (0, p^*)$:

$$\begin{aligned} g_i^s &= (c_i^s - c_i^a) + (c_i^a - c_i^{c*}) \\ &= t_i + V_i(p_i) \end{aligned}$$

Note that **we can call g_i^s the equivalent transfer as it is the transfer at zero price that makes i indifferent with s, i.e. the transfer such that $(g_i^s, 0)$ is welfare-equivalent to $s = (t_i, p_i)$**. The equivalent transfer is a very useful metric to compare the welfare of a country in different situations.

Correspondence with an equivalent price

Now, we have all the tools to study the correspondence between transfers, differentiated emission rights, and differentiated prices. Let p_i^* be the "equivalent price" such that $s = (t_i, p_i)$ is welfare-equivalent to $s* = (0, p_i^*)$.

$$\begin{aligned} g_i^s &= g_i^{s*} \\ t_i + V_i(p_i) &= V_i(p_i^*) \\ t_i + (p^* - p_i)e_i^*\varepsilon^* &\sim (p^* - p_i^*)e_i^*\varepsilon^* \end{aligned}$$

Therefore, at the first order, the equivalent price is:

$$p_i^* \sim p_i - \frac{t_i}{e_i^*\varepsilon^*}$$

The equivalent price is negative when $p_i e_i^* \varepsilon^* < t_i$. As a negative price would require a transfer from the rest of the world, a regime with differentiated (positive) prices is restrictive compared to a system that allows for international transfers. Therefore, **we prefer to use the concept of equivalent transfer g_i^s, rather than its dual the equivalent price**.

Correspondence between differentiated prices and rights

Imagine that countries establish a uniform carbon price p^*, for example through a cap-and-trade. Say each person in country i has an emission right r_i, so they are entitled a claim $r_i p^*$ on global carbon revenue. Then, the net monetary transfer to i is

$$t_i^* = r_i p^* - e_i^* p^*$$

In the static case, **there is a correspondence between emission rights r_i in a cap-and-trade and welfare-equivalent differentiated prices p_i in autarchy (without transfers)**:

$$\begin{aligned} g_i^a = V_i(p_i) = a_i^* - a_i &\sim (e_i - e_i^*)p^* \sim (p^* - p_i)e_i^*\varepsilon^* \\ g_i^* = t_i^* &= (r_i - e_i^*)p^* \\ g_i^* = g_i^a \Leftrightarrow t_i^* &= a_i^* - a_i \\ \Leftrightarrow (r_i - e_i^*)p^* &\sim (p^* - p_i)e_i^*\varepsilon^* \end{aligned}$$

The left-hand side is the cap-and-trade equivalent transfer, which corresponds to the net monetary transfer received in the uniform cap-and-trade. This transfer is equal to the extra abatement cost incurred by going from autarchy to the cap-and-trade without transfer. The (first-order) equivalence relation states that the transfer is negatively related to the difference between the autarchy price and the global cap-and-trade price. The coefficient of this linear relation is the emissions times their price elasticity: the higher the emissions and the more they are sensitive to the carbon price, the larger the effect of the autarchy carbon price on the cap-and-trade equivalent transfer.

One can easily isolate cap-and-trade emission rights or autarchy price in function of the other variables:

$$\begin{aligned} g_i^* = g_i^a \Leftrightarrow r_i \sim e_i &\sim (1 + (1 - \frac{p_i}{p^*})\varepsilon^*)e_i^* \\ \Leftrightarrow p_i &\sim (1 + \frac{e_i^* - r_i}{e_i^*\varepsilon^*})p^* \end{aligned}$$

Efficiency of a uniform price

When there is undue inequality between countries, differentiated carbon prices can help improve the world's welfare, as reduced abatement in low-income countries act as a subsitute for transfers. However, the Diamond-Mirrlees production efficiency theorem states that, in absence of other imperfections (such as market power or imperfect capital markets), direct transfers are always preferable to differentiated prices to address inequality.[23] In our setting, this theorem means that carbon trading is always beneficial. More precisely, for any country i, compared to the autarchy situation $(0, p_i)$, welfare is at least as high in the situation with uniform price where rights correspond to the autarchy emissions: $(\widetilde{t_i} = (e_i - e_i^*)p^*, p^*)$.

This results stems from the convexity of abatement costs, which gives:

$$a_i - a_i^* \geq (e_i - e^*)\frac{da_i^*}{de} = (e_i - e^*)(-p^*)$$

The transfer obtained from trading, $\widetilde{t_i}$, is therefore greater than the transfer equivalent to autarchy, t_i^*. Indeed:

$$\widetilde{t_i} = (e_i - e_i^*)p^* \geq a_i^* - a_i = t_i^*$$

Rearranging the inequality and adding y_i, we can verify that the consumption is greater under trading: $\widetilde{c_i} = y_i + \widetilde{t_i} - a_i^* \geq y_i - a_i = c_i^a$, which proves the efficiency of trading at a uniform price.

A.2 The dynamic case

Setting

In this section, we will show that the correspondence between transfers and differentiated carbon prices imperfectly extends to the dynamic case.

Let us keep the previous notations and add an index t to denote the value of a variable at time t. Let β_t be the discount factor between the initial period and t (containing the pure rate of time preference and the welfare discounting from growth). Intertemporal values are denoted with uppercase letters. Monetary variables are discounted while physical ones are not, e.g. i's intertemporal net gain is $G_i = \sum_t g_{it}\beta_t$ and its intertemporal emission right is $R_i = \sum_t r_{it}$.

A situation S is now given by the transfers and prices trajectories: $S = ((t_{it})_t, (p_{it})_t)$. Taking y_{it} as exogenous as a first approximation, for country i a situation S is welfare-equivalent to a situation S' with the same temperature trajectory iff:

$$\sum_t t_{it} - a_{it}(p_{it}) = \sum_t t'_{it} - a_{it}(p'_{it})$$

The uniform price without transfer case as benchmark

Consider the situation $C* = (0, (p^*_t)_t)$ of a uniform carbon price trajectory $(p^*_t)_t$ and within-country revenue recycling (i.e. without transfers). The carbon price trajectory may be fixed in advance or emerge from the temporal allocation of the global intertemporal carbon budget (or emission right) R in a cap-and-trade system: $(r_t)_t$. Let us define the net gain for i at t in a situation S (with the same emissions trajectory as $C*$) in relation to $C*$. As above: $g_{it} = t_{it} + V_{it}(p_{it})$, where $V_{it}(p_{it}) = a^*_{it} - a_{it}$.

A more limited correspondence between differentiated prices and rights

As in the static case, let us look for a correspondence between an autarchy situation A with differentiated prices and a cap-and-trade system U with uniform price. In the general case, $A = (0, (p_{it})_t)$, while $U = ((r_{it}p^*_t - e^*_{it}p^*_t)_t, (p^*_t)_t)$ is indirectly determined by $r = (r_{it})_t$. The welfare equivalence for i between A and U can be approximated as follows:

$$G^A_i = \sum_t (a^*_{it} - a_{it})\beta_t \sim \sum_t (p^*_t - p_{it})e^*_{it}\varepsilon^*_t\beta_t$$

$$G^U_i = \sum_t (r_{it} - e^*_{it})p^*_t\beta_t$$

$$G^U_i = G^A_i \Leftrightarrow \sum_t (r_{it} - e^*_{it})\beta_t p^*_t \sim \sum_t (p^*_t - p_{it})e^*_{it}\varepsilon^*_t\beta_t$$

Contrary to the static case, there is no direct equivalence between an intertemporal aggregate of the emission rights and an intertemporal aggregate of differentiated prices, since the welfare effect of emission rights depends on the cap-and-trade price trajectory p^*_t.

The same reason also complicates the comparison between two possible allocations r and r' of the intertemporal carbon budget in a cap-and-trade, even when the price trajectories coincide. Indeed, the condition $G_i^U > G_i^{U'} \Leftrightarrow \sum_t r_{it}\beta_t p_t^* > \sum_t r'_{it}\beta_t p_t^*$ does *not* imply that $R_i = \sum_t r_{it} > \sum_t r'_{it} = R'_i$. In other words, **there is no immediate relation between i's intertemporal carbon budget and its intertemporal welfare, as the price trajectory matters**.

Let us study whether we can find a correspondence in simpler cases. For the autarchy situation A, consider a homothetic carbon price vis-à-vis the world average: $p_{it} = \pi_i p_t$. For the cap-and-trade situation U, consider that i is granted a fixed share of the world's carbon budget: $r_{it} = r_i r_t$. Now, the equivalence between A and U rewrites:

$$G_i^U = G_i^A \Leftrightarrow r_i \sum_t r_t \beta_t p_t^* - \sum_t e_{it}^* p_t^* \beta_t \sim \sum_t (p_t^* - \pi_i p_t) e_{it}^* \varepsilon_t^* \beta_t$$

Provided that the price trajectories in autarchy are homothetic to the price trajectory in the cap-and-trade (without loss of generality): $p_{it} = \pi_i p_t^*$; the equivalence simplifies further:

$$G_i^U = G_i^A \Leftrightarrow r_i \mathscr{B} = \mathscr{E}_i^* + (1 - \pi_i)\Delta\mathscr{A}$$

where $\mathscr{B} = \sum_t r_t \beta_t p_t^*$, $\mathscr{E}_i^* = \sum_t e_{it}^* p_t^* \beta_t$, and $\Delta\mathscr{A} = \sum_t p_t^* e_{it}^* \varepsilon_t^* \beta_t$.

Although we do find a correspondence in this special case, the formula faces practical limitations, as **it requires knowing the future price trajectory $(p_t^*)_t$, which can only be imprecisely estimated** in the cap-and-trade situation. In any case, although one can find a trajectory of differentiated prices welfare-equivalent to a given allocation of emissions rights, and vice versa, the derivation cannot be done analytically, **one has to resort to an integrated assessment model**.

However, **in the Hotelling case** (with a fixed carbon budget, perfect foresight, and efficient capital markets), the formula simplify further. Indeed, the Hotelling price grows at the discount rate, so that the discounted price is constant: $\beta_t p_t^* = p_0$. Only in this very special case, **the formula simplifies to a formula analogous to the static case formula**:

$$G_i^U = G_i^A \Leftrightarrow R_i - E_i^* = (1 - \pi_i) \sum_t e_{it}^* \varepsilon_t^*$$

B Revenues and transfers from international taxes

We estimate the revenues by country from six global taxes: a tax on wealth above \$100 million, a small carbon tax, a higher minimum corporate income tax, a financial transaction tax, a tax on maritime fuel and one on aviation fuel (Table A1). \$2.1 trillion would be collected. We further estimate international transfers that could be financed. Namely, we reallocate 1% of each country's GNI to all countries in proportion to their population, and one half of the wealth tax to countries with a per capita GNI lower than twice the world

average, in proportion to their distance to this threshold. The combination of these taxes and transfers entail $766 billion in North–South transfers.

B.1 Wealth tax

We simulate two wealth taxes. First, a global tax on ultra-high wealth: a 3% tax on all individual wealth in excess of $100 million. Second, a national wealth tax: a 2% tax on wealth in excess of $5 million. These taxes add up,[l] so the highest marginal tax rate is 5%.

The World Inequality Lab offers an online simulator to estimate the revenue collected by a custom wealth tax in each world region. Building on this work, we disaggregate the revenue estimates at the country level. Courtesy of Félix Bajard, we obtained the simulator's underlying data for 50 countries covering 95% of global wealth tax revenue. To impute missing data, we predict the taxable base from a linear regression of the log of taxable base on the log of nominal GDP per capita, weighted by country population.

Following Zucman (2024)[69], we assume 20% of tax evasion. We also conservatively assume that asset prices would decline by 10%. Half of the revenue from the global tax on ultra-high wealth would not be retained domestically but channeled into a fund to finance sustainable development. This fund would return revenues to countries with a per capita GNI below a threshold. We fix this eligibility threshold at twice the world average per capita GNI, or $26,885 per year (in nominal terms). Finally, eligible countries receive a transfer per person proportional to the difference between the threshold and their GNI per capita.

B.2 Financial Transactions Tax

Pekanov et al. (2019)[53] estimate the revenues from a Financial Transactions Tax (FTT). Following the proposal by the European Commission (2011), they use a rate of 0.1% of bonds and stocks and a rate of 0.01% on derivatives. We use their baseline scenario, which assumes evasion rates of 15% on bonds and stocks and 70% on derivatives, together with an elasticity of trading volumes of -1.[m]

Pekanov et al. (2019)[53] provide estimates at the global level and for 18 high-income countries. We allocate the global revenue that does not originate from these 18 countries to remaining countries, in proportion to their GDP. 22% of world revenues would be collected in these remaining countries, with a revenue amounting to 0.1% of their GDP (vs. 0.56% of GDP for the 18 high-income countries).

[l] For example, with a wealth of $150 million, someone would pay each year a tax of 2.9% on their wealth: 1% from the tax on ultra-high wealth ($3\% \cdot (150 - 100) = 1.5M$) and 1.9% from the national wealth tax.

[m] The formula is: $\text{Revenue} = \text{tax rate} \cdot \text{volume} \cdot \text{evasion} \cdot (1 + \text{tax rate}/\text{transaction cost})^{\text{elasticity}}$.

B.3 Carbon price

We model simulate the international transfers a \$100/tCO$_2$ carbon price applied to all non-LULUCF CO$_2$ emissions. At the global level, and neglecting behavioral responses, 0.33% of the world nominal GDP would be collected.

B.4 Maritime fuel levy

We simulate the revenues of a \$100/tCO$_2$ levy on maritime fuel. The emissions from shipping by country are given by the simple average between the minimum and maximum estimates of Dequiedt et al.[22], who graciously provided the data.

B.5 Aviation fuel levy

Using data from Graver et al. (2018)[33],[n] we estimate the revenues from a tax on all flights (domestic and international). Due to complex climate effects such as contrails, aviation the global warming potential of aviation (GWP*$_{100}$) is 3 times the warming caused by its CO$_2$ emissions[45]. To fully account for all effects on global warming, the carbon levy on aviation should be multiplied by that factor. Therefore, we simulate a \$300/tCO$_2$ tax on aviation fuel, comparable to the \$100/tCO$_2$ tax on maritime fuel. We use the 2018 data without adjusting for the expected increase in air traffic, and without adjusting for the decrease in traffic that would follow the tax.[o]

B.6 Higher minimum corporate income tax

We estimate extra revenue by country if the internationally agreed minimum rate on corporate income tax was raised from 15% to 21%, with no carve-out. We use data from the tax deficit simulator from the EU Tax Observatory. These estimates are available for 45 countries (from OECD and the G20). We impute missing data only for three high-income countries (Iceland, Israel, New Zealand) and conservatively assume no extra revenue for other (developing) countries with missing data.

B.7 Carbon balance

On top of the proposed new taxes, we compute historical responsibilites for climate change. We define a carbon balance as the sum of a country's excess emissions compared to the world average, each year between 1850 and 2024, priced at $p = \$185/\text{tCO}_2$ (which corresponds to the social cost of carbon according to Rennert et al., 2022[56]). In Table A2, we report the carbon balance annualized at a risk-adjusted discount rate of $r = 3.5\%$.

[n] We use the data unadjusted for tourism.

[o] More generally, we do not adjust for inflation or changes in volumes throughout this technical note. Figures are only provided to get ballpark estimates and cannot be very precise.

Denoting e_t^c the emissions of country c in year t, and π_t^c its share of the world population at t, its annualized carbon balance over nominal GNI, B_c, is: $B_c = r \cdot p \cdot \sum_{t=1850}^{2024} e_t^c - \pi_t^c \cdot \sum_c e_t^c / \text{GNI}_c^{2023}$. Our computations are based on historical CO_2 emissions excluding LULUCF sector[36].

Table A1: Global taxes: int'l transfers, budget gain, revenues collected (% of GNI).

	Int'l transfers	Budget gain	Wealth Tax (3% >100M)	Wealth Tax (2% >5M)	Fin. Trans. Tax	Carbon Tax (10$/t)	Maritime fuel tax (100$/t)	Aviation fuel tax (300$/t)	Corporate inc. tax (min 21%)
World	0.0	3.2	0.72	1.28	0.32	0.33	0.10	0.22	0.3
Afghanistan	47.6	50.3	0.29	0.49	0.58	0.88	0.01	0.42	0.0
DRC	24.4	25.7	0.32	0.55	0.13	0.10	0.11	0.10	0.0
Sudan	16.8	19.0	0.34	0.59	0.40	0.47	0.05	0.32	0.0
Uganda	16.3	17.9	0.34	0.59	0.20	0.15	0.01	0.33	0.0
Myanmar	15.8	18.0	0.36	0.61	0.51	0.35	0.04	0.25	0.0
Ethiopia	14.7	16.4	0.35	0.60	0.14	0.12	0.00	0.45	0.0
Tanzania	13.1	14.8	0.36	0.61	0.22	0.20	0.02	0.26	0.0
Pakistan	11.3	12.4	0.02	0.05	0.35	0.49	0.04	0.18	0.0
Nigeria	7.8	9.6	0.10	0.62	0.24	0.34	0.35	0.09	0.0
Kenya	7.3	9.2	0.39	0.67	0.15	0.18	0.02	0.42	0.0
India	6.3	10.2	1.26	1.51	0.26	0.61	0.05	0.17	0.0
Bangladesh	5.9	6.4	0.03	0.06	0.13	0.17	0.02	0.08	0.0
Morocco	4.1	6.6	0.44	0.74	0.23	0.49	0.18	0.46	0.0
Vietnam	3.8	5.6	0.01	0.56	0.17	0.50	0.11	0.41	0.0
Egypt	3.5	5.6	0.44	0.47	0.29	0.63	0.07	0.20	0.0
Philippines	3.3	4.9	0.28	0.49	0.19	0.22	0.03	0.37	0.0
Iran	3.0	6.9	0.45	0.77	0.37	1.63	0.39	0.22	0.0
Ukraine	3.0	5.9	0.46	0.78	0.21	0.98	0.30	0.19	0.0
Indonesia	2.9	4.8	0.25	0.41	0.23	0.45	0.23	0.32	0.0
Algeria	2.5	5.1	0.46	0.78	0.26	0.72	0.18	0.14	0.0
Iraq	1.8	5.9	0.47	0.80	0.33	1.00	1.34	0.09	0.0
Thailand	1.6	4.8	0.49	0.83	0.25	0.61	0.20	0.79	0.0
Colombia	1.6	4.0	0.49	0.83	0.20	0.24	0.36	0.30	0.0
South Africa	1.6	5.6	0.33	0.64	0.19	1.12	0.53	0.38	0.8
Brazil	0.8	3.7	0.60	0.78	0.17	0.29	0.57	0.23	0.2
Turkey	0.5	2.0	0.13	0.23	0.24	0.45	0.10	0.37	0.0
Mexico	0.2	2.2	0.59	0.73	0.17	0.30	0.05	0.22	0.0
Argentina	0.2	2.5	0.54	0.92	0.15	0.35	0.18	0.23	0.0
China	-0.1	3.4	1.06	1.51	0.10	0.58	0.05	0.15	0.1
Russia	-0.1	3.1	0.87	1.06	0.18	0.79	0.16	0.24	0.0
Poland	-0.2	1.5	0.11	0.19	0.16	0.44	0.07	0.10	0.6
Saudi Arabia	-0.6	1.4	0.11	0.40	0.15	0.59	0.52	0.25	0.0
Spain	-0.6	1.1	0.24	0.40	0.22	0.14	0.06	0.37	0.3
Japan	-0.7	1.2	0.22	0.54	0.40	0.23	0.05	0.14	0.3
South Korea	-0.7	1.3	0.31	0.53	0.11	0.30	0.16	0.20	0.4
Italy	-0.8	0.8	0.35	0.50	0.17	0.13	0.04	0.15	0.2
United Kingdom	-0.8	3.2	0.25	0.43	2.36	0.12	0.04	0.28	0.6
Germany	-1.0	1.6	0.50	1.00	0.22	0.16	0.06	0.15	0.4
Canada	-1.0	2.4	0.59	1.25	0.09	0.27	0.08	0.26	0.9
France	-1.1	2.3	0.80	1.57	0.33	0.10	0.02	0.20	0.4
United States	-1.3	2.6	0.90	1.92	0.27	0.19	0.03	0.21	0.3

Note: Budget gain denotes the sum of all other columns: international transfer and revenues collected.

Table A2: Population vs. adult pop. entitlement comparison; carbon balance (% of GNI).

	Int'l transfers (population)	Int'l transfers (adult)	Budget gain (population)	Budget gain (adult)	Annualized carbon balance 1850-2024	Annualized carbon balance 1990-2024
Afghanistan	47.6	43.4	50.3	46.1	264.9	166.2
DRC	24.4	21.7	25.7	23.0	139.5	95.2
Sudan	16.8	15.6	19.0	17.7	96.2	65.3
Uganda	16.3	14.6	17.9	16.2	87.0	61.4
Myanmar	15.8	16.2	18.0	18.3	130.2	69.9
Ethiopia	14.7	13.7	16.4	15.4	88.0	58.1
Tanzania	13.1	11.9	14.8	13.5	75.1	52.0
Pakistan	11.3	10.7	12.4	11.9	60.9	39.3
Nigeria	7.8	7.1	9.6	8.8	47.4	30.1
Kenya	7.3	6.9	9.2	8.7	42.3	30.1
India	6.3	6.4	10.2	10.3	43.3	22.7
Bangladesh	5.9	6.0	6.4	6.5	44.5	26.2
Morocco	4.1	4.1	6.6	6.7	30.0	15.2
Vietnam	3.8	4.0	5.6	5.7	27.6	14.0
Egypt	3.5	3.4	5.6	5.5	19.1	10.0
Philippines	3.3	3.3	4.9	4.8	22.5	14.2
Iran	3.0	3.1	6.9	7.0	-6.0	-9.6
Ukraine	3.0	3.2	5.9	6.1	-47.4	-13.9
Indonesia	2.9	2.9	4.8	4.9	20.0	9.9
Algeria	2.5	2.5	5.1	5.1	10.3	3.9
Iraq	1.8	1.7	5.9	5.7	2.5	0.1
Thailand	1.6	1.8	4.8	4.9	10.1	1.9
Colombia	1.6	1.7	4.0	4.1	13.2	7.7
South Africa	1.6	1.6	5.6	5.6	-17.3	-10.3
Brazil	0.8	0.9	3.7	3.8	9.4	4.7
Turkey	0.5	0.5	2.0	2.0	3.6	0.3
Mexico	0.2	0.2	2.2	2.3	1.2	0.5
Argentina	0.2	0.2	2.5	2.6	1.9	0.3
China	-0.1	-0.1	3.4	3.5	3.8	-1.3
Russia	-0.1	-0.1	3.1	3.2	-22.9	-11.5
Poland	-0.2	-0.2	1.5	1.5	-13.7	-5.2
Saudi Arabia	-0.6	-0.6	1.4	1.4	-6.2	-5.6
Spain	-0.6	-0.6	1.1	1.1	-0.5	-1.2
Japan	-0.7	-0.7	1.2	1.2	-3.9	-3.1
South Korea	-0.7	-0.7	1.3	1.3	-2.5	-3.7
Italy	-0.8	-0.8	0.8	0.8	-1.3	-1.5
United Kingdom	-0.8	-0.8	3.2	3.2	-10.5	-1.6
Germany	-1.0	-1.0	1.6	1.6	-9.6	-2.6
Canada	-1.0	-1.0	2.4	2.4	-7.9	-4.3
France	-1.1	-1.1	2.3	2.3	-3.5	-0.7
United States	-1.3	-1.3	2.6	2.6	-9.2	-3.5

Note: Budget gain denotes the country net entitlements, i.e. the revenue it collects plus the net international transfer. International transfers denotes the country net entitlements minus taxes paid in the country. The carbon balance is separated from the tax proposals, it corresponds to the carbon credit or debt over 1850–2024 (or 1990–2024), priced at \$185/tCO_2 and annualized at 3.5%. For example, a country with excess emissions compared to the world average accumulates a carbon debt.

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