

# Carbon majors' trillion dollar damages

The case for contributions  
from fossil wealth to loss and  
damage finance



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# Summary

In 2022 Aramco announced what its CEO called “probably the highest net income ever recorded in the corporate world.”

Supply disruptions resulting from the illegal invasion of Ukraine by Russia - the largest gas supplier to Europe - led to huge spikes in price for gas, which then bled into demand for other fossil fuels, tightening energy markets around the world and pushing up prices for goods across supply chains.

Meanwhile, unprecedented disasters fuelled by climate change made the case for a robust funding mechanism for loss and damage more pressing. The 2022 United Nations’ climate conference saw a breakthrough, with the agreement to establish both a new fund for loss and damage and new funding arrangements.

In this report we explore who could pay for loss and damage through the lens of responsibility for historic emissions, and the financial gains generated from selling oil and gas.

We use a well-established methodology - the social cost of carbon - to calculate damage estimates from the 25 biggest emitting oil and gas companies in the world from 1985 to 2018, and compare it with the financial gains made over the same period. We look at Scopes 1, 2 and 3 emissions in our estimate of the total damages resulting from emissions attributable to fossil fuel companies.

To account for the potential responsibility of other actors such as consumers and policymakers, we also explore an established approach that uses a clean third split between producers, emitters and policymakers. We refer to this as partial damage allocation.

Between 1985 and 2018, we estimate partial damages of the combined CO<sub>2</sub> emissions from 25 companies - oil and gas carbon majors - of about 20 trillion USD. Over the same time period, their financial gains were about 50% larger - roughly 30 trillion USD.

Carbon majors could have paid for their damages and still made 10 trillion USD.

## The dirtiest dozen

The dirtiest dozen of the carbon majors account for about 15 trillion USD in damages and 21 trillion USD in gains.

Table 1. Estimated partial damages linked to emissions attributable to the 12 highest emitting fossil fuel companies and their respective financial gains between 1985-2018 by company and country in 2020 USD trillions.

| Entity |                                     | Partial Damage | Financial gain |
|--------|-------------------------------------|----------------|----------------|
|        |                                     | USD trillion   |                |
| 1      | Saudi Arabia: Aramco                | 2.8            | 5.4            |
| 2      | Russia: Gazprom                     | 2.2            | 2.9            |
| 3      | Iran: National Iranian Oil Co.      | 1.4            | 2.4            |
| 4      | ExxonMobil                          | 1.2            | 1.2            |
| 5      | Mexico: Pemex                       | 1.1            | 1.2            |
| 6      | Shell                               | 1.1            | 0.9            |
| 7      | BP                                  | 1.0            | 0.7            |
| 8      | Chevron                             | 0.9            | 0.6            |
| 9      | China: PetroChina                   | 0.9            | 1.3            |
| 10     | United Arab Emirates: Abu Dhabi NOC | 0.7            | 1.7            |
| 11     | Venezuela: Petroleos de Venezuela   | 0.7            | 1.1            |
| 12     | Kuwait: Kuwait Petroleum Corp.      | 0.6            | 1.4            |

Saudi Arabia, Russia, Iran, China and the United Arab Emirates are home to the largest state-owned carbon majors with both the largest financial gains and damages incurred. Of the private companies, ExxonMobil, Shell, BP, Chevron and TotalEnergies were responsible for the highest damages and saw the biggest financial gains.

For a subset of seven carbon majors including Aramco, Exxon Mobil, and Shell, we provide estimates for 2022. These seven carbon majors together amassed 497 billion USD in financial gains in 2022 compared to 260 billion USD in partial damage estimates. In other words, financial gains were almost twice the estimated partial damages.

### Self-perpetuating fossil wealth

Several countries channel parts of their fossil fuel gains into some of the biggest sovereign wealth funds world-wide. The sheer size of the funds, and their returns, points to the persistence of fossil-accumulated wealth well beyond extraction.

The United Arab Emirates is home to the biggest combined sovereign wealth funds in the world. Half of its funds could pay for the damages associated with its oil and gas industry, and it would still have 700 billion USD in wealth.

The United Nations Secretary General and leaders of vulnerable countries have called for the use of windfall taxes to redistribute huge profits from carbon majors (which look set to continue) for loss and damage funding. Governments that are home to these carbon majors, or perhaps the companies themselves, could well be called on to contribute to a loss and damage fund. It's clear they are good for it.

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# The need for loss and damage funding

Human-induced climate change is impacting people's lives today. Fires, floods, food insecurity and more are making headlines. As emissions rise, so too does the scale and intensity of these impacts.

This was foreseen. Climate scientists have consistently spelled out this warming trajectory, and the multitude of impacts for different regions. Climate change, while a global problem, is not affecting all regions equally. It is a terrible irony that those places that have done the least to cause climate change, are the first affected, and remain the most vulnerable.<sup>1</sup>

Recognising this, countries on the frontlines of the climate crisis have been pushing for the recognition of loss and damage from climate change since 1991 in international climate negotiations. Progress had been incredibly slow, and fraught with concerns from historic big emitters about assuming liability.<sup>2</sup> In 2022 at COP27, a decision was finally agreed to establish a dedicated fund for loss and damage, as a part of a wider package of new funding arrangements, to help developing countries that are particularly vulnerable to the adverse effects of climate change respond to climate-induced loss and damage.

To action this, a transitional committee was established consisting of representatives from 24 member states: 14 from developing countries, including two small island developing states and two least developed countries. The committee has provided recommendations to COP28 for the establishment of the fund as a new and independent entity under the Convention and the Paris Agreement with an interim operationalisation period at the World Bank.<sup>3</sup> The committee's recommendations on how the fund should be designed and operated will be presented for consideration and adoption at COP28 in Dubai.

<sup>1</sup> Calvin, K. et al. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (2023) doi:10.59327/IPCC/AR6-9789291691647.

<sup>2</sup> Calliari, E., Serdeczny, O. & Vanhala, L. Making sense of the politics in the climate change loss & damage debate. *Global Environmental Change* 64, 102133 (2020).

<sup>3</sup> UNFCCC. Operationalization of the new funding arrangements, including a fund, for responding to loss and damage referred to in paragraph 2 and paragraph 3 of decisions 2/CP.27 and 2/CMA.4. (2023).

## What is loss and damage?

Loss and damage refers to climate impacts that are felt regardless of adaptation action. The latest assessment cycle from the Intergovernmental Panel on Climate Change provides the most comprehensive scientific overview of loss and damage to date. It shows that loss and damage is anticipated to increase with every increment of warming and is disproportionately concentrated in the poorest and most vulnerable populations.<sup>4</sup>

It also provides evidence to demonstrate that financial, governance, and institutional arrangements do not give adequate attention to loss and damage, especially in developing countries.<sup>5</sup>

Importantly, the report is clear that socioeconomic development affects risk levels.<sup>6</sup> If a place doesn't have the resources to invest in resilient infrastructure, it is more likely that housing and public services will be impacted by an extreme climate event.

Last year's flooding in Pakistan proves a prime example. On the back of a record-breaking heatwave, roughly a third of the country was left underwater when the climate-driven torrential rains struck. Nearly 2000 people were killed, over one million homes were damaged or destroyed, more than 800,000 livestock lost, 3500 km of road was damaged and over 160 bridges collapsed.<sup>7</sup> The bill from this extreme event exceeds 30 bn USD, with estimated 15.2 bn in losses and 14.9 bn in damages.<sup>8 9</sup>

Already waiting for a bailout from the International Monetary Fund before the flooding, and facing political instability, Pakistan's ability to both prepare and respond to such an extreme event was curtailed by its socioeconomic circumstances. From this example, we see how socioeconomic circumstances shape countries' vulnerabilities as much as the physical impacts of climate change.

<sup>4</sup> Pörtner, H.-O. et al. Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. (2022).

<sup>5</sup> Pörtner et al. 2022

<sup>6</sup> Pörtner et al. 2022

<sup>7</sup> Saeed, F. Pakistan's floods must be a wake up call on climate action ahead of Sharm El-Sheikh. Climate Analytics Blog <https://climateanalytics.org/blog/2022/pakistans-floods-must-be-a-wake-up-call-on-climate-action-ahead-of-sharm-el-sheikh/> (2022).

<sup>8</sup> World Bank. Pakistan: Flood Damages and Economic Losses Over USD 30 billion and Reconstruction Needs Over USD 16 billion - New Assessment. World Bank <https://www.worldbank.org/en/news/press-release/2022/10/28/pakistan-flood-damages-and-economic-losses-over-usd-30-billion-and-reconstruction-needs-over-usd-16-billion-new-assessme> (2022).

<sup>9</sup> UNEP. What you need to know about the COP27 Loss and Damage Fund. UNEP <http://www.unep.org/news-and-stories/story/what-you-need-know-about-cop27-loss-and-damage-fund> (2022).

## Estimates of loss and damage

The scale of loss and damage inflicted by global warming is staggering. Due to historic global warming, gross domestic product per capita in tropical vulnerable countries has been reduced by about a quarter since the 1960s compared to a world without climate change.<sup>10</sup> Global estimates for damages sit at the order of trillions per year by 2025, and roughly 30 trillion USD per year by 2075 if warming continues along the trajectory it has.<sup>11</sup>

For small island states alone, annual damage from coastal flooding to date already amounts to about 1.64 billion USD per year, and are expected to increase by at least 15 times until the end of the century.<sup>12</sup>

## Innovative sources of funding

A core tenet of the international climate negotiations is the recognition of 'common but differentiated responsibility', i.e. governments share the responsibility of tackling climate change, but not equally, on the basis that developed countries had emitted much more than their developing country counterparts. Developed countries acknowledged that they should not only lead the energy transition, but also that they should provide adequate climate finance to developing countries to take action. The continuing obligation on developed countries to provide financial resources from public sources to assist developing countries remains central under the Convention and Paris Agreement.

However, in light of the sheer scale of damages, and the continued underdelivery of climate finance promises,<sup>13</sup> attention is increasingly turning to sources and modes of funding beyond just the public purse. This is evident in the outcomes on the loss and damage funding arrangements agreed in Sharm El-Sheikh at the end of last year.

At COP27, all governments agreed that:

- existing funding arrangements are not sufficient to address the gaps in responding to loss and damage.<sup>14</sup>

<sup>10</sup> Diffenbaugh, N. S. & Burke, M. Global warming has increased global economic inequality. *Proceedings of the National Academy of Sciences* 116, 9808–9813 (2019).

<sup>11</sup> Howard, P. & Sylvan, D. Gauging Economic Consensus on Climate Change.pdf. [https://policyintegrity.org/files/publications/Economic\\_Consensus\\_on\\_Climate.pdf](https://policyintegrity.org/files/publications/Economic_Consensus_on_Climate.pdf) (2021).

<sup>12</sup> Voudoukas, M. I. et al. Small Island Developing States under threat by rising seas even in a 1.5 °C warming world. *Nat Sustain* 1–13 (2023) doi:10.1038/s41893-023-01230-5.

<sup>13</sup> Guilbeault, Steven & Morgan, Jennifer. Climate Finance Delivery Plan Progress Report: Advancing the Ten Collective Actions. <https://www.auswaertiges-amt.de/blob/2560806/8cc5034f86da07811f8cb6adacba1130/neuer-inhalt--1--data.pdf> (2022).

<sup>14</sup> UNFCCC. Decision -/CP.27 -/CMA4 Funding arrangements for responding to loss and damage associated with the adverse effects of climate change, including a focus on addressing loss and damage. <https://unfccc.int/documents/624440> (2022).



- there is an “urgent and immediate need for new, additional, predictable and adequate financial resources” for responding to both economic and non-economic loss and damage, including extreme and slow onset events.<sup>15</sup>

Lots has been written about the establishment of the new loss and damage fund, but governments also decided to “establish *new funding arrangements* for assisting developing countries that are particularly vulnerable to the adverse effects of climate change”<sup>16</sup> for “mobilising new and additional resources”<sup>17</sup> and these would “complement and include sources, funds, processes and initiatives under *and outside* the Convention and the Paris Agreement”<sup>18</sup> (our emphasis).

In other words, governments are opening the door to other sources of money to fund responding to loss and damage that could sit inside, alongside, or feed into the loss and damage fund.

## Should the polluter pay?

The 2022 negotiations on loss and damage happened against the backdrop of the biggest supply shock for fossil fuels since the 1970s.<sup>19</sup> Supply disruptions resulting from the illegal invasion of Ukraine by Russia - the largest gas supplier to Europe - led to huge spikes in price for gas, which then bled into demand for other fossil fuels, tightening energy markets around the world and pushing up prices for goods across supply chains. Nowhere was this felt more than in the developing world, despite the war being situated in Europe.<sup>20</sup>

Where there is high demand for any product, money is being made. In early 2023 the top five oil companies reported nearly 200 billion USD in profit.<sup>21</sup>

The threat of sky-high prices being passed along to consumers in the face of record numbers in profits forced the hand of many policymakers. Alongside other measures to ease household bills, governments in Europe and the UK introduced windfall taxation schemes.

<sup>15</sup> UNFCCC 2022

<sup>16</sup> UNFCCC 2022

<sup>17</sup> UNFCCC 2022

<sup>18</sup> UNFCCC 2022

<sup>19</sup> Elliott, L. World Bank warns oil price could soar to record \$150 a barrel. The Guardian (2023).

<sup>20</sup> High food prices and strong US dollar are ‘double burden’ for developing countries, UNCTAD says | UNCTAD. <https://unctad.org/news/high-food-prices-and-strong-us-dollar-are-double-burden-developing-countries-unctad-says> (2022).

<sup>21</sup> Meredith, S. Big Oil rakes in record profit haul of nearly \$200 billion, fueling calls for higher taxes. CNBC <https://www.cnbc.com/2023/02/08/big-oil-rakes-in-record-annual-profit-fueling-calls-for-higher-taxes.html> (2023).

Mia Mottley, Prime Minister of Barbados  
addresses COP27, November 7 2022  
Image: UNclimatechange



In September 2022 at the United Nations General Assembly, the United Nations Secretary General went a step further, recognising that the climate crisis was also a driver of the strain on the cost of living, and that companies who were profiting from both were also in a position to pay. In short: he proposed a windfall tax on fossil fuel companies to pay for loss and damage.<sup>22</sup>

Later that year at COP27 his call became a chorus, when leaders of small island developing states explicitly asked for contribution from fossil fuel companies towards loss and damage finance.<sup>23</sup>

Different forms of innovative financing for climate action have been proposed in recent years. Perhaps the most well-known is the Bridgetown Initiative, spearheaded by the Prime Minister of Barbados. It calls for financial support to vulnerable countries in the forms of increased availability of emergency liquidity, multilateral lending to governments, and private sector funding.<sup>24</sup> While it is primarily focused on Multilateral Development Banks, it also makes the case for a taxation on fossil fuel companies.

*“We believe the non-state actors, the stakeholders and the oil and gas companies and those that facilitate them, need to be brought into convocation between now and COP28. How do companies that make 200 billion in profits in the last three months not expect to contribute at least 10 cents in every dollar in profit into a loss and damage fund?”*

Mia Mottley, Prime Minister of Barbados<sup>25</sup>

<sup>22</sup> Milman, O. & Borger, J. ‘Polluters must pay’: UN chief calls for windfall tax on fossil fuel companies. The Guardian (2022).

<sup>23</sup> Quartucci, S. Mia Mottley, Prime Minister of Barbados, Speaks at the Opening of COP27. Latina Republic <https://latinarepublic.com/2022/11/08/mia-mottley-prime-minister-of-barbados-speaks-at-the-opening-of-cop27/> (2022).

<sup>24</sup> Urgent and Decisive Action Required for an Unprecedented Combination of Crises The 2022 Bridgetown Initiative for the Reform of the Global Financial Architecture. (2022).

<sup>25</sup> Mia Mottley, Prime Minister of Barbados at the Opening of the #COP27 World Leaders Summit - YouTube. <https://www.youtube.com/watch?v=5J0egwAf00w&themeRefresh=1>.

The question of who would pay for loss and damage is inherently a political one. However, it's no great logical leap to look first for where capital and responsibility converge. Here we look at large fossil fuel producers - specifically oil and gas producers - often referred to as 'carbon majors'.<sup>26</sup>

## The carbon majors' historical responsibility

Research on the role of corporations in climate change has been pioneered by Richard Heede at the Climate Accountability Institute, and unsurprisingly shines a particular light on the role of fossil fuel production. In 2019 they made headlines, showing that between 1965-2018 more than one third of global fossil carbon dioxide and methane emissions could be attributed to the products and operations of just 20 investor- and state-owned fossil fuel companies.<sup>27 28</sup>

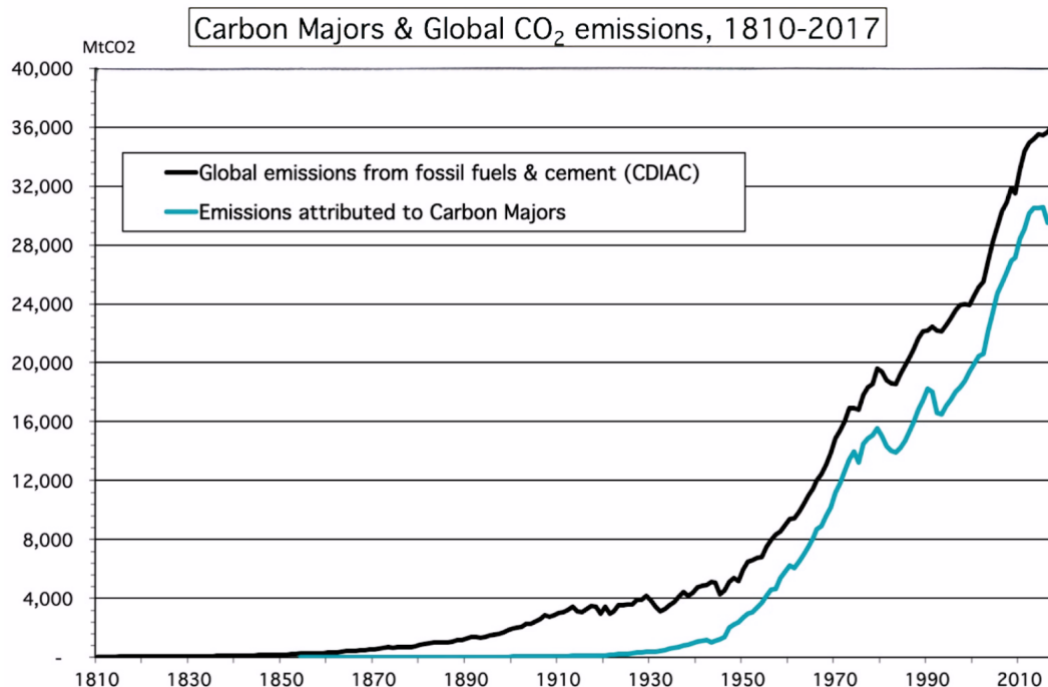


Figure 1 A comparison of total global CO<sub>2</sub> and CH<sub>4</sub> emissions (black line) from the Carbon Dioxide Information Analysis Center's database of global CO<sub>2</sub> emissions and the European Commission's Joint Research Centre's EDGAR database with such emissions from 103 Carbon Majors (red line) for the years 1810-2017.<sup>29</sup>

<sup>26</sup> Heede, R. Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854–2010. *Climatic Change* 122, 229–241 (2014).

<sup>27</sup> Kenner, D. & Heede, R. White knights, or horsemen of the apocalypse? Prospects for Big Oil to align emissions with a 1.5 °C pathway. *Energy Research & Social Science* 79, 102049 (2021).

<sup>28</sup> Taylor, M. & Watts, J. Revealed: the 20 firms behind a third of all carbon emissions. *The Guardian* (2019).

<sup>29</sup> Heede, R. Carbon Majors: Update of Top Twenty companies 1965-2017.

<https://climateaccountability.org/pdf/CAI%20PressRelease%20Top20%20Oct19.pdf> (2019).

Out of those 100 companies discussed in a 2017 Carbon Majors Report,<sup>30</sup> 41% are public investor-owned, 16% are privately owned, and 43% were state owned or state producers.

The analysis in this report focuses on the 25 biggest oil and gas emitters between 1985 and 2018.

## A history of deceit and fossil lobbyism

Carbon majors have long been aware of the environmental, social and economic repercussions of their business models. ExxonMobil, for example, produced projections of global warming as early as 1977.<sup>31</sup> Rather than acting based on the evidence, or perhaps even less ambitiously, not covering it up, many companies instead chose to promote and spread false and misleading climate change claims, undermining scientific and political consensus.<sup>32 33</sup>

Evidence from internal emails shows that this was driven by a desire to protect their oil and gas business.<sup>34</sup> It was also revealed that on multiple occasions Exxon's leadership encouraged their scientists to influence the Intergovernmental Panel on Climate Change - the UN's top science body.<sup>35</sup>

Shell, TotalEnergies and others also produced confidential internal reports and were privy to climate science information as early as the 1960's, and yet pursued a global, coordinated effort to dispute climate science, push back against carbon regulation and protect their business models.<sup>36</sup> This included the creation of the Global Climate Coalition in 1989, an industry-funded body that lobbied against climate legislation throughout the 1990s.<sup>37</sup>

<sup>30</sup> Griffin, P. CDP Carbon Majors Report. <https://cdn.cdp.net/cdp-production/cms/reports/documents/000/002/327/original/Carbon-Majors-Report-2017.pdf> (2017).

<sup>31</sup> Supran, G., Rahmstorf, S. & Oreskes, N. Assessing ExxonMobil's global warming projections. *Science* 379, eabk0063 (2023).

<sup>32</sup> Beusch, L. et al. Responsibility of major emitters for country-level warming and extreme hot years. *Commun. Earth Environ.* 3, (2022).

<sup>33</sup> Frumhoff, P. C., Heede, R. & Oreskes, N. The climate responsibilities of industrial carbon producers. *Climatic Change* 132, 157–171 (2015).

<sup>34</sup> Matthews, C. M. & Eaton, C. WSJ News Exclusive | Inside Exxon's Strategy to Downplay Climate Change. *WSJ* <https://www.wsj.com/business/energy-oil/exxon-climate-change-documents-e2e9e6af> (2023).

<sup>35</sup> Matthews & Eaton 2023

<sup>36</sup> Franta, B. What Big Oil knew about climate change, in its own words. *The Conversation* (2021).

<sup>37</sup> 1989 GCC Membership. *Climate Files* <https://www.climatefiles.com/denial-groups/global-climate-coalition-collection/1989-membership/> (1989).

In addition to the emissions from their products, wider disinformation and delay tactics for action to reduce emissions have significantly contributed to the continuation of human-induced global warming to date.<sup>38</sup> And therefore to the widespread adverse impacts and related loss and damage it has caused.<sup>39 40</sup> Climate change has also had profound negative effects on the economic output of many developing countries, contributing to increasing global economic inequality.<sup>41</sup>

Actions by most carbon majors can be contrasted with other companies, such as DONG Energy, which since the early 2000s, has gradually transformed its business model, divesting from its oil and gas assets to become the wind energy giant Ørsted.<sup>42</sup>

Identifying carbon majors as potential new sources for loss and damage finance has economic and legal precedence. The 'polluter pays principle' is a well-recognised norm in economics and is well established in environmental law, and in international organisations, like the Organization for Economic Cooperation and Development.<sup>43</sup>

On the other hand, carbon majors' and their defenders have claimed that societies have net benefited from fossil fuels as a driver of economic wealth, inferring that their business model is fundamental to poverty alleviation.<sup>44</sup> This might have historically been the case, but the availability of cheaper renewable energy means that energy access and economic development are less and less dependent on fossil fuels.<sup>45</sup> However, these historic benefits have only materialised in richer countries with significant emissions, not in those most vulnerable to climate change that have contributed the least to historic emissions (0.5% for Small Island Developing States and less than 0.4% for Least Developed Countries<sup>46</sup>, despite together being home to about 13% of the world's population). The case for carbon majors contributing to funding schemes for loss and damage specifically for vulnerable countries is even stronger than for the global total. We reflect on this further below in the next section.

<sup>38</sup> Frumhoff et al. 2015

<sup>39</sup> Pörtner et al. 2022

<sup>40</sup> Supran et al. 2023

<sup>41</sup> Diffenbaugh & Burke 2019

<sup>42</sup> Abraham-Dukuma, M. C. Dirty to clean energy: Exploring 'oil and gas majors transitioning'. *The Extractive Industries and Society* 8, 100936 (2021).

<sup>43</sup> de Sadeleer, N. The Polluter-Pays Principle. in *Environmental Principles: From Political Slogans to Legal Rules* (ed. de Sadeleer, N.) 0 (Oxford University Press, 2020). doi:10.1093/oso/9780198844358.003.0003.

<sup>44</sup> Jack, S. Oil giant Shell warns cutting production 'dangerous'. *BBC News* (2023).

<sup>45</sup> Shukla, P. R. et al. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (2022) doi: 10.1017/9781009157926.001.

<sup>46</sup> Shukla et al. 2022

Emissions are considered negative externalities for these companies. A wealth of scientific literature suggests that taxing carbon and therefore forcing companies to internalise the true price of carbon, gains could be accomplished in reducing emissions without affecting economic growth and employment.<sup>47</sup>

## Estimating damages and financial gains

In this report we seek to advance the conversation around who could pay for loss and damage through the lens of responsibility for historic emissions, and the financial gains generated from selling oil and gas.

We estimate societal damages associated with the emissions from the products of some of the world's largest fossil fuel companies, known as carbon majors. We then compare these costs to their financial gains (rents in the case of state-owned companies), as well as selected sovereign wealth funds.

### Estimating damages based on the social costs of carbon

The social cost of carbon is the monetary value of societal damage caused by incremental CO<sub>2</sub> emissions.<sup>48</sup> It is a key metric that can inform policy.

Quantifying climate change costs is notoriously difficult and requires many methodological and ethical assumptions.<sup>49</sup> One established approach is estimating the social cost of carbon through the present value of future damage to society of emitting one additional tonne of CO<sub>2</sub>.<sup>50</sup>

We calculate damages using the mean estimate from the recent publication of Rennert et al.<sup>51</sup>, of 185 USD per tonne of CO<sub>2</sub>. The full range of estimates vary widely so we also provide low and high estimates, ranging from 44 to 413 USD, a 5-95% range.<sup>52</sup> Our central estimate is in line with the recent proposal of the United States' Environmental Protection Agency of 190 USD per tonne of CO<sub>2</sub>.<sup>53</sup>

<sup>47</sup> Köppl, A. & Schratzenstaller, M. Carbon taxation: A review of the empirical literature. *Journal of Economic Surveys* 37, 1353–1388 (2023).

<sup>48</sup> Rennert, K. et al. Comprehensive evidence implies a higher social cost of CO<sub>2</sub>. *Nature* 610, 687–692 (2022).

<sup>49</sup> Piontek, F. et al. Integrated perspective on translating biophysical to economic impacts of climate change. *Nature Climate Change* 11, 563–572 (2021).

<sup>50</sup> Rennert et al. 2022

<sup>51</sup> Rennert et al. 2022

<sup>52</sup> Rennert et al. 2022

<sup>53</sup> U.S. Environmental Protection Agency. *Supplementary Material for the Regulatory Impact Analysis for the Supplemental Proposed Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate*

Another question is how responsible should fossil fuel companies be for the emissions along their value chain i.e. Scopes 1, 2 and 3? This is critical for oil and gas companies as Scope 3 emissions typically account for 80-95% of their emissions.<sup>54</sup>

Responsibility for Scope 3 emissions, when they are a significant part of the total emissions of a company, is well-recognised by initiatives like the GHG Protocol's Corporate Value Chain (Scope 3) Accounting and Reporting Standard,<sup>55</sup> and the Science Based Targets initiative.<sup>56</sup> Scope 3 emissions are also included in both Shell and BP's 2050 climate targets.

The 2021 Dutch case against Shell, amongst other aspects, specifically names a reduction obligation across its entire energy portfolio and all emissions (Scopes 1 through to 3).<sup>57</sup> On Scope 3, it explicitly states a "best-efforts obligation",<sup>58</sup> and that Shell needs to take the necessary steps to remove or prevent the serious risks ensuing from the CO<sub>2</sub> emissions generated by the business relations, including for end-users.<sup>59</sup>

We look at Scopes 1, 2 and 3 emissions in what we call the **'total damage'** allocation estimates.

However, it has also been argued (perhaps unsurprisingly, by fossil fuel companies), that consumers and regulators also bear responsibility for emissions. To explore this line of argument, we follow an approach set out in Grasso and Heede.<sup>60</sup> It suggests a clean third split between producers, emitters and policymakers: 33%. We refer to this as **'partial damage'** allocation.

Adopting this approach renders our estimates conservative, as only a share of the damages associated with the emissions linked to fossil fuel companies is actually attributed to fossil fuel companies.

*Review": EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. (2022).*

<sup>54</sup> Mackenzie, W. Few oil and gas companies commit to Scope 3 net zero emissions as significant challenges remain | Wood Mackenzie. <https://www.woodmac.com/press-releases/few-oil-and-gas-companies-commit-to-scope-3-net-zero-emissions-as-significant-challenges-remain/> (2022).

<sup>55</sup> Bhatia, P. et al. Corporate Value Chain (Scope 3) Accounting and Reporting Standard. [https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporting-Standard\\_041613\\_2.pdf](https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporting-Standard_041613_2.pdf) (2011).

<sup>56</sup> SBTi CRITERIA AND RECOMMENDATIONS FOR NEAR-TERM TARGETS. <https://sciencebasedtargets.org/resources/files/SBTi-criteria.pdf> (2023).

<sup>57</sup> THE HAGUE DISTRICT COURT judgment case number / cause list number: C/09/571932 / HA ZA 19-379 (engelse versie). [https://climatecasechart.com/wp-content/uploads/non-us-case-documents/2021/20210526\\_8918\\_judgment-1.pdf](https://climatecasechart.com/wp-content/uploads/non-us-case-documents/2021/20210526_8918_judgment-1.pdf) (2021).

<sup>58</sup> "THE HAGUE..." 2021

<sup>59</sup> "THE HAGUE..." 2021

<sup>60</sup> Grasso, M. & Heede, R. Time to pay the piper: Fossil fuel companies' reparations for climate damages. *One Earth* 6, 459–463 (2023).

It is important to highlight that this approach provides global damage estimates and does not allow for a separation of damages specifically inferred in developing countries. However, given that these damages would be only a share of the total global damages, it only strengthens the case that carbon majors could well pay for the loss and damage caused in developing countries.

## Estimating financial gains

Methods to estimate financial gains differ depending on an oil and gas company's ownership. To estimate gains, we follow two approaches:

Bloomberg data<sup>61</sup> is used for investor-owned companies, for the period of 1985-2018. To get a more transparent picture, we show cash flow from operations for individual companies, rather than their reported profits. This is because reported profits can be (artificially) lowered for example depreciation of the value of assets. Investor-owned company data from 2022 is gathered directly from financial statements.

For state-owned companies, we follow the approach of Verbruggen<sup>62</sup> and apply it to the country level based on World Bank estimates of oil and gas rents. Oil and gas rent estimates contain a degree of uncertainty due to difficulty of observing costs of production and because they vary over the lifetime of an extraction project. Entries for gains for state-owned companies are calculated on the basis of their shares in the total emissions from oil and gas companies based in their state (e.g., if a company is responsible for 50% of the total emissions from oil and gas in the country, it is allocated 50% of the gains). This applies to PetroChina (China), Equinor (Norway), and all Russian companies.

For simplicity, we refer to cash flow from operations for investor-owned companies, and rents from state-owned companies jointly as gains.

## How damages compare to gains

Between 1985 and 2018, 25 companies - oil and gas carbon majors - made roughly 30 trillion USD. We estimate that their combined CO<sub>2</sub> emissions over this period has led to 20 trillion USD in damages (using the partial damage estimate). The dirty dozen of highest emitting enterprises (see Table 2) accounts for about 15 trillion USD in damages and 21 trillion USD in gains.

<sup>61</sup> Bloomberg Finance L.P. Cash flow from operations, Net income, and Revenues. (2023).

<sup>62</sup> Verbruggen, A. The geopolitics of trillion US\$ oil & gas rents. *Int. J. Sustain. Energy Plan. Manag.* 36, 3–10 (2022).



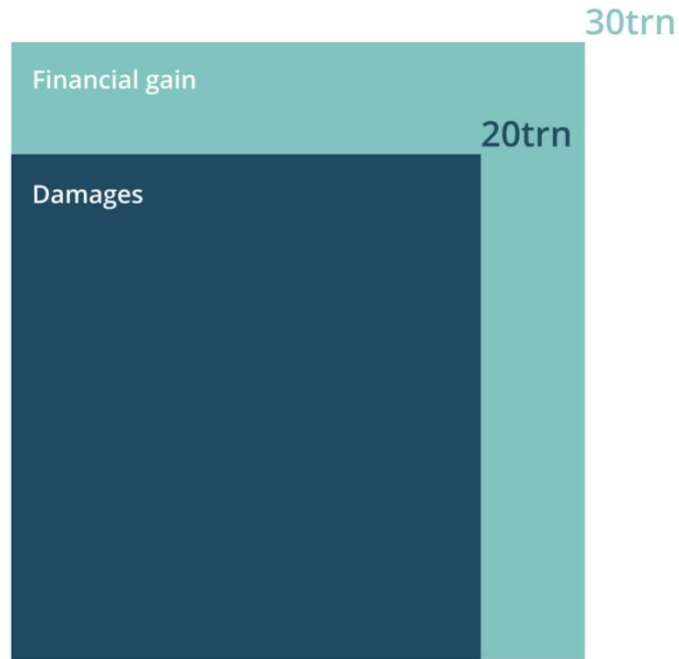


Figure 2 : Gains vs estimated partial damages from emissions.

*Gains combine rent estimates for state-owned and cash flow from operations for investor-owned companies. Estimated societal damages from CO<sub>2</sub> emissions are based on the social cost of carbon of 185 USD. Here we show one-third of the total damage attributable to individual fossil fuel companies. Both estimates cover the period of 1985-2018 for most complete data coverage and are expressed in 2020 USD.*

If a total damages approach was taken, damages of the top 25 would sit at 60 trillion USD (central estimate). Accounting for the spread in different social costs of carbon estimates gives damages of 15 at the low (5%) and 140 at the high (95%) end.

Depending on the estimate chosen, this suggests that carbon majors could have more than paid for their damages over this period, and remained profitable. Or, if a total damage allocation was adopted, they could still have paid for a substantial part of the damages out of their business operations.

Table 2. Estimated damages linked to emissions attributable to fossil fuel companies between 1985-2018 by company and country in 2020 USD trillions. We provide partial damage attribution (one third of the central estimate of the damage attributed to the “source” - the carbon majors). For comparison we also show the damages associated with a full attribution of emissions to carbon majors (central estimate. For a low and high estimate [5-95%] see Annex). We contrast this with the gains of these companies/countries over that period. Note that gains [rents] are assessed on the country levels. Entries for gains for state-owned companies are calculated on the basis of their shares in the total emissions from oil and gas companies based in their state (e.g., if a company is responsible for 50% of the total emissions from oil and gas in the country, it is allocated 50% of the gains). The Top 12 (“the dirtiest dozen”) are highlighted in bold.

| Entity    |  | Partial Damage | Full damage | Financial gain |
|-----------|--|----------------|-------------|----------------|
|           |  | USD trillion   |             |                |
| <b>1</b>  | <b>Saudi Arabia: Aramco</b>                | <b>2.8</b>     | <b>8.4</b>  | <b>5.4</b>     |
| <b>2</b>  | <b>Russia: Gazprom</b>                     | <b>2.2</b>     | <b>6.7</b>  | <b>2.9</b>     |
| <b>3</b>  | <b>Iran: National Iranian Oil Co.</b>      | <b>1.4</b>     | <b>4.3</b>  | <b>2.4</b>     |
| <b>4</b>  | <b>ExxonMobil</b>                          | <b>1.2</b>     | <b>3.7</b>  | <b>1.2</b>     |
| <b>5</b>  | <b>Mexico: Pemex</b>                       | <b>1.1</b>     | <b>3.2</b>  | <b>1.2</b>     |
| <b>6</b>  | <b>Shell</b>                               | <b>1.1</b>     | <b>3.3</b>  | <b>0.9</b>     |
| <b>7</b>  | <b>BP</b>                                  | <b>1.0</b>     | <b>3</b>    | <b>0.7</b>     |
| <b>8</b>  | <b>Chevron</b>                             | <b>0.9</b>     | <b>2.6</b>  | <b>0.6</b>     |
| <b>9</b>  | <b>China: PetroChina</b>                   | <b>0.9</b>     | <b>2.6</b>  | <b>1.3</b>     |
| <b>10</b> | <b>United Arab Emirates: Abu Dhabi NOC</b> | <b>0.7</b>     | <b>2.2</b>  | <b>1.7</b>     |
| <b>11</b> | <b>Venezuela: Petroleos de Venezuela</b>   | <b>0.7</b>     | <b>2.2</b>  | <b>1.1</b>     |
| <b>12</b> | <b>Kuwait: Kuwait Petroleum Corp.</b>      | <b>0.6</b>     | <b>1.8</b>  | <b>1.4</b>     |
| 13        | Algeria: Sonatrach                         | 0.6            | 1.8         | 1.0            |
| 14        | TotalEnergies                              | 0.6            | 1.8         | 0.5            |
| 15        | ConocoPhillips                             | 0.5            | 1.6         | 0.3            |
| 16        | Iraq: Iraq National Oil Co.                | 0.5            | 1.6         | 1.5            |
| 17        | Brazil: Petrobras                          | 0.5            | 1.4         | 0.7            |
| 18        | Russia: Rosneft                            | 0.5            | 1.4         | 0.6            |
| 19        | ENI  | 0.4            | 1.1         | 0.5            |
| 20        | Norway: Equinor                            | 0.4            | 1.1         | 0.6            |
| 21        | Russia: Lukoil                             | 0.4            | 1.1         | 0.5            |
| 22        | Nigeria: Nigerian National Petroleum       | 0.4            | 1.3         | 1.0            |
| 23        | Malaysia: Petronas                         | 0.4            | 1.2         | 0.4            |
| 24        | Qatar: Qatar Petroleum                     | 0.4            | 1.1         | 0.8            |
| 25        | Indonesia: Pertamina                       | 0.3            | 0.9         | 0.6            |

Nationalised oil producers control the majority of the world's oil and gas (up to 90% of reserves), and it's estimated that in at least 25 countries, national oil revenues account for more than 20% of the total government revenues.<sup>63</sup> They are therefore in equal measures important and notoriously hard to get data on.

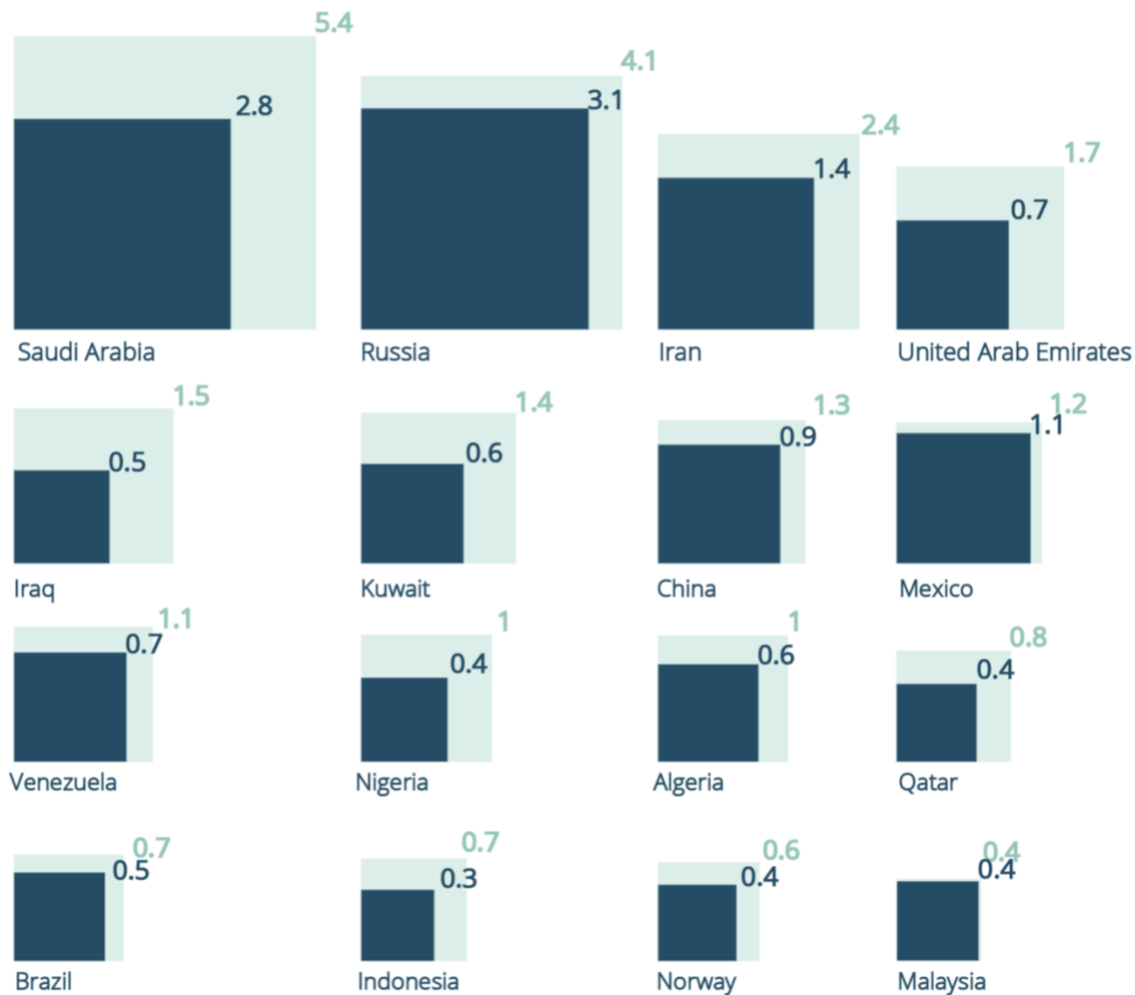
In our analysis we find that money made by state-owned companies consistently dwarfs the estimates from partial damages (Figure 3). Saudi Arabia's financial gains are nearly double that of its estimated partial damages at 5.4 trillion USD.

The picture is different for investor-owned companies where cumulative partial damage estimates exceed gains over the 1985-2018 period in most cases. We note that this systematic difference between state-owned and investor-owned companies might well be linked to the different methodological approaches to estimate their gains (see above and Annex).

However, the differences between damages and gain estimates are highest for states from the Arab Peninsula with access to some of the most profitable fossil fuel reserves in the world. For countries with less financially profitable fossil fuel reserves (i.e. Mexico and Brazil), the difference is smaller and closer to the estimates for investor-owned companies.

<sup>63</sup> Heller, P. R. P. & Mihalyi, D. Massive and Misunderstood Data-Driven Insights into National Oil Companies.  
<https://nationaloilcompanydata.org/api/publications/content/BWEOxwI3qpbpPk5RkZmWr3g5TEvNgLD4LD21foHP.pdf> (2019).

### Countries with state-owned carbon majors



### Investor-owned carbon majors

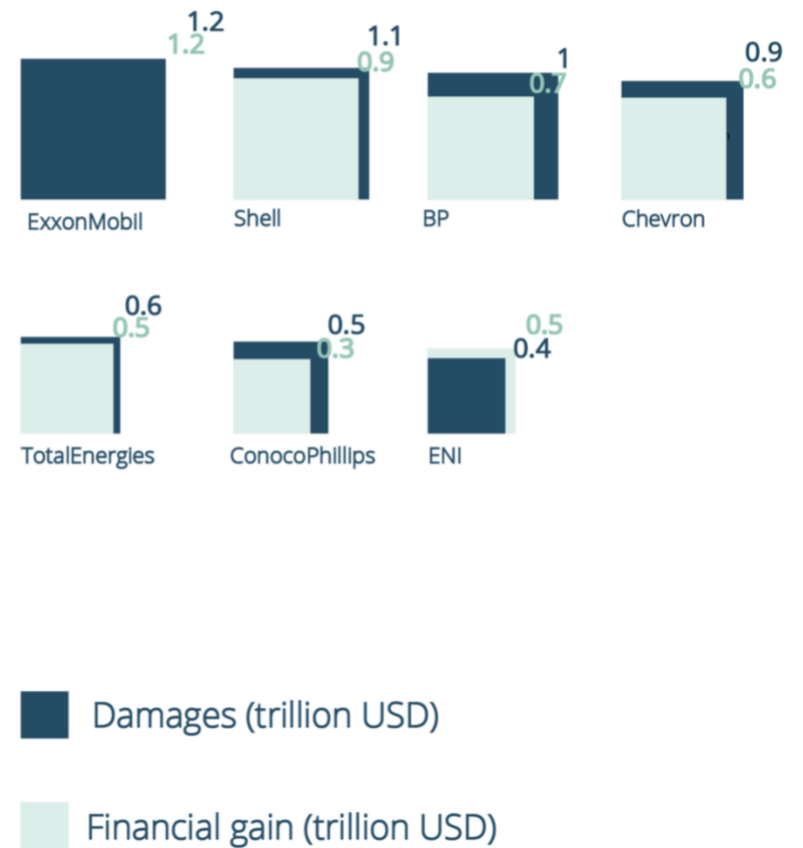


Figure 3: Gains vs estimated partial damages from emissions for countries of state-owned and investor-owned fossil fuel companies. All numbers are in trillions of 2020 USD.

## Super gains in 2022

In 2022 Aramco announced what its CEO called “probably the highest net income ever recorded in the corporate world.” Their cash flow from operations was 186 billion dollars.

Financial gains from oil and gas reached a new record. So too did the amount of subsidies governments paid to try to insulate consumers from rising prices and keep fossil fuels competitive.<sup>64</sup> Despite this, the industry invested less than 1% of cash spending into low carbon capital expenditure.<sup>65</sup> Some even went the other direction. Shell, Total and BP announced that they would slow down plans to transition away from oil and gas production in the wake of their historic earnings.<sup>66 67</sup>

Our analysis shows that 2022 gains for carbon majors substantially eclipse damages from emissions. These seven carbon majors together amassed 497 billion USD in financial gains in 2022 compared to 260 billion USD in partial damage estimates.

Financial gains in 2022 are thus almost twice the estimated partial damages, and for individual companies such as Shell, gains are almost three times as high. For comparison, gains were about 20% higher than estimated damages for this subset of companies over the 1985-2018 period (10.2 to 8.5 trillion USD).

Windfall taxes on some of these companies have already been levied, with huge popular support.<sup>68</sup> Where these revenues are directed is at the discretion of national treasury departments, but there can be no doubt that in 2022, there was more than enough funds for these carbon majors to pay for the estimated damages from their emissions, several times over.

<sup>64</sup> Black, S., Parry, I & Vernon, N. Fossil Fuel Subsidies Surged to Record \$7 Trillion. IMF <https://www.imf.org/en/Blogs/Articles/2023/08/24/fossil-fuel-subsidies-surged-to-record-7-trillion> (2023).

<sup>65</sup> IEA. Distribution of cash spending by the oil and gas industry, 2008-2022 – Charts – Data & Statistics. IEA <https://www.iea.org/data-and-statistics/charts/distribution-of-cash-spending-by-the-oil-and-gas-industry-2008-2022>

<sup>66</sup> Dunkley, E. & Wilson, T. BP slows oil and gas retreat after record \$28bn profit. Financial Times (2023).

<sup>67</sup> Limb, L. ‘Pure climate vandalism’: Shell backtracks on plans to cut oil. euronews (2023).

<sup>68</sup> Gas crisis prompts mass support for windfall tax. Friends of the Earth <https://friendsoftheearth.uk/climate/gas-crisis-prompts-mass-support-windfall-tax> (2023).

## Financial gain vs. damages 2022

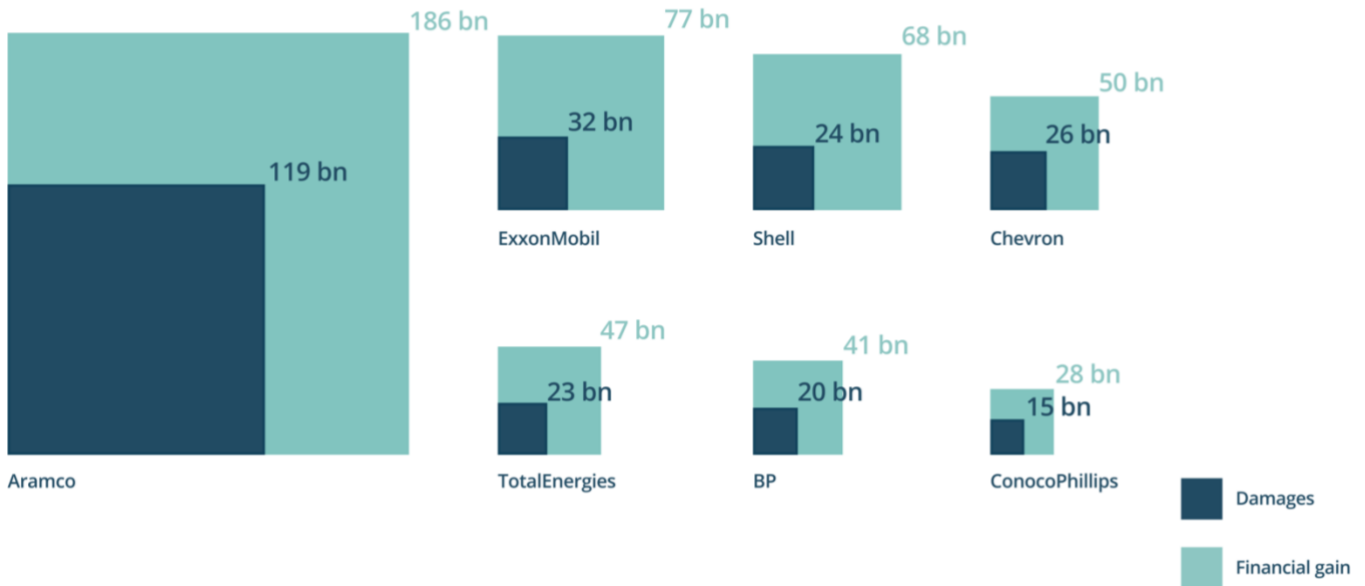


Figure 5: Gains vs estimated suggested partial damages from emissions for selected companies for 2022 - the year of record-breaking gains for the fossil fuel industry. All numbers are in billions of 2022 USD.

## Sovereign wealth funds

Most sovereign wealth funds were established in the latter half of the 20th century, though some were established decades earlier. They mostly stem from a surplus and are set up to provide what essentially is a financial safety net for national economies, with explicit mandate to benefit their citizens and invest for future generations.<sup>69</sup>

However, sovereign wealth funds are by no means homogenous in their behaviour and are very much tied to the policy objectives of their respective countries.<sup>70</sup>

<sup>69</sup> Kunzel, P. J., Lu, Y., Petrova, I. & Pihlman, J. Chapter 11 Investment Objectives of Sovereign Wealth Funds: A Shifting Paradigm. in *Economics of Sovereign Wealth Funds* (International Monetary Fund, 2010).

<sup>70</sup> Boubakri, N., Fotak, V., Guedhami, O. & Yasuda, Y. The heterogeneous and evolving roles of sovereign wealth funds: Issues, challenges, and research agenda. *J Int Bus Policy* 6, 241–252 (2023).

They have grown at rapid rates. Boubaker et. al estimates an annual growth rate of 11% in the last two decades.<sup>71</sup> In 2006/7 sovereign wealth funds were estimated to have a value of 2.6 trillion.<sup>72</sup> In February 2023, this has grown to US\$11.5 trillion.<sup>73</sup>

The primary source of income for establishing sovereign wealth funds is fossil fuels. For one of the biggest individual sovereign wealth funds, the Government Pension Fund of Norway, about 60% of money earned from the sale of nationally produced fossil fuels over the past decades has been invested into the fund.<sup>74</sup> Norway's fund is roughly equal to our calculated *total* damage estimate - 1.1 trillion USD - allocated to the emissions associated with Norway's fossil fuel extraction (Figure 4).

Fossil fuel gains are not the only source of income for the fund, as with growing volume their investments become more relevant. However, these two are not independent. Given their size, and the structural benefits arising from it, sovereign wealth funds are positioned to achieve return on investment rates well above the global growth rate.<sup>75</sup> An advantage, they would not have been able to gain without the fossil gains in the first place.

Over the 1998-2022 period, the Government Pension Fund of Norway generated an average annual return of 6%,<sup>76</sup> twice as high as the average global GDP growth rate of about 3% over the same period.<sup>77</sup> Although revenue from oil and gas production is continuously transferred to the fund, according to the fund these deposits now account for less than half of its value. The fund claims that most of its earnings have been made by investing in equities, fixed income, real estate and also renewable energy infrastructure. However, it appears that as of the end of 2022 renewable energy infrastructure only accounted for 0.1% of its total investments (in one project in the Netherlands<sup>78</sup>).

This massive amount of wealth accumulated, and the perpetuating nature of its returns, point to a continued persistence of fossil-accumulated wealth well beyond the end of extraction of fossil fuels.

<sup>71</sup> Boubaker, S., Boubakri, N., Grira, J. & Guizani, A. Sovereign wealth funds and equity pricing: Evidence from implied cost of equity of publicly traded targets. *Journal of Corporate Finance* 53, 202–224 (2018).

<sup>72</sup> Blundell-Wignall, A., Hu, Y.-W. & Yermo, J. Sovereign Wealth and Pension Fund Issues. SSRN Scholarly Paper at <https://doi.org/10.2139/ssrn.1217270> (2008).

<sup>73</sup> Megginson, W. L., Malik, A. I. & Zhou, X. Y. Sovereign wealth funds in the post-pandemic era. *J Int Bus Policy* 6, 253–275 (2023).

<sup>74</sup> Piketty, T. *Capital in the twenty-first century*. Harvard University Press. (2014)

<sup>75</sup> Piketty 2014

<sup>76</sup> The fund. Norges Bank Investment Management <https://www.nbim.no/en/> (2017).

<sup>77</sup> World Bank. GDP growth (annual %) | Data.

<https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG>.

<sup>78</sup> Investments. Norges Bank Investment Management <https://www.nbim.no/en/the-fund/investments/> (2018).

So while the world suffers from the devastating consequences of climate change, including slow, but irreversible threats such as potential multi-meter sea-level rise, for decades and centuries to come, historic fossil fuel-emitting countries will continue to reap the benefits of their fossil income generated.

Comparing the size of sovereign wealth funds with the allocated partial damages on the country level reveals that the size of the sovereign wealth funds vary substantially. It is clear that the size of a sovereign wealth fund does not necessarily reflect the amount of gains from oil and gas over time. Russia’s sovereign wealth fund, for example, is smaller than most, despite having the second highest gains from fossil fuels (compare Figure 2).

Given the global impact of the damages caused from fossil fuels, it should be reflected on whether fossil sovereign wealth funds should only benefit citizens of the countries of their origin. Or whether they could not substantially contribute to a global financial loss and damage mechanism to support those suffering from the consequences of the fossil business model that continues to create income.

This argument, of course, is not limited to sovereign wealth funds, but equally applies to state or investor-owned companies. For investor-owned companies, however, it is less transparent who has benefited from the rents accrued over time. The biggest share of it has contributed to the operations and asset stock of the companies, but a significant part has also been dispersed to investors. This does not mean that those emissions should go unaccounted for.

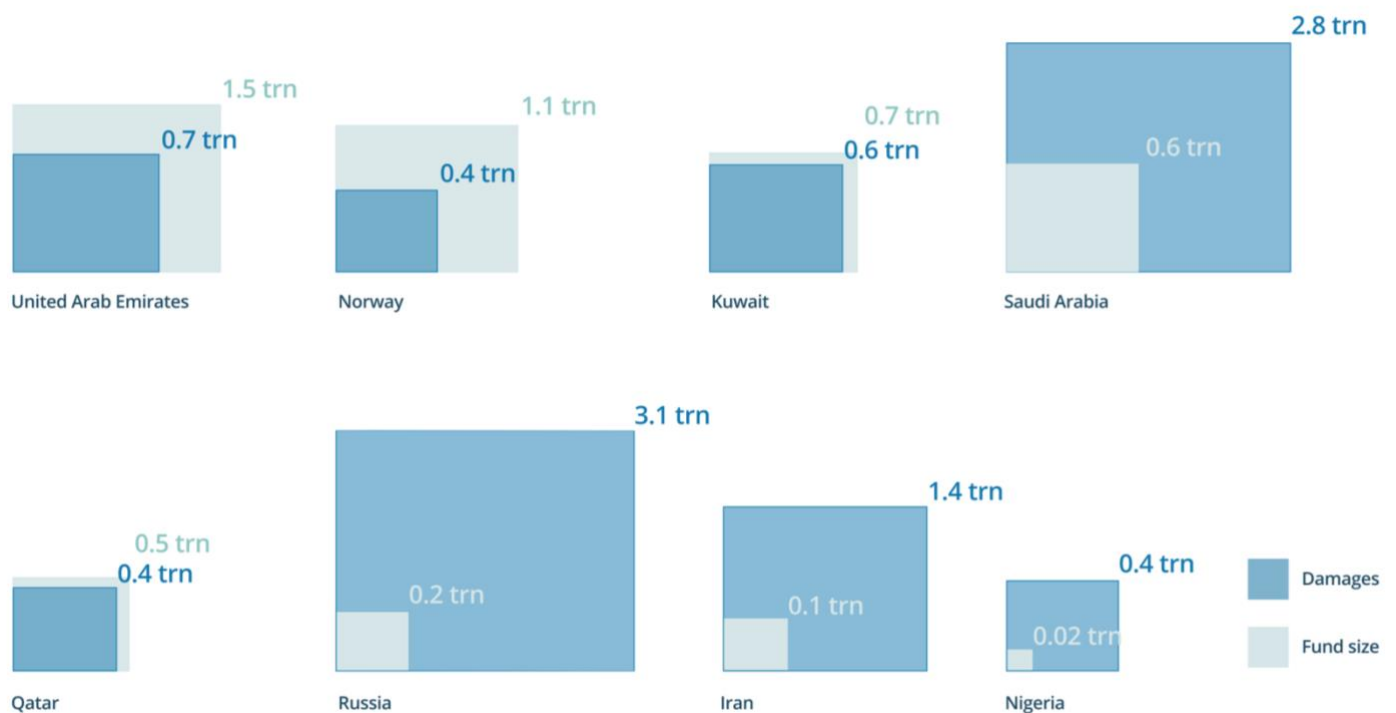


Figure 4: Total value of national, fossil-revenue based Sovereign Wealth Funds vs estimated societal damages from emissions. All numbers are in trillions of 2020 USD.



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# Annex

## Calculating the social cost of carbon

Quantifying the costs of climate change is notoriously difficult and requires a range of methodological and ethical assumptions.<sup>79</sup> One of the most established approaches is reflected in estimates of the social cost of carbon as a present value of the future damage to society of emitting one additional tonne of CO<sub>2</sub>.<sup>80</sup>

As a central estimate we choose the recent preferred social cost of carbon estimate from Rennert et al. of 185 USD per tonne of CO<sub>2</sub>.<sup>81</sup> This is similar to the value recommended by the Environmental Protection Agency of the United States, with a 2% discount rate.<sup>82</sup> To also capture a range of uncertainty in estimating costs and damages, we provide the 5th-95th percentile range of Rennert,<sup>83</sup> from 44 to 413 USD. This range comprises many social cost of carbon estimates suggested in the recent literature, although substantially higher values cannot be ruled out.<sup>84 85</sup>

In this analysis we use the social cost of carbon to provide an indication of the scale of projected damages of CO<sub>2</sub> emissions attributable to fossil fuel companies. We follow established approaches of attribution of future climate impacts to individual emitters<sup>86</sup> by comparing climate impacts (including all emissions) against a counterfactual of a world without those emissions of individual emitters. In this specific case it means that we do treat the cumulative emissions of carbon majors as emissions to date. This rests on the central insight that the timing of emissions of a unit of CO<sub>2</sub> is irrelevant as the warming impact depends on the cumulative emissions over time.

The social cost of carbon is calculated as the marginal impacts of CO<sub>2</sub>, meaning that the individual emissions quantities of each entity should not constitute a substantial change in the climate system. We find this to be the case given that the cumulative emissions attributable to individual fossil fuel companies since 1985 amount to less than 2 years of today's global fossil fuel emissions.

<sup>79</sup> Piontek et al. 2021

<sup>80</sup> Rennert et al. 2022

<sup>81</sup> Rennert et al. 2022

<sup>82</sup> U.S. Environmental Protection Agency 2022

<sup>83</sup> Rennert et al. 2022

<sup>84</sup> Kikstra, J. S. et al. The social cost of carbon dioxide under climate-economy feedbacks and temperature variability. *Environ. Res. Lett.* 16, 094037 (2021).

<sup>85</sup> Rising, J., Tedesco, M., Piontek, F. & Stainforth, D. A. The missing risks of climate change. *Nature* 610, 643–651 (2022).

<sup>86</sup> Nauels, A. et al. Attributing long-term sea-level rise to Paris Agreement emission pledges. <https://www.pnas.org/doi/10.1073/pnas.1907461116>. (2019)

<sup>87</sup> Beusch et al. 2022

Alternative approaches exploring the implications of time-variant SCCO<sub>2</sub> estimates are explored in Schleussner et al.<sup>88</sup> We only look at the future impacts of the already emitted CO<sub>2</sub> of each company, while following standard approaches for future discounting.

Furthermore, a value judgement needs to be made about how much of the responsibility for the emissions should be allocated to the fossil fuel companies. Given the knowledge of climate change and the mounting evidence for lobbying by fossil fuel companies to undermine a societal consensus on climate change<sup>89</sup> a full allocation of responsibility of fossil fuel companies for all emissions linked to their business (scope 1-3) activities can well be argued for. Nevertheless, it is also plausible that some responsibility should be assigned to consumers and policy authorities/governments. We here follow the approach by Grasso & Heede<sup>90</sup> and allocate 33% of responsibility to fossil fuel producers, consumers and policy authorities alike in the main estimates shown. The numbers for the total damage allocation is provided for comparison.

We do not assess the damages attributable to methane emissions, but including these would result in consistently higher damages and derived financial consequences.<sup>91</sup>

## Estimating profits and rents

### Calculation of oil and gas rents

The World Bank calculates oil and gas rents by subtracting the average cost of producing the commodity from its price, and multiplying by the quantity of the commodity extracted. Costs of production include a “normal” rate of return on fixed capital and the consumption of fixed capital. They are then expressed as a share of GDP.<sup>92</sup>

To derive oil and gas rents in absolute monetary terms, we follow the approach used in Verbruggen<sup>93</sup>: inflation-adjusted country-level GDP in a given year is multiplied by the share of GDP that is attributed to oil and gas rents.

<sup>88</sup> Schleussner, Carl-Friedrich, Marina Andrijevic, Jarmo Kikstra, Richard Heede, and Joeri Rogelj. "Fossil fuel companies' true balance sheets." (2023) DOI: [10.22541/essoar.167810526.62141909/v1](https://doi.org/10.22541/essoar.167810526.62141909/v1)

<sup>89</sup> Supran et al. 2023

<sup>90</sup> Grasso & Heede 2023

<sup>91</sup> Azar, C., Martín, J. G., Johansson, D. JA. & Sterner, T. The social cost of methane. *Climatic Change* 176, 71 (2023).

<sup>92</sup> World Bank. *Changing Wealth of Nations 2021: Managing Assets for the Future*. <https://www.worldbank.org/en/publication/changing-wealth-of-nations> (2021).

<sup>93</sup> Verbruggen 2022

Entries for gains for state-owned companies are calculated on the basis of their shares in the total emissions from oil and gas companies based in their state (e.g., if a company is responsible for 50% of the total emissions from oil and gas in the country, it is allocated 50% of the gains). This applies to PetroChina (China), Equinor (Norway), and all Russian companies.

It should be noted that the estimates of oil and gas rents contain a degree of uncertainty stemming from the difficulty of always precisely observing the costs of production or because they vary over the lifetime of an extraction project, as well as the assumed proportional allocation of gains to individual companies.

### Investor-owned companies

For Investor owned companies we use data from Bloomberg Finance covering the period 1985-2018.<sup>94</sup> Data coverage before 1985 is insufficient for an analysis, though it should be noted that even since 1985, the data is not available for all companies for the early years, partly because some have been founded later or have undergone restructuring of ownership. For transparency reasons we show cash flow from operations for individual companies, rather than reported profits, but show on Figures A1 and A2 the differences between profits and cash flows from operations. For 2022 we gather the data directly from each company's financial statement.

<sup>94</sup> "Bloomberg finance..." 2023

Table A1. As Table 2, but also providing low and high estimates for the full damage allocation based on the 5-95% assessed range of social cost of carbon estimates from Rennert et al.

| Entity |  | Partial damage | Full damage: central estimate [5th, 95th percentile] | Financial gain |
|--------|--|----------------|--|----------------|
|        |  |                |  |                |
| 1      | <b>Saudi Arabia: Aramco</b>                | 2.8            | 8.4 [2, 18.6]  | 5.4            |
| 2      | <b>Russia: Gazprom</b>                     | 2.2            | 6.7 [1.6, 14.9]                                      | 2.9            |
| 3      | <b>Iran: National Iranian Oil Co.</b>      | 1.4            | 4.3 [1, 9.6]   | 2.4            |
| 4      | <b>ExxonMobil</b>                          | 1.2            | 3.7 [0.9, 8.3]                                       | 1.2            |
| 5      | <b>Mexico: Pemex</b>                       | 1.1            | 3.2 [0.8, 7.1]                                       | 1.2            |
| 6      | <b>Shell</b>                               | 1.1            | 3.3 [0.8, 7.3]                                       | 0.9            |
| 7      | <b>BP</b>                                  | 1.0            | 3 [0.7, 6.8]   | 0.7            |
| 8      | <b>Chevron</b>                             | 0.9            | 2.6 [0.6, 5.9]                                       | 0.6            |
| 9      | <b>China: PetroChina</b>                   | 0.9            | 2.6 [0.6, 5.8]                                       | 1.3            |
| 10     | <b>United Arab Emirates: Abu Dhabi NOC</b> | 0.7            | 2.2 [0.5, 4.9]                                       | 1.7            |
| 11     | <b>Venezuela: Petroleos de Venezuela</b>   | 0.7            | 2.2 [0.5, 4.9]                                       | 1.1            |
| 12     | <b>Kuwait: Kuwait Petroleum Corp.</b>      | 0.6            | 1.8 [0.4, 4.1]                                       | 1.4            |
| 13     | Algeria: Sonatrach                         | 0.6            | 1.8 [0.4, 3.9]                                       | 1.0            |
| 14     | TotalEnergies                              | 0.6            | 1.8 [0.4, 3.9]                                       | 0.5            |
| 15     | ConocoPhillips                             | 0.5            | 1.6 [0.4, 3.5]                                       | 0.3            |
| 16     | Iraq: Iraq National Oil Co.                | 0.5            | 1.6 [0.4, 3.6]                                       | 1.5            |
| 17     | Brazil: Petrobras                          | 0.5            | 1.4 [0.3, 3.2]                                       | 0.7            |
| 18     | Russia: Rosneft                            | 0.5            | 1.4 [0.3, 3.1]                                       | 0.6            |
| 19     | ENI  | 0.4            | 1.1 [0.3, 2.4]                                       | 0.4            |
| 20     | Norway: Equinor                            | 0.4            | 1.1 [0.3, 2.4]                                       | 0.6            |
| 21     | Russia: Lukoil                             | 0.4            | 1.1 [0.3, 2.5]                                       | 0.5            |
| 22     | Nigeria: Nigerian National Petroleum       | 0.4            | 1.3 [0.3, 2.9]                                       | 1.0            |
| 23     | Malaysia: Petronas                         | 0.4            | 1.2 [0.3, 2.6]                                       | 0.4            |
| 24     | Qatar: Qatar Petroleum                     | 0.4            | 1.1 [0.3, 2.5]                                       | 0.8            |
| 25     | Indonesia: Pertamina                       | 0.3            | 0.9 [0.2, 2.1]                                       | 0.6            |



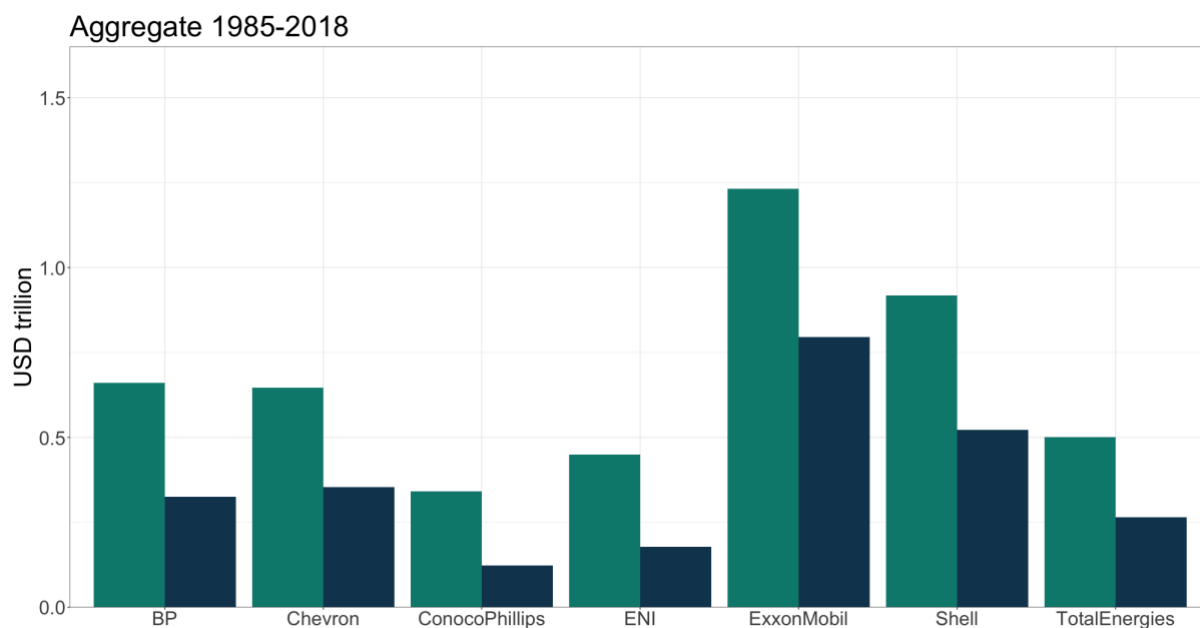


Figure A1 Comparison of cash flow from operations and profits for selected companies aggregated over the 1985-2018 period.

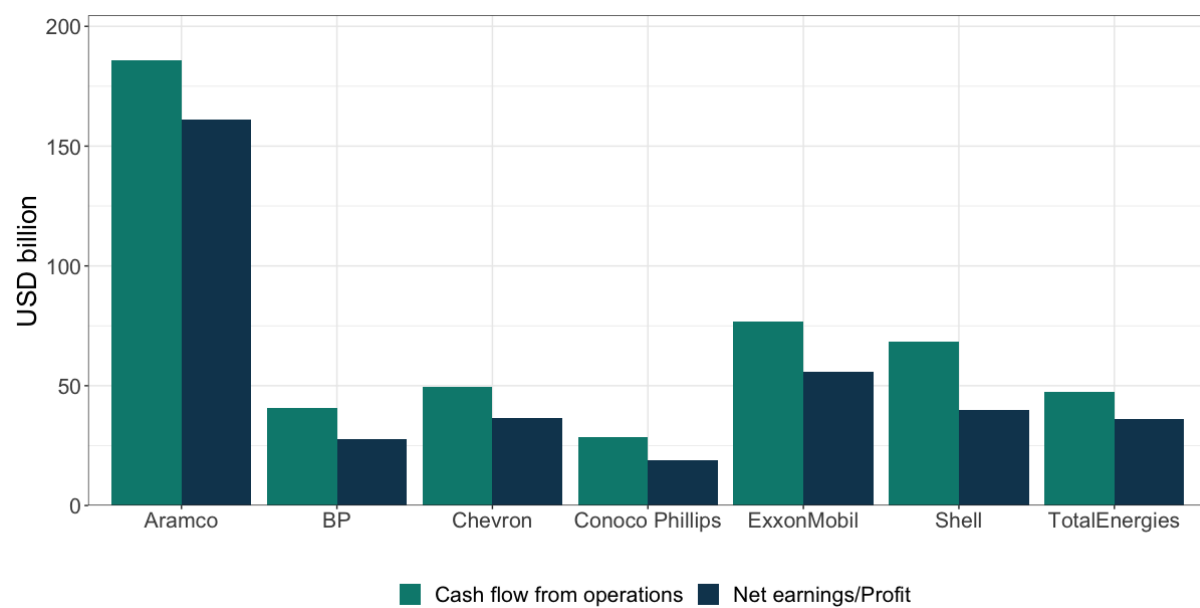


Figure A2 Comparison of cash flow from operations and profits for selected companies aggregated for the year 2022.

## Sovereign Wealth Funds

Table A2: Assets in individual sovereign wealth funds displayed as national totals in Figure 4 of the main text.

| Country              | Fund name                              | Assets (USD billion) |
|----------------------|--|----------------------|
| Iran                 | National Development Fund of Iran      | 139                  |
| Kuwait               | Kuwait Investment Authority            | 750                  |
| Mexico               | Fondo Mexicano del Petroleo            | 1                    |
| Nigeria              | Nigeria Sovereign Investment Authority | 23                   |
| Norway               | Norway Government Pension Fund Global  | 1136                 |
| Qatar                | Qatar Investment Authority             | 461                  |
| Russia               | National Welfare Fund                  | 182                  |
| United Arab Emirates | Total                                  | 1480                 |
| United Arab Emirates | Abu Dhabi Investment Authority         | 790                  |
| United Arab Emirates | Investment Corporation of Dubai        | 299                  |
| United Arab Emirates | Mubadala Investment Company            | 284                  |
| United Arab Emirates | Emirates Investment Authority          | 87                   |
| United Arab Emirates | Ras Al Khaimah Investment Authority    | 20                   |

