'BAD' OIL, 'WORSE' OIL AND CARBON MISALLOCATION

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Overview

Not all barrels of oil are created equal: their extraction varies in both private cost and carbon intensity. Using a rich micro-dataset on World oil fields and estimates of their carbon intensities and private extraction costs, this paper quantifies the additional emissions and costs from having extracted the 'wrong' deposits. We do so by comparing historic deposit-level supplies to counterfactuals that factor in pollution costs, while keeping annual global consumption unchanged. Between 1992 and 2018, carbon misallocation amounted to at least 10.02 GtCO2 with an environmental cost evaluated at US$ 2 trillion (US$ 2018). This translates into a significant supply-side ecological debt for major producers of dirty oil. Looking towards the future, we estimate the gains from making deposit-level extraction socially-optimal, and document the very unequal distribution of the subsequent stranded oil reserves across countries.

Methods

Our estimation of past carbon misallocation relies on the difference in cumulative pollution between the historic oil-supply curve and the socially-optimal counterfactual that minimizes environmental and private extraction costs, while leaving annual global aggregate extraction unchanged. As any barrel used before 2018 is no longer available in the future, our measure of past misallocation accounts for the opportunity costs attached to the extraction of barrels in the past. More precisely, our counterfactual takes oil to be optimally extracted from 1992 up to 2050, the date at which carbon neutrality is reached (IPCC, 2018; European Council, 2019). This counterfactual is compared to the extraction path from the historic 1992-2018 supply and a future supply (with the same annual global production up to 2050) that we take to be either competitive and ignoring pollution heterogeneity, or optimal.

Our empirical analysis is based on one of the most comprehensive datasets of oil fields, the Rystad UCube Database (Rystad, afterwards). This covers most of World oil production, with 12,463 active deposits between 1970 and 2018. It includes precise field-level data on oil production, exploitable reserves, discoveries, capital and operational expenditures from exploration to field decommission, current governance (e.g., ownership and operators), field-development dates (discovery, license, start-up, and production end), and oil characteristics (e.g., oil type, density and sulfur content) and reservoir information (e.g., water depth, basin and location). The Rystad dataset does not contain information on fields' upstream carbon intensities. However, it does record the key variables that influence emissions from extraction or refining, such as oil type (e.g., bitumen or light), API gravity, gas-to-oil ratio, sulfur content, use of steam injection, and the location of the field offshore or onshore. We complement these data using the geocoded flaring volumes calculated by the Visible Infrared Imaging Radiometer Suite (VIIRS) algorithm from National Oceanic and Atmospheric Administration (NOAA) satellite observations. We add steam-injection data from the International Energy Agency. We then use these data and the *Oil Production Greenhouse Gas Emissions Estimator* (OPGEE) of the Oil-Climate Index (OCI, Carnegie Endowment for International Peace) to estimate upstream emissions of each oil deposit.

Results

Our central findings indicate that inefficient emissions from oil misallocation over the 1992-2018 period amount at least to 10.02 gigatons of CO2 (GtCO2). These emissions are substantial, representing two years of life-cycle emissions of the global transportation sector, and their cost is estimated at 2 trillion US$. We also find that the optimal allocation of extraction across deposits results not only in less carbon-intensive extraction but also lower private extraction costs, as our optimal counterfactual solves both carbon mispricing and other market imperfections. Though the historic deposit-level supplies reveal that deposits' carbon heterogeneity was ignored *and* extraction was not competitive, we document that inefficient emissions can be attributed to carbon mispricing, rather than imperfect competition. Solving only private cost misallocation in oil supply, that is expensive oil was extracted in lieu of cheaper oil, while ignoring pollution reduces cumulative emissions by 1.87 GtCO2 only. Thus, carbon misallocation is distinct from private cost misallocation. In a next step, we use our deposit-level data to map countries' supply-side 'ecological debts', i.e., their over-extraction from the comparison of their aggregate historical supply to their optimal supply. This allows us to determine the winners and losers from carbon misallocation. We in particular show that Annex B countries, which committed to mitigation targets in the 1997 Kyoto Protocol, over-extracted oil by 66% in the 1992-2018 period, whereas the Rest of the World under-extracted by 30%. We then evaluate the gains from the optimal extraction of resources in the future, as compared to a perfectly-competitive future supply with identical annual demands in which pollution heterogeneity is ignored. Extracting oil optimally starting in 2019 yields future emission savings of 7.64 GtCO2. We then estimate the stranded reserves of oil-producing countries, i.e., the share of their 2019 oil reserves that should optimally remain underground. These vary widely across countries, from a figure of 15.3% in Kuwait to 97.4% in Canada. Finally, we consider alternative dates to start the recomposition of past supply, as the 1992 Earth Summit was not the only missed window of opportunity. We show that starting to extract optimally one year earlier always yields large additional environmental benefits, even for periods that are as far in the past as the 1970s.

Conclusions

Our findings contribute to the ongoing debate about the decarbonization of the World economy. The main takeaway is that the missed opportunities for carbon mitigation in the oil industry are large: optimal oil-deposit reallocation would have reduced emissions by at least 10.02 GtCO2 over the 1992-2018 period. This is economically significant as compared to the remaining carbon budget (Mengis et al., 2018; IPCC, 2014, 2018) or if translated into environmental costs. These inefficient extra emissions are robust to varying the social cost of carbon between US$50 and US$400. Our data also allow us to map supply-side ecological debts: We find that Annex B countries, which committed to mitigation targets in the Kyoto Protocol, over-extracted oil by 66% over the 1992-2018 period. Some non-Annex B countries, such as Algeria, Venezuela, Nigeria, Mexico, also over-extracted oil during this period.

The second takeaway is that past carbon misallocation is largely different from private cost misallocation. We find large misallocation in private extraction costs, with expensive oil being extracted in place of cheaper oil. However, solving this latter market failure alone produces emission reductions that are 10 times smaller than those from optimal supply. We have shown that even were carbon intensities and private extraction costs to be perfectly correlated, cost-efficient extraction (that ignores pollution) may differ from the optimal extraction path. The difference between these two paths is obviously even larger in real life. Using our field-level data, we have provided evidence that private extraction costs and carbon intensities are poorly correlated, which makes carbon misallocation empirically very distinct from private-cost misallocation.

The third takeaway concerns what can still be changed. We evaluate the gains from optimally extracting available resources, as compared to a competitive future supply with identical annual demand but in which pollution is ignored. Starting to extract oil optimally in 2019 reduces emissions by 7.64 GtCO2. Last, we estimate countries' stranded reserves as of 2019 under an optimal future-extraction scenario. There is great heterogeneity in stranded assets across countries, with figures varying from 15.3% for Kuwait to 97.4% in Canada.

This brings into question the political feasibility of first-best supply. Although optimal supply comes with both environmental and private economic gains, so that the winners could compensate the losers, these transfers may be difficult to put in place. However, we have shown that recomposing supply while constraining the changes in some countries' productions still leaves large potential gains from supply recomposition. This partly alleviates political-feasibility concerns.

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