DEVELOPMENT FUTURES SERIES WORKING PAPERS

UNITED NATIONS DEVELOPMENT PROGRAMME

Global Decarbonization in Fossil Fuel Export-Dependent Economies

Fiscal and economic transition costs

by Lars Jensen

UNDP GLOBAL POLICY NETWORK

UNDP is the leading United Nations organization fighting to end the injustice of poverty, inequality, and climate change. Working with our broad network of experts and partners in 170 countries, we help nations to build integrated, lasting solutions for people and planet. Learn more at undp.org or follow at @UNDP.

United Nations Development Programme
1 UN Plaza, New York, NY 10075, USA

Global Decarbonization in Fossil Fuel Export-Dependent Economies

Fiscal and Economic Transition Costs

by Lars Jensen (lars.jensen@undp.org) [1]

[1] Lars Jensen is a Senior Economist in UNDP's Global policy Unit, Bureau for Policy and Programme Support. **Acknowledgements:** The author is grateful for comments, feedback and/or guidance from Yanchun Zhang, Degol Hailu, Eduardo Ortiz-Juarez and George Gray Molina from UNDP. Peter Nagle from the World Bank. Òscar Jordà from the Federal Reserve Bank of San Francisco. Marcelo LaFleur from UN DESA. All mistakes are my own.

Contents

Figures

Boxes

Tables

Abstract

This paper identifies 40 economies that depend heavily on the extraction and exports of fossil fuels (FF). For the average country, FF generate 14.3 percent of GDP in rents annually, accounting for more than 60 percent of exports and likely more than one third of total government revenue. Aside from a handful of primarily high-income countries, most countries have little or no savings to help them cushion the transitory cost associated with an inevitable steep fall in demand and prices for their resources under an ambitious global decarbonization scenario, i.e., any scenario compatible with the Paris Agreement. It is estimated that the group of 40 will lose more than 60 percent or between (present value adjusted) US$12-14 trillion in oil rents alone during the period 2023-2040 under a net-zero 2050 global decarbonization scenario compared to a 'business as usual' scenario reflecting stated policies. This represents a loss of rents equivalent in size to between 120-142 percent of current GDP. Estimating a local projection model on panels of *emerging markets and developing economies (*EMDE) oil exporters versus importers, results from five-period cumulative impulse response functions suggest that for exporters, a ten percentage point (pp) decrease in (real) oil price inflation is associated with a decline of 1.58 percent in (real) GDP four periods after the shock, equivalent to an average annual growth rate of -0.31 percent; a decrease in annual government revenue as a percentage of GDP by between 0.6 and 0.7 pp and; an addition of about 0.5 pp to government debt as a percentage of GDP every year, reaching a total of 2.5 pp four periods after the shock. Finally, the paper discusses how vulnerable countries are to the economic impacts of global decarbonization and the domestic and international policy options that could help mitigate their transition costs.

Introduction

1

To limit global warming to the goals set out in the Paris Agreement, global decarbonization must proceed rapidly over the next two decades.[2] The Intergovernmental Panel on Climate Change (IPCC) estimated the remaining global carbon budget at the beginning of 2020 to lie between 300-900 gigatonnes of CO2 (GtCO2) for an 83 percent chance of staying within a 1.5°C - 2.0°C rise in global temperature (over pre-industrial temperature) by the end of this century (IPCC, 2021).[3] If we assume that annual average emissions will stay at the 2019 level of 40 GtCO2 going forward, the 1.5°C budget would, therefore, be expended before the end of 2027 and the 2.0°C-budget before 2042. Estimates suggest that annual emissions are now back at pre-pandemic levels and expected to rise further, while reaching net-zero emissions by 2050 would require an average emissions reduction of about 1.4 billion tonnes per year (GCP, 2022).[4] Current policies do not lend much optimism to limiting global warming. The Climate Action Tracker initiative has estimated that under current policies, the end of century warming would be 2.7°C. Even under all 2030 nationally determined contribution (NDC) targets, the world would emit roughly twice as many greenhouse gasses (GHGs) in 2030 as required to stay on a 1.5°C compatible pathway (CAT, 2022). Similarly, in its latest assessment report, the IPCC concludes that if considering only those countries that have already implemented mitigation policies, projected emissions would lead to a warming of 3.2°C, and when accounting for NDC targets, 2.8°C (IPCC, 2023). The IPCC report also concludes that global surface temperature is already higher by 1.1°C degrees and that staying within 1.5°C of warming by 2100 will require a 60 percent fall in GHG emissions by 2035.

Whatever our likelihood of limiting warming to 1.5°C, any major global decarbonization effort will unequivocally require a major reduction in the use of fossil fuels (FF), the burning of which accounts for about 85 percent of human-caused annual CO2 emissions and 65 percent of total GHGs.[5] The International Energy Agency (IEA) estimates that to have a 50 percent chance of staying within 1.5°C, the global energy sector will have to reach net-zero emissions by 2050 (IEA, 2021a). Achieving this objective is believed to require a fall in demand from the current levels of 90 percent, 75 percent and 55 percent for coal, oil and gas, respectively, by 2050.

While limiting global warming will undoubtedly make everyone better off in the long-run, decarbonization will be a painful adjustment for some countries. Identifying the potential winners and losers of the transition is fraught with uncertainty and is particularly sensitive to national and international policy choices and cooperation, technological developments, natural resource endowments, etc. However, the group of developing economies that rely heavily on extracting and exporting FF can be considered among the most vulnerable.

FF-dependent countries rely on FF, and mostly oil, to support economic activity, earn foreign exchange, fund public spending and investments, etc. Even disregarding their efforts to decarbonize, these countries are likely to suffer the hardest fiscal and economic consequences from global decarbonization, which in many cases could spill over to already fragile socio-economic fundamentals. Managing the 'exogenous impact' from global decarbonization in countries with already low per capita earnings and savings, low levels of human capital and strained public finances, will be nearly impossible without much more international support accompanied by urgent domestic fiscal and economic reform.

[2] Article 2 (a) of the 2015 Paris Agreement reads: *"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 ..."* (United Nations, 2015).

[3] The IPCC estimates that for every 1,000 GtCO2 emitted by human activity, global temperature rises by 0.45°C.

[4] These include emissions from fossil fuels, industry and land use changes. In 2020, and despite widespread lockdowns, emissions reached 34.7 GtCO2, grew to 36.3 GtCO2 in 2021 and is estimated to have reached 36.6 GtCO2 in 2022 and 37.5 GtCO2 in 2023.

[5] https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

The natural resource endowment 'flip side' of a lower FF demand is an expected increase in the demand for so-called transition minerals, broadly understood as the minerals needed in cleaner energy technologies and electrification (World Bank, 2020a). By some estimates, demand for transition minerals could push the production value of just four key metals (cobalt, nickel, lithium and copper) close to US$13 trillion over the next two decades (Boer, Pescatori, & Stuermer, 2021). But only few of the FF-dependent countries can hope to substitute FF rent losses with mineral rent gains, as metal ore reserves and production are concentrated in fewer countries relative to FF reserves and production, hereunder oil, which is by far the largest source of rent (World Bank, 2021a). In addition, mineral rents tend to be smaller, and governments on average also take a smaller share as revenue compared to FF rents (World Bank, 2021b). Another major challenge of global decarbonization is that mining activities are often riddled with social and ecological injustices likely to intensify with an increasing demand (Bainton, Kemp, Lèbre, Owen, & Marston, 2021). Furthermore, mining is both energy- and emissions-intensive with some estimates suggesting that GHG emissions associated with primary mineral and metal production account for about ten percent of global energy-related GHG emissions (Axadi, Northey, Ali, & Edraki, 2020).

Based on estimates of FF rents, this paper identifies 40 highly FF-dependent countries (31 of which are low- and middle-income countries) that on average have generated FF rents (from oil, coal and gas) worth more than three percent of GDP annually from 2015 to 2019. The average/median country generated FF rents of 14.3/11.1 percent of GDP; FF accounted for 61.2/61.5 percent of exports; and resource revenue represented 38.6/33.8 percent of total government revenue. It is likely that FF rents alone contributed one third of total revenue. Under the most ambitious global decarbonization scenario aimed at limiting global warming to 1.5°C degrees, this paper estimates that the group could, in present value adjusted terms (PV), lose between $12-14 trillion of oil rents alone in the period 2023-2040 compared to a 'business as usual scenario'. This represents a loss of rents of more than 60 percent and equivalent in size to between 120-142 percent of the group's current GDP. Econometric analysis confirms the possibility of very high economic and fiscal transitory costs in oil export-dependent emerging markets and developing economies (EMDEs) from falling oil prices. Results from five-year cumulative impulse response function estimates suggest that a ten pp decrease in (real) oil price inflation is associated with an annual average contraction in (real) GDP of 0.31 percent with GDP 1.58 percent smaller four periods after the oil price shock; a fall in annual government revenue as a percentage of GDP by between 0.6 and 0.7 pp over the full projection horizon, and; an addition of about 0.5 pp to government debt as a percentage of GDP every year with the debt ratio 2.5 pp higher four periods after the shock.

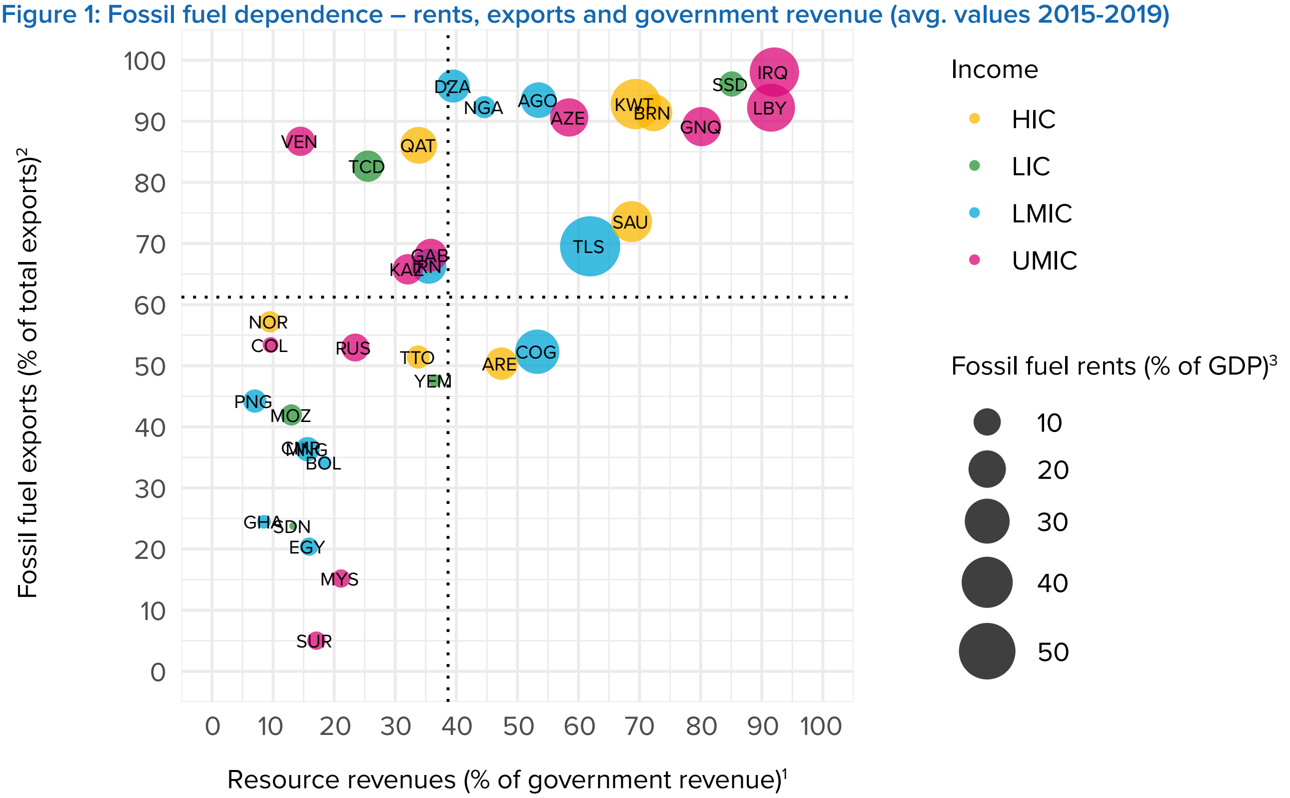
Section 2 identifies the world's most FF-dependent economies based on three key measures of dependency: rents, exports and government revenue. Section 3 estimates the loss of oil rent (the largest source of non-renewable resource rents) from 2023 to 2040 under an ambitious 1.5°C compatible scenario versus a non-ambitious ('business-as-usual') reference scenario representing 'stated policies' where warming is expected to reach 2.6°C by 2100 and continue to rise. Section 4 estimates cumulative impulse response functions for growth, government revenue, expenditure and debt from (real) oil price shocks on panels of oil exporting versus importing EMDEs using a local projections model. Section 5 presents and discusses the different policy challenges and options available both internationally and domestically for highly FF-dependent economies under global decarbonization. Finally, Section 6 concludes the study.

Fossil fuel export-dependent countries 2

This section looks at FF dependency using available data on FF rent as a percentage of GDP, fuel exports as a percentage of total exports and resource revenue as a percentage of total government revenue.[6] The main selection variable is FF rent, and here 40 countries extract annual rents higher than three percent of GDP, which is used as the cut-off level.[7]

Available data on 35 of the identified 40 highly FF dependent countries show that on average FF generate rents as high as 14.3 percent of GDP annually, make up 61.2 percent of total exports, and revenues from natural resources contribute 38.6 percent of total government revenue (Figure 1). In Figure 1, the dotted lines denote the average values across countries for the natural resource share of government revenues on the x-axis and the FF share of exports on the y-axis. The size of FF rents (as a percentage of GDP) is denoted by the size of the bubbles, which are colored based on four income groups: high (HIC), upper-middle (UMIC), lower-middle (LMIC) and low (LIC).

Figure 1: Fossil fuel dependence – rents, exports and government revenue (avg. values 2015-2019)



Source: Author based on data from WDI, GRD, EITI, BACI, CEIC and WEO. Note: The figure includes 35 of the 40 highly fossil fuel-dependent countries, as five do not have recent data on resource revenues (Bahrain, Ecuador, Oman, Turkmenistan, Uzbekistan).
[1]Data based on GRD except for Colombia and Mozambique, where data is from the latest EITI reports. For Libya, Venezuela and Yemen, the latest GRD data is from 2012. Datapoints for these countries are estimates of their 2019 FF revenue shares obtained by scaling their oil production times global crude price in 2012 with their oil production and crude price in 2019 using CEIC data for oil production and IMF WEO data for revenue.
[2]Exports are based on data from WDI. For countries with all or many missing observations, we relied on export data from the BACI database from CEPII.
[3]Based on available datapoints from WDI. Data for Venezuela is from 2014 and South Sudan 2015. Syria is not included, as the latest datapoint is from 2007.

[6] Rents measure the difference between a unit's market price and cost of extraction. For details on rents, see Section 3 or (World Bank, 2021b).

[7] Latest datapoint used is 2019, except for Iran (2018) South Sudan (2015) and Turkmenistan (2018). Syria is not included as the latest datapoint is from 2007.

While comparable cross-country data on government resource revenue is scarce and only lets one look at the total resource component (UNU-WIDER, 2021), rents data suggest that an overwhelming majority of resource revenues must come from FF, especially oil. For the average country, FF rents comprise 92.7 percent of total non-renewable resource rents, and oil alone makes up 75.3 percent of total FF rents.[8] Eight countries produce more than 50 percent of their FF rents from sources other than oil: Malaysia (gas), Mongolia (coal), Mozambique (coal), Papua New Guinea (gas), Trinidad and Tobago (gas), Timor-Leste (gas), Turkmenistan (gas) and Uzbekistan (gas). To obtain an estimate of the FF share of total government revenue only, the total resource revenue share is adjusted downwards by the ratio of FF rent to total natural resource rent, although this will likely result in an underestimation.[9] Doing so, the FF share of total government revenue is estimated at 35 percent for the average country. In other words, it is likely that the average country receives more than one third of total government revenue from FF rents alone.

Table 1 lists the 40 countries grouped on income level and geographical region. Annex Table A.1 includes the available data and estimates for each of the three chosen measures depicted in Figure 1. Nine countries are HICs, of which six are from the Middle East and North Africa (MENA) region. Five countries are LICs and all are from the SSA region except for Yemen. The remaining 26 are middle-income countries split evenly between LMICs and UMICs. MENA has the highest number of countries (12), followed by SSA (11), EAC and LAC (each 6) and finally EAP (5).

Table 1: Number of countries where fossil fuel rents exceed three percent of GDP

REGION / INCOME	LIC	LMIC	UMIC	HIC	Total
East Asia & Pacific		Mongolia, Papua New Guinea, Timor-Leste	Malaysia	Brunei Darussalam	5
Europe & Central Asia		Uzbekistan	Azerbaijan, Kazakhstan, Russia, Turkmenistan	Norway	6
Latin America & Caribbean		Bolivia	Colombia, Ecuador, Surinam, Venezuela	Trinidad and Tobago	6
Middle East & North Africa	Yemen	Algeria, Egypt, Iran	Iraq, Libya	Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates	12
Sub-Saharan Africa	Chad, Mozambique, South Sudan, Sudan	Angola, Cameroon, Congo (Republic of the), Ghana, Nigeria	Equatorial Guinea, Gabon		11
Total	**5**	**13**	**13**	**9**	**40**

Source: World Development Indicators database.

Thirteen of the 40 are on the World Bank's list of 39 'Fragile and Conflict-affected Situations' with Yemen in the most severe category, 'High-Intensity Conflict'.[10] While Yemen's position in Figure 1 suggests that the country is not among the most FF dependent, this is likely due to the war, which has caused large disruptions to oil production, an economic collapse and a humanitarian catastrophe.[11]

[8] Non-renewable rents cover oil, gas, coal and minerals, but exclude forest rents. Among our selection of 40 highly FF-dependent countries, seven also generate large rents from forests: Cameroon, Ghana, Malaysia, Mozambique, Papua New Guinea, Sudan and Suriname.

[9] This adjustment would likely underestimate the FF share of government revenue as FF rents are normally taxed at a higher effective rate than other resource rents. See for instance (World Bank, 2021b).

[10] Syria is also a 'high-intensity conflict' country, but not included in the group of 40 FF-dependent countries due to missing data. See the World Bank's list here: *https://www.worldbank.org/en/topic/fragilityconflictviolence/brief/harmonized-list-of-fragile-situations*

[11] Before the war FF rents accounted for about one third of GDP, 90 percent of exports and it was estimated that the hydrocarbon industry generated 50-60 percent of government revenue (World Bank, 2017).

It can be noted that new oil and gas field exploration and development continue in many countries hoping to cash in on their reserves before the world weans off FF. Some of these countries already extract significant FF rents and are thus included in this paper's group of FF-dependent producers. Others have no history of producing FF and are, therefore, not included. Mozambique, included here, has historically generated most of its FF rents from coal, but more recent discoveries of large gas reserves have raised hopes of huge future windfalls, although developments have been disrupted by conflict (Parker, 2021). Before these disruptions, the IMF estimated that fiscal revenues from gas rent would start accruing to the government in 2023 and could account for more than 50 percent of total fiscal revenue by 2030 (IMF, 2019b). Guyana is an example of a country with no history of FF production, and thus not included in this paper. However, large oil fields started producing for the first time in late 2019.[12]

The size of FF rents a country can hope to receive over the next couple of decades will depend on the speed and scale of global decarbonization and on where the country ranks in terms of cost competitiveness and the size of remaining reserves. Low-cost producers, with adequate reserves, are likely to grab a larger share of a shrinking market, and high-cost producers will lose rents faster; some will likely have to shut down production entirely as demand and prices fall steeply. The next section takes a closer look at these dynamics through the size of future oil rents for the 40 countries under a 'business as usual' scenario versus an 'ambitious' scenario that aims to limit global warming to 1.5°C degrees.

[12] According to World Bank data, Guyana generated oil rents of 12.3 percent of GDP in 2020. In IMF's latest Article IV consultation from September 2019 (before COVID), the IMF estimated that real GDP growth in 2020 would be as high as 85.6 percent based on oil sector investments and production (IMF, 2019a).

Oil rents and revenue under global decarbonization

3

Conceptually, rents can be thought of as the upper bounds of revenue that governments can hope to collect from the ownership of natural resources.[13] In practice, however, resource revenues and rents can differ extensively. Estimates suggest that governments, on average, took 77 percent of oil rents between 2010-2014 (World Bank, 2021b), and the IMF has argued that a reasonable achievable range of a discounted average effective tax rate on petroleum rents lies between 65 and 85 percent (IMF, 2012).

This section estimates the potential loss of oil rents for the 40 countries under the most ambitious versus an unambitious ('business-as-usual') global decarbonization scenario. More specifically, the rent loss is estimated as the difference in total discounted oil rents from 2023 to 2040 between a 'net-zero 2050 scenario' (NZE) versus a 'stated policies scenario' (STEPS). The analysis only covers oil rents, as these are by far the largest source of resource rents and because oil is by and large a global market (with output trading at global prices) making cross-country comparisons easier.

FF rents have been large in 2021 and 2022, as prices for oil, coal and gas have been relatively high, and forecasts suggest that prices will remain elevated in 2023. Regardless of shorter term price forecasts, the uncertainty surrounding global decarbonization leaves FF producers in a dilemma. They are reluctant to leave resources in the ground, but also to undertake large investments that risk becoming idle. In any 1.5°C or 2°C compatible pathways there is little to no room for new major investments. Under an assumed 50 percent chance of staying within 1.5°C, one study concludes that of the existing (technically and economically) proven reserves, 58, 59 and 89 percent of oil, gas and coal reserves must be left in the ground by 2050 (Welsby, Price, Pye, & Ekins, 2021). A UN study found that under a 1.5°C pathway, FF production must decrease by about six percent each year from 2020-2030 (The Production Gap, 2020). Similarly, in IEA's NZE scenario (representing a 50 percent chance of staying within a 1.5°C degrees of warming) demand for oil, gas and coal will need to have fallen by 75, 55 and 90 percent by 2050.[14]

Box 1: Global decarbonization scenarios

The NZE scenario is the most ambitious in terms of limiting global warming; it is termed 'extremely ambitious' by the IEA themselves. Both the NZE and the sustainable development scenario (SDS) are expected to limit global warming to 'well below 2°C while pursuing efforts to limit the temperature rise to 1.5 degrees' by 2100 and are, therefore, compatible with the Paris Agreement adopted in 2015. The stated policies scenario (STEPS) is the least ambitious, as it 'only' accounts for policies that are put in place or announced. This is different from the Announced Pledges Scenario (APS), which includes all pledges made regardless of existing policies.

Stated Policies Scenario (STEPS): Represents all specific policies in place or announced by governments / 50 percent chance that global warming will reach 2.6°C by 2100.

Announced Pledges Scenario (APS): Represents all pledges made regardless of whether specific policies are in place / 50 percent chance that global warming will reach 2.1°C by 2100.

Sustainable Development Scenario (SDS): Aims to reach net-zero emissions by 2070 / 50 percent chance that global warming will reach 1.6°C by 2100.

Net-Zero by 2050 (NZE): Aims to reach net zero emissions by 2050 / 50 percent chance that global warming will reach 1.4°C by 210

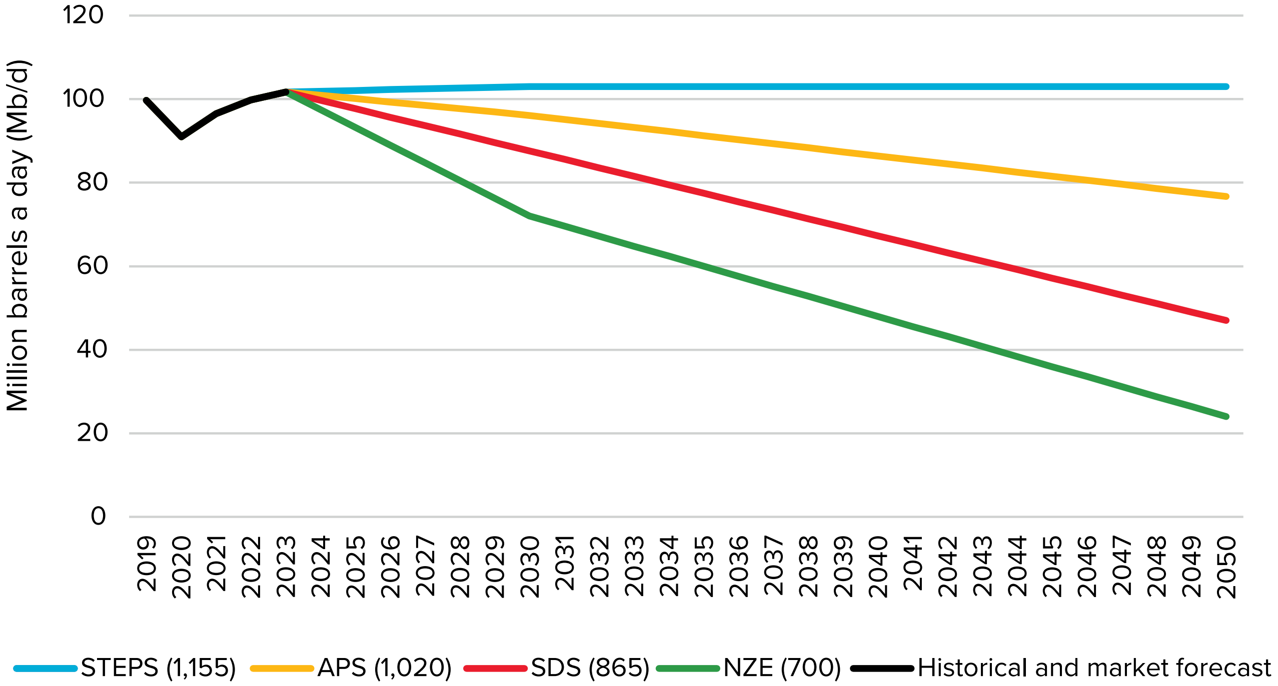
Source: IEA World Energy Outlook 2021. Note: For an overview see https://www.iea.org/reports/world-energy-model/understanding-weo-scenarios#abstract

[13] Unit rents are defined as the difference between the average market price and extraction costs of a particular resource, where costs exclude taxes but include what is considered a 'normal' rate of return on fixed capital and the consumption of fixed capital.

[14] The NZE scenario also assumes a significant future role for carbon capture, utilization and storage (CCUS) technologies. More specifically, by 2050 CCUS technologies will capture 7,602 MtCO2 (up from 40 MtCO2 today), equal to more than 22 percent of today's global energy sector emissions.

Figure 2 depicts the future oil demand trajectories measured in million barrels per day (mb/d) under the different decarbonization scenarios based on data from the IEA (see Box 1). Values for 2019-2023 cover historical values for 2019-2022 and the forecast for 2023. Beyond 2023, it is assumed that demand will adjust to follow IEA scenario trajectories. The NZE scenario is the most ambitious and compatible with a 50 percent chance of staying within 1.5°C degrees of warming (IEA, 2021a). Under the NZE, total oil consumption from 2023 to 2050 is about 700 billion barrels (bb). The least ambitious scenario is STEPS, representing a 50 percent chance that global warming will exceed 2.6°C degrees by 2100 and continue to rise (no stabilization). Under STEPS demand is expected to stabilize at 103 mb/d around 2030, consuming a total of approximately 1,155 bb of oil from 2023 to 2050.

Figure 2: Oil demand under different decarbonization scenarios, (Mb/d)



Source: Author based on IEA Net-Zero, IEA Oil 2021 and IEA WEO 2021. Note: The figure uses the latest market forecast until 2023 and then assumes that demand returns to the scenario trajectories. Note: Scenario trajectories are based on datapoints for 2030 and 2050, as stated in WEO 2021, and assuming linearity between price points. Numbers stated in parentheses in the legend are total billion barrels of oil from 2023 to 2050.

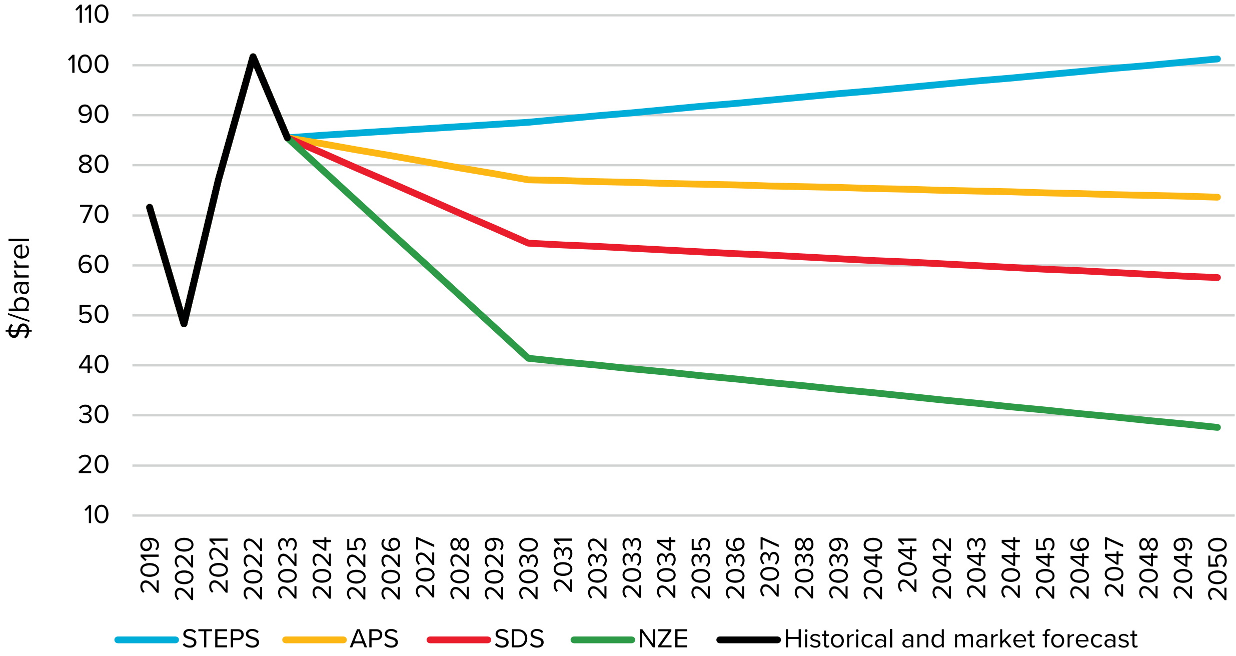
With estimated global (proven) reserves totaling about 1,662 bb the world will not run out of oil by 2050 in any of the scenarios.[15] However, only the NZE scenario is expected to stay within already producing reserves, the size of which consultant Rystad estimated in 2019 at about 800 bb (Rystad Energy, 2019). In other words, there would be no need for further oil exploration or development of new fields in the NZE scenario, as future demand can be met by continued investments in already developed fields.

The longer term implication of falling demand under an ambitious global decarbonization scenario is that FF producers will price oil closer and closer to the operating cost of the marginal project needed to meet a lower demand. This is the underlying assumption behind IEA's steep fall in oil prices under NZE, although the agency points out that if resource-rich producers chose to increase production (to grab a larger market share) prices could fall even further (IEA, 2021a). The different scenario price schedules based on IEA are plotted in Figure 3.[16] As an example, IEA's NZE scenario assumes a 43 percent fall in the real price of oil from 2020-2050 compared to a 110 percent increase under STEPS.

[15] EIA's Global Energy Statistics database '*Crude oil including lease condensate reserves*'.

[16] Figure 4 shows the oil price in real terms using IMF data for average crude oil price and adjusted by US GDP deflator.

Figure 3: Oil prices (real terms, US$2023)* under different decarbonization scenarios



*Source: Author based on IMF WEO October 2022, IEA WEO 2021 and IEA Net-Zero 2050. Note: *The oil price follows the latest forecast from the IMF World Economic Outlook (October 2022) until 2023. From that point forward, price scenarios are based on datapoints provided for 2030 and 2050 in WEO 2021 and assumed linearity. Historical series is adjusted with US GDP deflator (base year 2023) from IMF WEO.*

3.1 - Estimating the potential oil rent loss under global decarbonization

The oil rent loss is estimated as the sum of the present value adjusted (PV) oil rents from 2023 to 2040 under an NZE scenario relative to a reference scenario STEPS. Arriving at this estimate requires many non-trivial assumptions, not the least of which is due to the scarcity of publicly available data, explained below and discussed in greater detail in Box 2.

The main equation for determining the PV of future oil rents under each of the two scenarios is as in (1).

(1) $$Rent\_value_i = \sum_{t=0}^{n} \frac{q_{i,t}(p_{w,t}-c_i)}{(1+r)^t}$$

Here $q_{i,t}$ is country i's oil production volume at time t, $p_{w,t}$ is the world price of a barrel of crude oil, c_i is country i's average unit extraction cost and *r* is the chosen discount rate. Country annual production volume is determined by multiplying total global demand at time t, $q_{w,t}$, with a country's latest market share of global crude oil production as shown in (2) where country shares, sh_i, are based on EIA production data for the year 2020.[17]

(2) $$q_{i,t} = sh_i q_{w,t}$$

Without direct access to unit cost estimates these are instead 'backed out' from the available rents data using (3), where the dollar value of country rents, $rents_{i,t}$, is taken from the WDI database for country i at time t. In (1), *c*, is constant for each country over the projection period and estimated as the average value for the five-year period 2015-2019 to smooth out fluctuations.

(3) $$c_{i,t} = p_{w,t} - \frac{rents_{i,t}}{q_{i,t}}$$

[17] We rely on EIA Global Energy Statistics, petroleum production, 'crude oil including lease condensate'.

Based on (3), MENA is by far the most cost competitive region, as most producers have an estimated unit cost of less than $10/b compared to a world average of $24/b. The weighted average unit cost from 37 of the 40 countries identified in this paper with available data is $16.9/b compared to $36.2/b for the rest of the world's oil producers. The prices applied to each scenario are, as in Figure 3, linear projections based on the 2030 and 2050 price points reported in IEA World Energy Outlook 2021 (IEA, 2021b).

The estimation proceeds by first assuming that all current 99 oil producing countries in the world keep their 2020 share of global production.[18] Second, it assumes that a country will stop production if either the oil price falls below its unit extraction cost or if cumulative production exceeds its size of proven reserves.[19] A third assumption is that if a country stops production, the resulting global supply shortfall will be picked up fully by the remaining producers and in proportion to their market shares.

Under these assumptions, it can be noted that in both scenarios, low cost producers with large reserves grow their market share. Under STEPS, this happens as larger annual demand volumes deplete reserves faster (within the used projection horizon) in some countries, leaving others to pick up the supply gap. Whereas under NZE lower annual demand prolongs the production life of reserves for all, but the sharp drop in price makes reserves unprofitable for some countries thus shifting production to lower cost producers.

Results are, needless to say, highly sensitive to the simple assumptions explained above. However, it is believed that the approach adopted here, albeit crude, is useful in understanding and illustrating the scale of the decarbonization challenge for FF-dependent economies. Another important caveat is that (proven) oil reserves are not declining; rather, they have grown over time. As previously mentioned, several countries that have never produced oil (or gas) are in the process of exploring and developing new fields in the hopes that they will still be able to extract these rents. A second important point is that the author does not have access to lifecycle data on oil fields and, therefore, operates with only one fixed aggregate (country-level) unit extraction cost estimated using (3). Box 2 discusses in greater detail the limitations and implications of the methodology and assumptions.

[18] According to EIA's Global Energy Statistics, there were 99 oil producing countries globally in 2020.

[19] For reserves we rely on 'crude oil incl. lease condensate' reserves data provided by EIA Global Energy Statistics. EIA reserves data is defined as 'the estimated quantities of all liquids defined as crude oil that geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from reservoirs under existing economic and operating conditions.'

Box 2: Assumptions underlying the loss of rent estimates

Price and volume: In both scenarios the projections use the 2023 (average crude) price forecast from the IMF's World Economic Outlook October 2022, and the 2023 volume demand forecast from the IEA Oil Market Report January 2023. Beyond 2023, price and volume are based on IEA's different global decarbonization scenarios as depicted in Figures 2 and 3.

Unit extraction costs: In (1) unit extraction costs are based on the average estimate for the five-year period 2015 to 2019, calculated using (3) and held fixed throughout the projections. Ideally, one should be using country-level supply cost-curves (aggregated from oil field lifecycle data), as extraction costs tend to increase for higher outputs. The consequences of this assumption on the rent loss estimate are, however, uncertain. On the one hand, it could overestimate future rents in STEPS relative to NZE, as volumes are much greater in the former. On the other hand, the NZE scenario assumes that carbon taxation will be one of the key drivers of falling demand. A carbon tax would push up the extraction costs (thus lowering rents) under the NZE relative to STEPS.

Market shares and reserves: It is assumed that current market shares remain the same in the future, and that countries only stop producing if the market price drops below unit costs or if cumulative production exceeds the size of proven reserves. Any resulting supply shortfall is immediately picked up by the remaining producers in proportion to their market share. However, the reality is that reserves have been growing over time, reserves data is highly uncertain and market shares change. In addition, a lot of oil and gas exploration and field developments are currently taking place, not only in existing producer countries, but also in countries that have never produced before. These new fields and country producers will compete with existing fields and producers in the future and the 'static' approach adopted in this estimation does not attempt to take such dynamics into account. In these estimations, the same 99 countries that were producing oil in 2020 are the future producers under each scenario, and the starting value of their reserves is their 2020 reserves volume as reported by EIA. Another complication is that the size of 'proven reserves' changes with market conditions. This is because 'proven' refers to both technical and economic feasibility, and with higher prices and/or lower production costs (for instance through technological developments) the size of proven fields are likely to increase. It is, therefore, likely that the size of proven reserves is higher under STEPS versus NZE, even in the absence of new discoveries.

3.2 - Results

The latest estimates from the World Bank suggest that global oil rents totaled $752 billion in 2020, of which the group of 40 FF-dependent countries identified in this paper accounted for $558 billion or about three quarters.[20] Estimation results here suggest that in PV-adjusted[21] terms, the group of 40 could see total cumulative oil rents from 2023-2040 decline by $14.0 trillion, or 61 percent, under STEPS compared to NZE.[22] For the average/median country this is equivalent in size to 197/141 percent of nominal GDP. Given its large production volume, sizable reserves and low production costs, Saudi Arabia accounts for about one quarter of the total estimated rents loss.

The results are sensitive to the reserves estimates used, especially as three major oil producers, the US, China and Russia, under the STEPS scenario would run out of crude oil reserves before 2040 leaving substantial amounts of annual oil production (and rents) to be picked up by remaining producers (including the group of 40).[23] Given the large uncertainties surrounding reserves data and the large market share of these three countries (almost one third of crude oil production in 2020), estimates are recalculated as a sensitivity check under an assumption that reserves are not a constraint among the three producers. Doing so lowers the PV-adjusted rent loss estimate from $14.0 trillion to $11.8 trillion.

[20] Oil rents are reported in the World Bank's World Development Indicators database.

[21] The analysis uses a five percent discount rate.

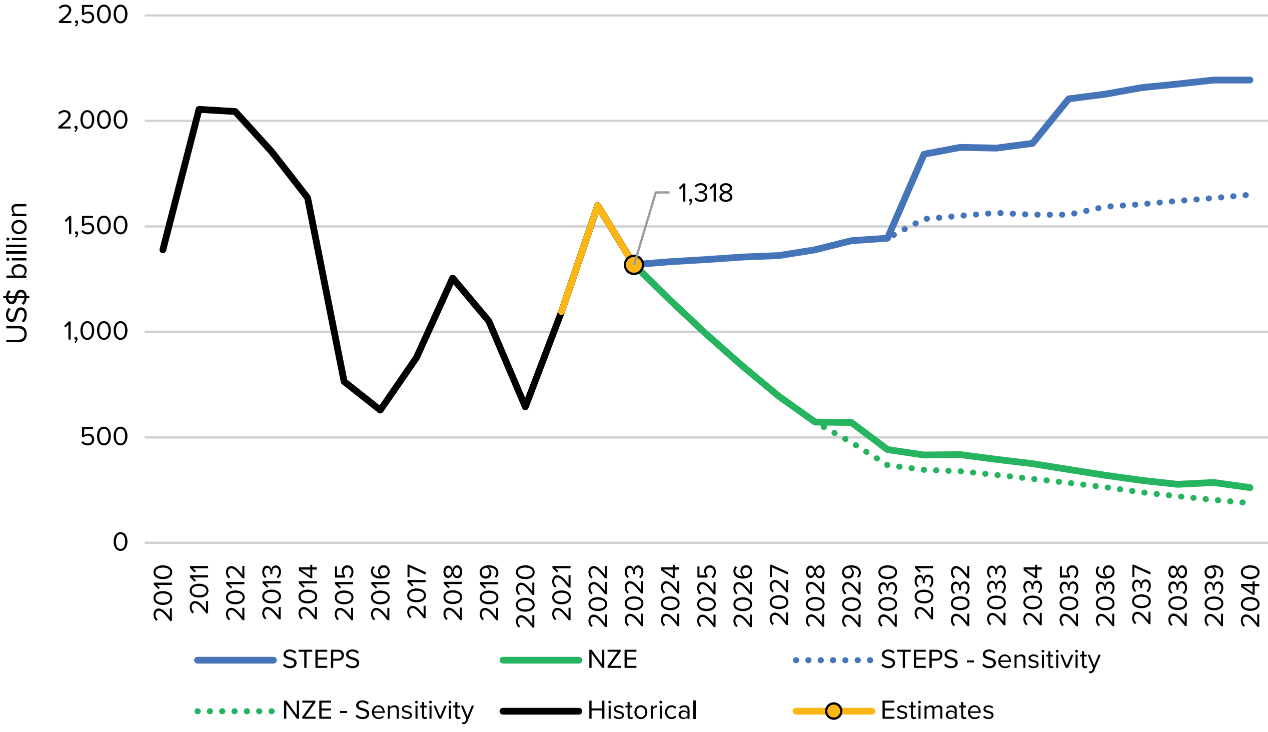
[22] In PV-adjusted terms cumulative oil rents for the period 2023-2040 would be $22.1 trillion under STEPS compared to $8.1 trillion under NZE.

[23] According to EIA Global Energy Statistics China, Russia and the US together accounted for almost one third of global crude oil (including lease condensate) production in 2020. The US was close to 15 percent, Russia close to 13 percent and China, little more than 5 percent. Under STEPS the US would run out of reserves in 2030, China in 2034 and Russia in 2036. As an example, according to EIA, the US had at the end of 2020, 47 billion barrels of crude oil (including lease condensate) in reserves. In 2020 alone, the US produced about 4.1 billion barrels (or 11.3 Mb/d).

Figure 4 shows the rent estimates for the group of 40 under NZE and STEPS from 2023-2040 with the dotted lines representing the sensitivity check estimates. Figure 4 also shows the historical data for oil rents from 2010-2020 and estimates for the three years 2021, 2022 and 2023. The three year estimates are based on the methodology described in Section 3.1, but using actual oil prices (crude average) for 2021 and 2022 and a market forecast of $85.5/barrel for 2023.

During the peak years of the oil price supercycle in 2011 and 2012, annual rents exceeded $2 trillion (in 2023 prices). In 2023, it is estimated that rents will total around $1.32 trillion.

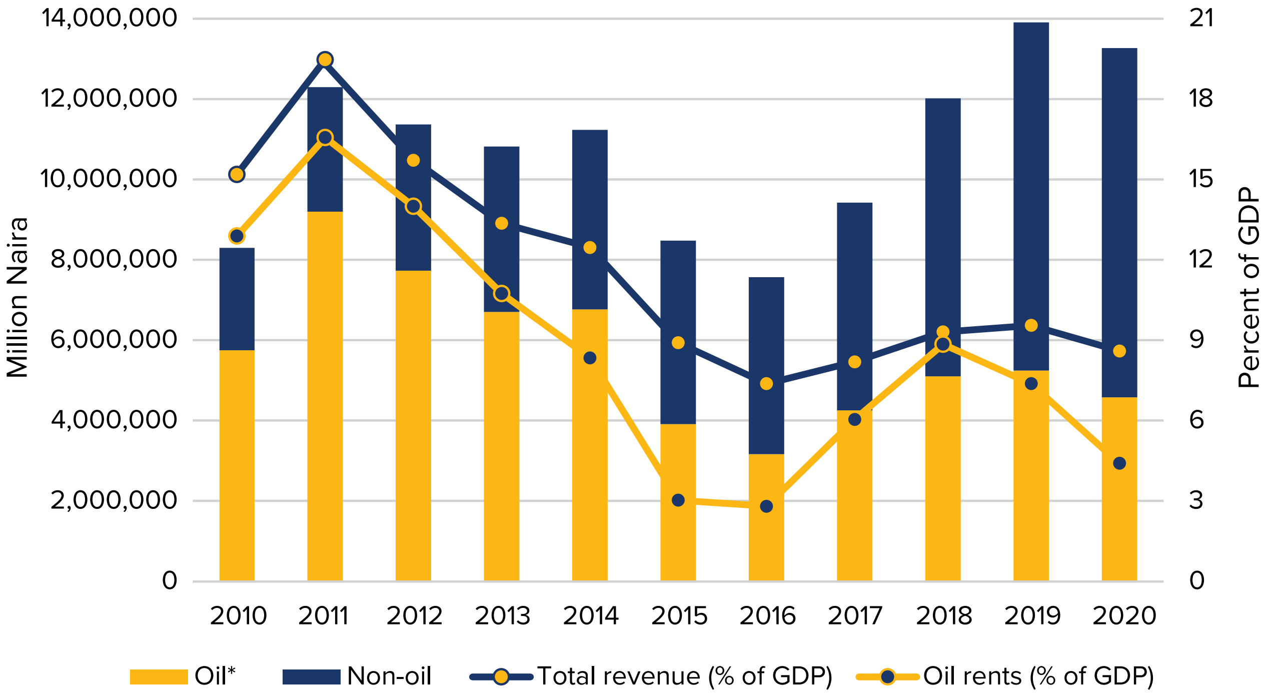
Figure 4: Oil rents for the group of FF-dependent economies, real terms (US$2023)*



*Source: Author's estimations for STEPS and NZE. WDI for historical data. Note: VEN and SSD are missing from historical. VEN and UZB are missing from NZE and STEPS. *Rents are in 2023 prices (adjusted by the United States GDP deflator from IMF WEO. October 2022). The dotted lines show the rent estimates under the sensitivity check of keeping the three large oil producers (China, US and Russia) as producers throughout the projection period.*

To give a country example, Nigeria, Africa's largest oil producer and exporter, generated little more than $19 billion (4.4 percent of GDP) in oil rents in 2020 (Figure 5). In this paper it is estimated that in 2023 Nigeria will generate about $46 billion in oil rents because of higher oil prices. Nigeria's (PV) cumulative oil rents from 2023-2040 under the NZE is estimated at $252 billion compared to $812 billion under STEPS. In other words, cumulative oil rents under NZE are expected to be less than one third of rents under STEPS with a loss of $560 billion. Under the sensitivity calculation the (PV) cumulative rents estimate for NZE is $236 billion compared to $665 under STEPS, resulting in a loss of $428 billion. To put the rent loss into perspective, $560 and $428 billion is 111 and 85 percent of Nigeria's current (nominal) GDP.

Figure 5: Nigeria – Revenue composition and oil-rents (2010-2019)



*Source: OECD Global Revenue Statistics Database and World Development Indicators. Note: *Oil revenue covers tax revenue from the petroleum profits tax and non-tax revenue in the form of revenue from revenue sharing agreements, royalties, fees and licensing.*

According to these results, and if Nigeria taxes oil rents at a fixed rate, government revenue from oil can, therefore, also be expected to be about two thirds lower under NZE versus STEPS. Even though Nigeria's non-oil revenues have grown in recent years, oil revenue in 2020 (a year with low oil prices) still accounted for more than one third of the total, and total revenue as a percentage of GDP closely follows oil rents and was in 2020 an unimpressive 8.6 percent of GDP (Figure 5).

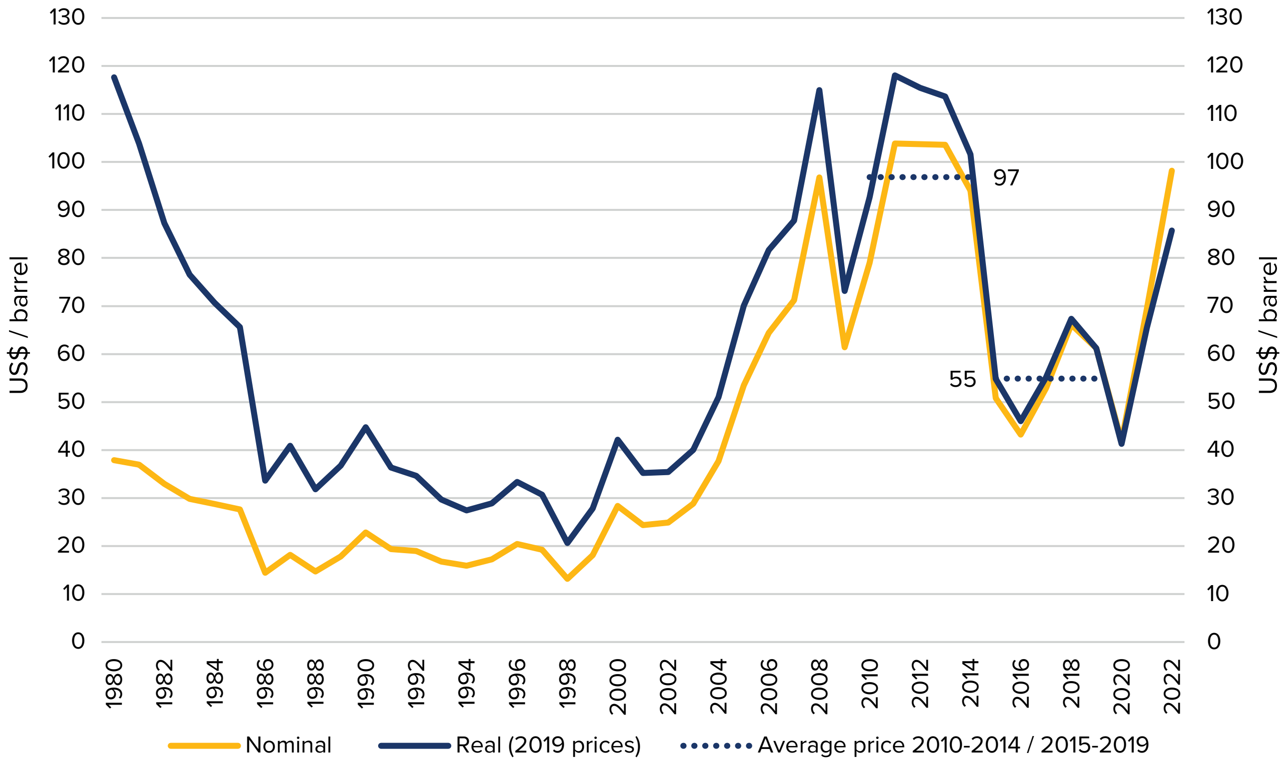
Empirical analysis: macroeconomic and fiscal implications of falling oil prices

4

4.1 - The 2014-2015 oil price collapse

The period from 2000-2014 is often considered a commodity supercycle under which prices, including oil prices, broadly soared only temporarily interrupted by the financial crisis in 2008-2009 (Figure 6). After growing rapidly for more than a decade, oil prices collapsed in 2015. From the height of the 'boom' period covering the five years from 2010-2014 to the five-year 'bust' period from 2015-2019, the average price of a barrel of crude oil fell from $97 to $55, a 43.5 percent fall (or 47.4 percent in real terms). The sharp fall in oil prices was first attributed to supply factors (a supply glut) including the boom in United States' shale oil production but did not, as initially expected by many, cause a pick-up in global growth. As an example, from the boom to bust period the annualized global GDP (real) growth rate slowed by 0.33 percentage points.[24]

Figure 6: Oil price in US$/barrel of crude, 1980-2022



Source: Based on IMF WEO October 2022 and FredStats. Note: the oil price is the simple average of the three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh. The real oil price is the nominal oil price adjusted for US CPI inflation and with the base year of 2019.

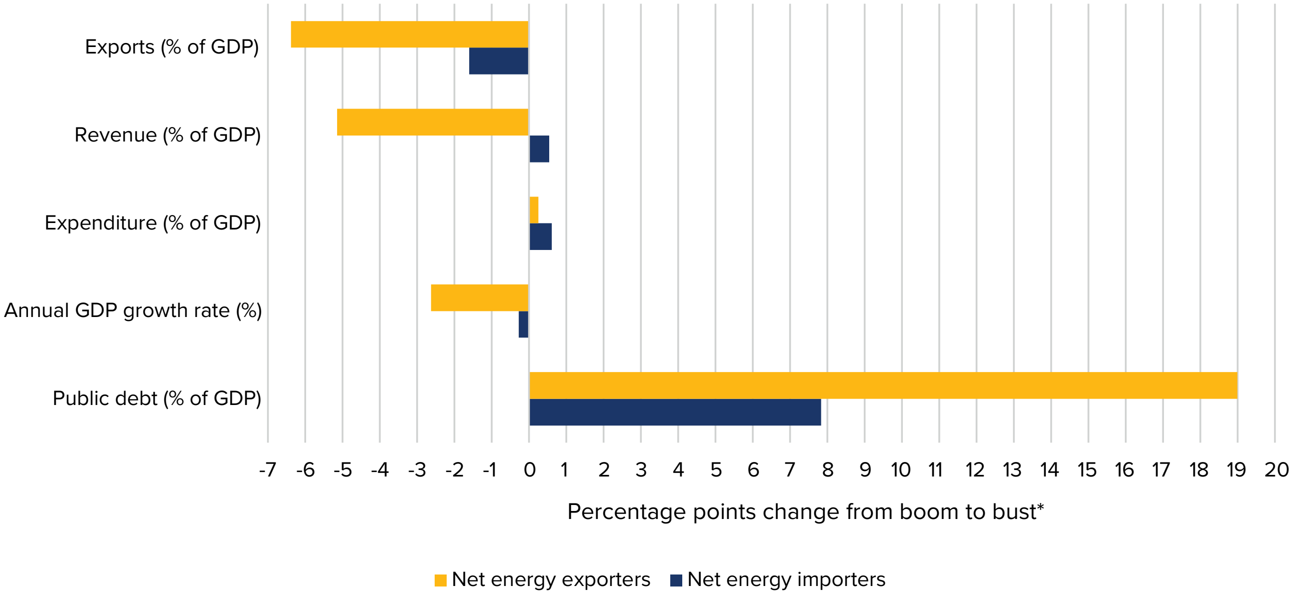
This global growth 'puzzle' has been attributed to several factors (Stocker, Baffes, Some, Vorisek, & Wheeler, 2018). The price drop was one of the largest in history, which led to a substantial economic slowdown in oil-exporters, and it did not deliver an economic boost to the US (at that time still a net oil importer), as it led to a sharp contraction in US energy investments. Deteriorating demand factors also played a role, especially

[24] From 2010 to 2014, the global economy grew by 15.6 percent compared to 14.1 percent from 2015 to 2019.

in emerging markets and developing economies[25] and importantly from China - the world's second largest economy and largest importer of crude oil, which continued its economic slowdown.[26]

From oil price boom to bust, the difference in changes to key macroeconomic and fiscal variables were highly noticeable between the group of EMDE net energy exporters versus importers (Figure 7).

Figure 7: EMDEs - Average change from oil price boom (2010-2014) to bust (2015-2019)



Source: Export, import and growth data are from the World Bank Development Indicators database. Debt and revenue data are from IMF WEO (April 2021). Note: Results reflect the difference between the annual average value of the five-year 'boom' period (2010-2014) and the five-year 'bust' period (2015-2019). Included in the sample are all countries not categorized as an 'advanced economy' and only countries that had more than three observations on imports and exports in each of the five-year periods. Countries with at least three of five years in each period as a net energy exporter (importer) are categorized as net-energy exporting (importing) countries. This amounts to 29 exporters and 110 importers.

Both the average EMDE importer and exporter witnessed a slowdown in GDP growth and exports, and an increase in debt, but with much larger changes for the group of exporters. Whereas revenue fell sharply among exporters, it rose a bit among importers, and expenditures rose some in both groups. More specifically, the average exporting country saw a decline in annual exports (as a percentage of GDP) of 6.4 pp from boom to bust, compared to 1.6 pp for the average importer. Annual government revenue (as a percentage of GDP) fell by more than 5.1 pp for exporters compared to a small rise of 0.5 pp for importers. The average annual GDP growth rate for exporters slowed by 2.6 pp compared to 0.28 pp for importers. Finally, public debt (as a percentage of GDP) rose by as much as 19 pp for exporters compared to 7.8 pp for importers.

4.2 – Local projections analysis of growth and fiscal responses to oil price inflation

To take a closer look at fiscal and growth implications of oil price changes for oil exporters, this section estimates five-year cumulative impulse response functions (CIRFs) for revenue, expenditures, debt and GDP to changes in (real) oil price inflation for EMDE oil exporters versus importers using a local projections (LP) model. The model includes country fixed effects and uses standard errors robust to heteroscedasticity, auto-correlation and cross-sectional dependence. All fiscal outcome variables and the GDP growth rate enter in all regressions and other control variables include the domestic (CPI) inflation rate and the growth

[25]EMDEs refers to all countries not categorized as advanced economies by the IMF.

[26]From the boom to bust period, China's annualized real GDP growth rate slowed by 1.5 pp.

rate of global (real) industrial production, an often used proxy for global oil demand. The model includes four lags for each variable, and model results for each response variable are compared between the oil exporter and importer country samples. The full analysis can be found in Annex B.

Results suggest that oil price shocks have large and persistent impacts on growth, revenue and debt in exporters, but little or no impact in importers. More specifically, a ten pp increase in (real) oil price inflation is associated with the following:

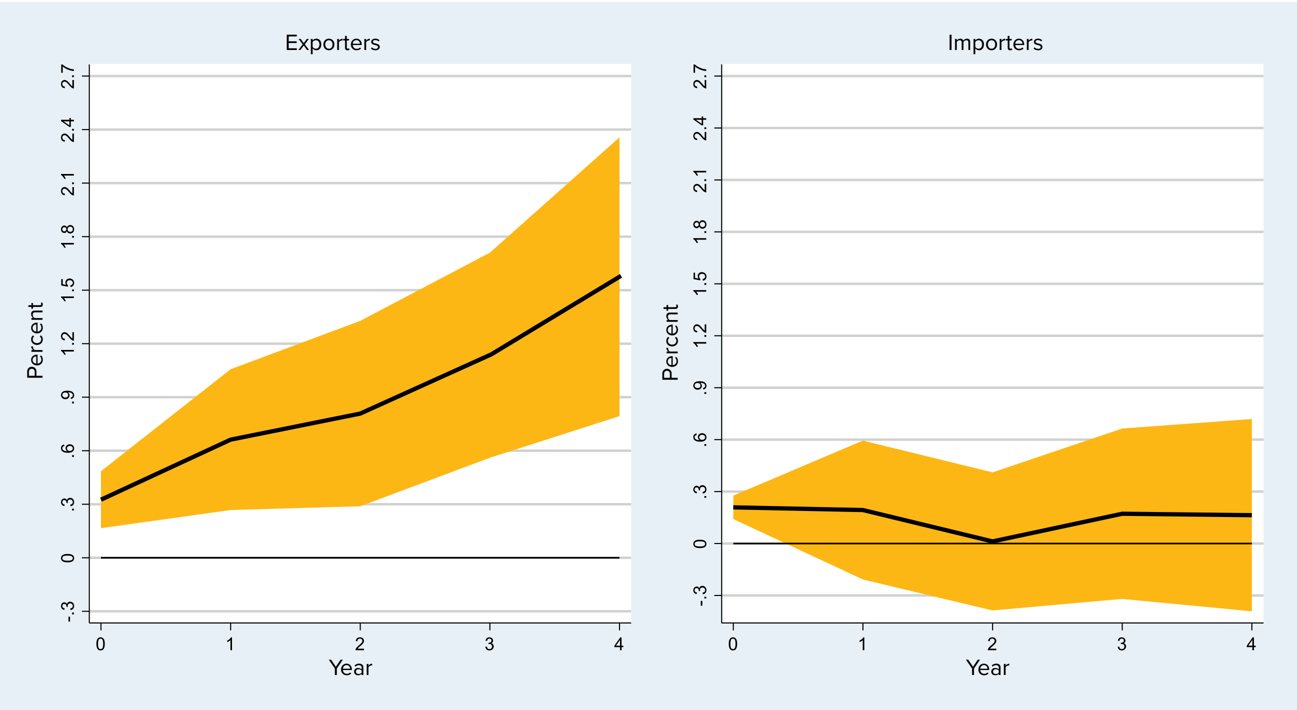
- A significant and persistently growing positive impact on real GDP for exporters, with no cumulative impact on importers beyond the initial shock. Four periods after the shock, GDP is 1.58 percent higher in exporters (Figure 8), equivalent to an annual average growth in (real) GDP of approximately 0.31 percent.

- An immediate increase in revenue measured as a percentage of GDP by close to 0.6 pp for exporters and with the cumulative impact remaining significant between 0.6 and 0.7 pp throughout the five-year projection horizon. For importers the initial response is small and negative, and the cumulative response is only borderline statistically significant four periods after the shock (Figure 9).

- In both exporters and importers, no significant impact on government expenditure (Annex Figure B1). Coupled with the revenue result, this implies an improvement in fiscal balances in exporters following a positive oil price shock, also supported by estimating CIRFs for the overall and primary fiscal balances. However, results suggest that fiscal balance improvements abate over time (Annex Figures B2 and B3). In other words, the analysis finds no strong evidence of counter- or pro-cyclical spending behaviour in the chosen sample of countries.

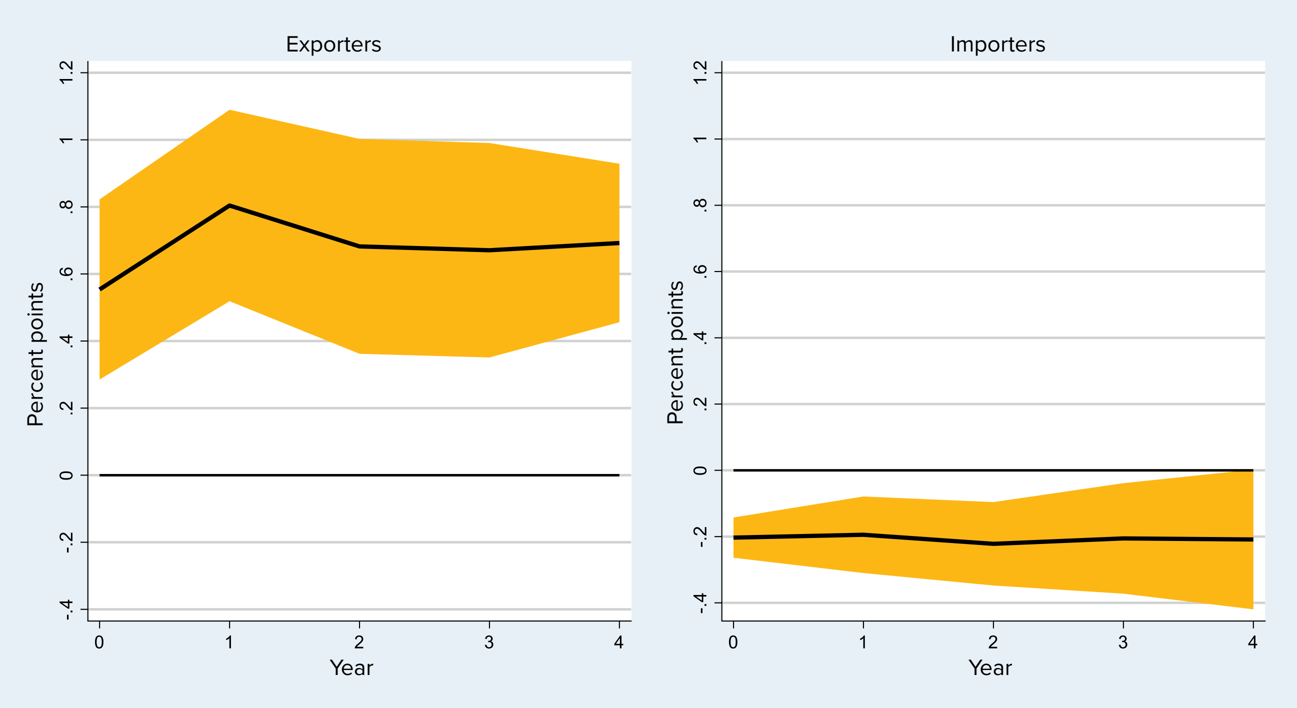
- A significant, and persistently growing negative impact on general government debt measured as a percentage of GDP in exporters, with no significant impact in importers. Four periods after the shock, debt as a percentage of GDP has decreased by close to 2.5 pp in exporters (Figure 10), equivalent to 0.5 pp per year.

Figure 8: EMDEs - GDP (constant prices) response to a ten pp increase in (real) oil price inflation



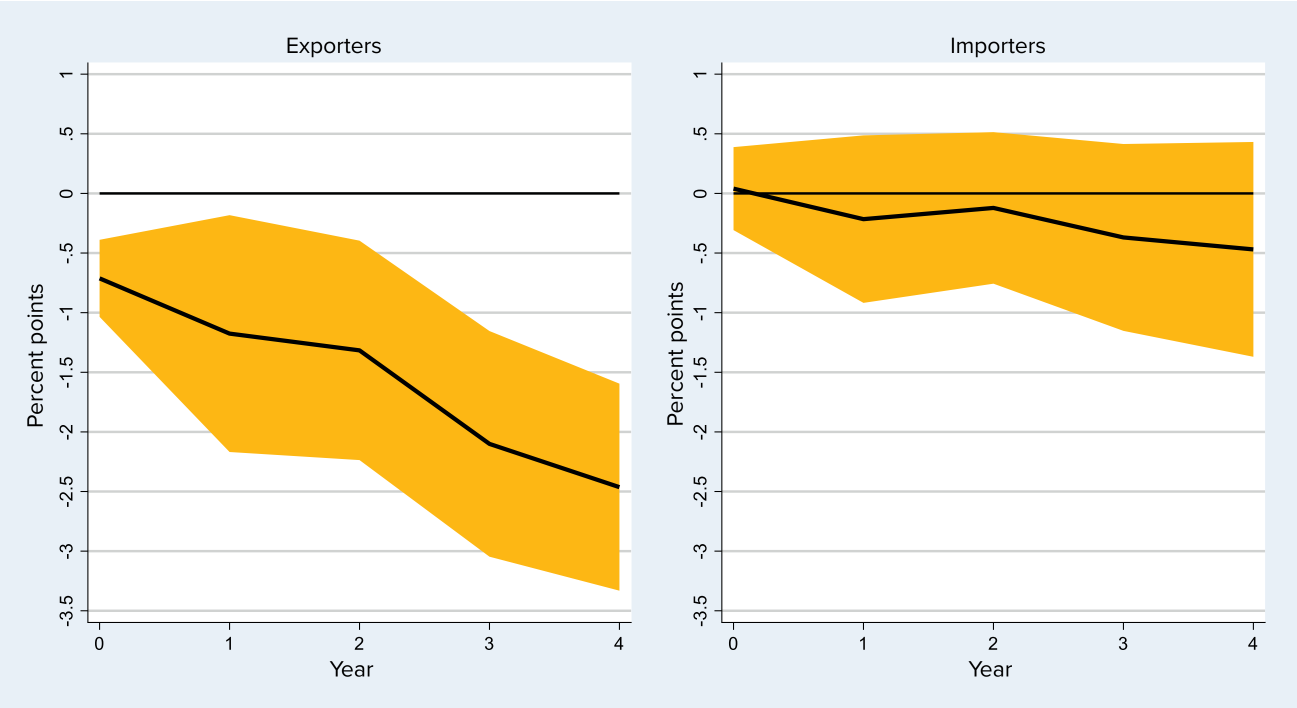
Source: UNDP. Note: Cumulative response of real GDP from a ten pp increase in the real oil rice from a local projections model. The shaded area delineates the 95 percent confidence band.

Figure 9: EMDEs - Revenue response to a ten pp increase in (real) oil price inflation



Source: UNDP. Note: Cumulative response of government revenue (as a percentage of GDP) from a ten pp increase in the real oil price from a local projections model. The shaded area delineates the 95 percent confidence band.

Figure 10: EMDEs - Public debt response to a ten pp increase in (real) oil price inflation



Source: UNDP. Note: Cumulative impulse response of general government gross debt (as a percentage of GDP) from a ten pp increase in the real oil price from a local projections model. The shaded area delineates the 95 percent confidence band.

Under an assumption of symmetric oil price impacts (discussed in greater detail in Annex B) the results of this analysis, therefore imply that there will be significant and persistent fiscal and macroeconomic transitory costs associated with global decarbonization in oil export-dependent EMDEs.

If the world is to reach net-zero emissions by 2050, the recent and current high oil prices provide FF exporters with the last major resource windfall before a sharp (policy- and regulatory-driven) fall in demand and prices in FF sets in. If oil export-dependent economies do not anticipate this global transition in time and do not receive international financial assistance to support their economic diversification, the transitory costs they could potentially face through a falling GDP, a loss of a government revenue and a higher debt-burden will be profound and could roll back current levels of development by decades.

The policy implications of an ambitious global decarbonization

5

5.2 Fiscal stabilization, economic diversification and saving for future generations

The literature on managing (non-renewable) resource revenue in resource-rich economies typically describes three competing objectives: fiscal and macroeconomic stabilization, economic diversification and saving for future generations (OECD, 2018). Stabilization is desirable due to the volatility of commodity prices, and resource revenue can be managed to stabilize budget revenue, and thereby, also help to stabilize the economy throughout the commodity cycle. Beyond the funds needed for stabilization, countries must choose between undertaking more strategic spending and investments today aimed at economic diversification (growth of the non-extractives sector) and other development objectives, or saving rents for later use and/or paying down debt. This decision can be heavily influenced by the economy's absorptive capacity with a higher preference for savings (or reducing debt) if capacity is low. The trade-off between saving and spending is generally also tilted towards spending the lower a country's physical and human capital stocks (or level of development).

Under an ambitious global decarbonization scenario, the typical policy advice does not fundamentally change, but it takes on a different nature. As the high FF prices enjoyed over the last couple of years are expected to provide countries with their final major rent windfall before a steep fall sets in, stabilization policies become less about managing volatility and more about managing a steady decline in resource revenue and exports. For fiscal stabilization, this implies a much greater urgency and emphasis on increasing revenue from the non-extractive sectors. This will require an overhaul of tax systems, and on the expenditure side, for many countries, also a move away from broad-based (inefficient and regressive) subsidies towards a more targeted approach to social protection. As for economic diversification, an ambitious decarbonization scenario severely reduces the time and (rent-based) finances available to undertake an economic transformation. The challenge will be even more daunting for countries with weak institutions, high spending inefficiencies and little or no savings.

Although comparable data on countries' financial assets is quite opaque, only a handful of FF exporters and all high-income countries are believed to have any significant savings, for instance, in sovereign wealth funds (CTI, 2021b). As an example, the IMF has estimated that in 2020 oil exporting SSA countries held assets of up to only 1.8 percent of GDP compared to 72 percent in MENA countries (Abdel-Latif, Rawlings, Reyes, & Zhang, 2022). Estimates for the end of 2022 suggest that the total capitalization of African sovereign wealth funds was only $72.9 billion, of which $60 billion belonged to Libya's fund alone (Addison & Amir, 2022). Nigeria, a country of 213 million people and expected to reach more than 320 million by 2040, has a fund of only $2.95 billion, which is less than one percent of GDP or $14 per capita.[27] By comparison, Saudi Arabia, a country of 36 million people and more than 11 times richer than Nigeria (in GDP per capita terms), has a fund worth $607 billion, which is 73 percent of GDP or almost $17,000 per capita.[28]

This is not to say that there will be no economic benefits associated with a lower demand for a country's natural resources. According to the 'resource-curse' literature, resource wealth can lock countries into a pattern of a long-term declining terms of trade, disrupt economies through high volatility, crowd out the manufacturing sector, entrench autocratic/oligarchic institutions and increase the risk of conflict (Frankel, 2012). However, the materialization and timeline of such mitigating economic dynamics remain highly uncertain and unlikely to work fast enough to significantly counteract the potentially high transition costs

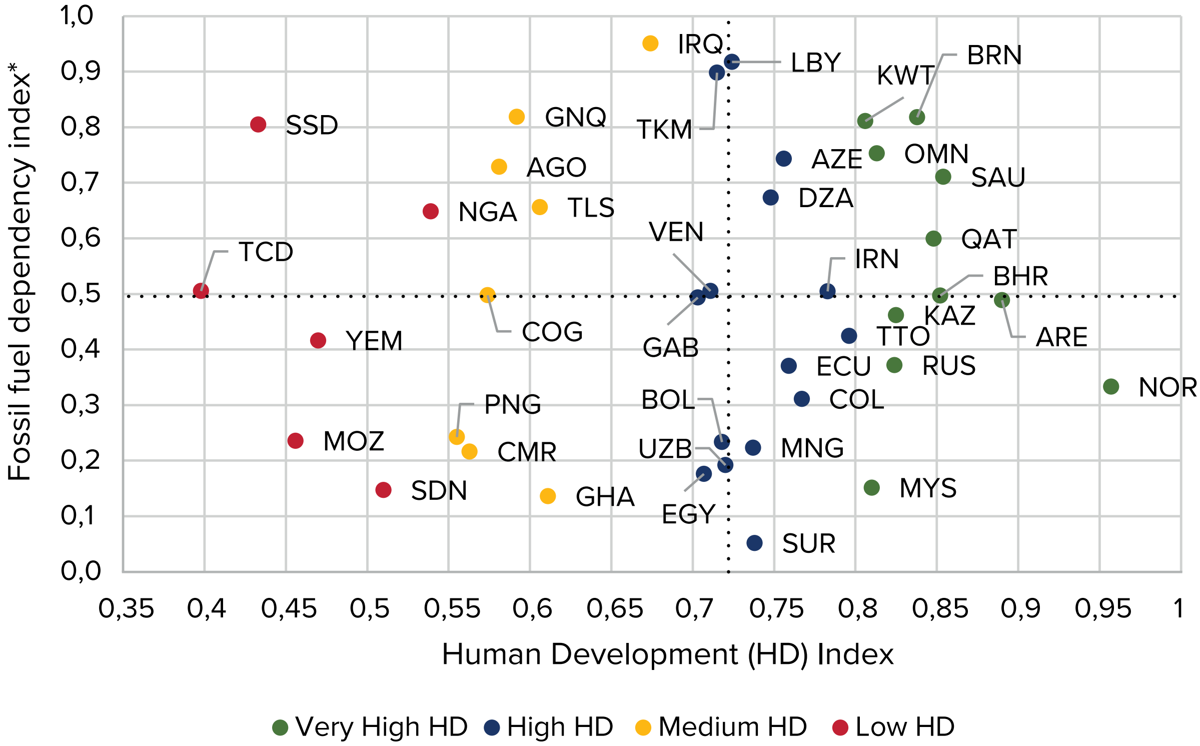
[27] https://www.swfinstitute.org/profile/598cdaa60124e9fd2d05b968

[28] https://www.swfinstitute.org/profile/598cdaa60124e9fd2d05bc3b

from a rapid loss of external demand, as also suggested by the results of the regression analysis in Section 4.2. It should also be noted that some countries, from an energy resources perspective, are well-positioned to capitalize on decarbonization. Estimates, for instance, suggest that Africa could become a global energy powerhouse as it holds 39 percent of the world's wind and solar capacity (CTI, 2021a). But taking advantage of such opportunities will, for many countries, require significant international assistance to plug major technical and financial capacity gaps.

Taken together, FF exporters' vulnerability to global decarbonization depends both on its level of dependency on FF (exposure) and its level of (physical, financial and human) resources (resilience).[29] While it is beyond the scope of this study to discuss vulnerability in details, Figure 11 makes a simple mapping of the level of human development on the x-axis measured by UNDP's Human Development Index (HDI)[30] and the level of FF dependency on the y-axis (measured as the simple average of the FF share of government revenue and exports) for the group of 40.

Figure 11: Fossil fuel dependency and human development



*Source: Author based on UNDP and World Bank. Note: *Fossil fuel dependency is measured as a simple average of the FF-share of government revenue (using the rents adjustment on resource revenue explained in the main text) and exports (see Annex Table A1 for details). Revenue data is missing for five countries (BHR, ECU, OMN, TKM and UZB) where datapoints are just the export shares. Dotted lines represent the median. Color coding represents the HDI classification from 'low' to 'very high' human development.*

In the bottom right corner of Figure 11, countries like Malaysia and Norway have 'very high' levels of human development and relatively low FF dependency. Such countries are economically less exposed to the impacts of global decarbonization, and better equipped to manage them. In the upper right corner are most of the high-income MENA oil exporters. These countries are heavily exposed to the impacts, but also relatively better equipped to manage them. For most of these countries, massive FF rents (relative to population size) is a key reason why they have been able to achieve and sustain higher levels of human

[29] For an in-depth discussion on resilience and vulnerability to the climate transition see for instance (World Bank, 2020b).

[30] The HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living: http://hdr.undp.org/en/content/human-development-index-hdi

development notwithstanding their low levels of economic diversification. Countries towards the upper left corner are both heavily exposed to the impacts and are not well equipped to successfully manage them. In these countries, global decarbonization could significantly worsen conditions for millions of already struggling people and impede development prospects for decades. As an example, more than 40 percent of the populations in Angola, Chad, Nigeria and South Sudan are believed to live in extreme poverty.[31] Africa's largest oil producer and exporter Nigeria is the continent's most populous country and believed to have the second largest population of extreme poor in the world, accounting for 12 percent of the total population (Katayama & Wadhwa, 2019), and, according to some estimates, numbering more than 88 million people.[32]

Without greater international cooperation in ensuring a just global energy transition, many countries face a highly uncertain future with potentially devastating socio-economic consequences.

5.1 International/multilateral financial support

Transition costs as described in this paper are minimally featured in discussions about climate finance. Such discussions are primarily focused on the financing of emissions reduction (mitigation), as, for instance, those set out in countries' nationally determined contributions (NDCs) and adaptation to the impacts of climate change. For the group of countries analysed in this paper, however, the greatest adaptation costs are likely to come from global decarbonization.

International commitments on climate finance have so far been disappointing and far short of what is needed and can be justified. Wealthy countries in 2009 pledged at COP15 to give $100 billion a year by 2020 in climate finance to developing countries, but much more is likely needed. A United Nation's report estimates that developing countries will need between $140-300 billion a year by 2030 and $250-500 billion a year by 2050 for climate adaptation alone (UNEP, 2021). It is well-known that today's wealthy economies bear the main responsibility for climate change as they account for the vast majority of GHG stocks in the atmosphere.[33] It is also well-known that many developing economies are, and will continue to bear the brunt of the negative impacts of climate change through their greater exposure to climate hazards, rising temperatures and lower coping capacities due to weak institutions and lower incomes. It should be the obligation of wealthy nations that have long ago depleted their carbon budgets to compensate poorer low-emitting nations for the damages instilled upon them from global decarbonization and climate change, and to help them fund their own decarbonization with the aim of ensuring that they will not have to forego other pressing developing objectives in the process. Such an approach would require a simple and transparent approach to collecting and distributing climate finance, which currently does not exist, at least on the scale needed. The underlying principles of such a system are outlined below.

The polluter pays: This simply means that the more a country emits, the more it should have to contribute to the pool of available climate finance. For instance, some have suggested using a simple average per capita emissions threshold to guide global climate finance transfers from high to low emitters (Rajan, 2019). Others have elaborated on such ideas and proposed the establishment of a global carbon incentives fund (Russell-Jones, 2021). A simple calculation suggests that if the group of 67 countries with CO2 emissions above the world average were to finance the $100 billion a year in climate finance agreed upon at COP15, a ton of CO2 would be priced at about $3.8. The largest recipient would be India with close to $27 billion (27 percent) a year, little more than one percent of India's GDP. The two largest contributors would be China and the United States. The US would pay about $25 billion (about 0.13 percent of GDP) and China $34 billion (0.19 percent of GDP). Accounting for historical contributions to CO2 stocks in the atmosphere would, however, lower China's contribution to $17 billion and increase the US's contribution to $30 billion.[34]

[31] According to the World Poverty Clock, the extreme poverty rate in Nigeria is 41, Chad 45, Angola 54 and South Sudan 86 percent.

[32] Ibid

[33] According to data from Ourworldindata, 72 high-income countries out of a total of 205 countries account for 57 percent of cumulative CO2 emissions from 1750 to 2020.

[34] This calculation takes into account country cumulative emissions from 1750-2020 provided by the Global Carbon Project as reported by Our World in Data.

The most vulnerable countries receive the largest compensation: Transferring climate capital from countries above some per capita emissions threshold to countries below is simple and upholds the right incentive structure. Countries above the threshold will have to pay less, as they bring down emissions and countries below will receive less as they allow emissions to rise. However, for the group of countries set to receive compensation, the amount should be based on a 'needs adjustment' and not just on the distance of per capita emissions to some agreed level. This is because two countries with the same levels of per capita emissions can have very different exposure and resilience (i.e. vulnerability) to climate change, and thus, very different climate finance needs. To undertake such a 'needs adjustment' will require that the international community agrees on a new framework for assessing and quantifying countries' climate adaptation and mitigation needs.

Needs adjustments should be flexible and include transition costs: As argued in this paper, the greatest climate-related socio-economic threat to some countries comes via a potential massive loss of demand for their exports. This type of transitory cost should feature in assessments alongside adaptation and mitigation needs. Needs assessments should be flexible allowing for adjustments, as evidence of the impacts of climate change, climate change policies and decarbonization grows.

Conclusion and perspectives

6

The future of global decarbonization, and thus our chances of limiting warming to the goals set out in the Paris Agreement, remains extremely uncertain. With emissions now expected to have surpassed pre-pandemic levels, and with temperature expected to reach 2.8°C at the end of the century even under current NDC targets, it is hard to remain optimistic. Any scenario, however, in which the world starts making great advances on decarbonization inevitably requires a fast large-scale reduction in the use of fossil fuels (FF).

The objective of this paper has been to identify the countries that are heavily dependent on extracting and exporting FF and empirically assess their potential fiscal and macroeconomic impacts from an ambitious global decarbonization scenario. This research issue has been motivated by the ongoing discussions on climate adaptation and mitigation, which most often do not significantly consider such possible economic transition costs in highly FF-dependent economies.

The paper's main conclusion is that many countries face potentially massive fiscal and economic transition costs under an ambitious global energy transition compatible with the Paris Agreement. Some countries are better equipped to handle a rapid and large-scale global decarbonization, as their FF dependency (exposure) is relatively low and/or their levels of existing (physical, human and financial) capital stocks (resilience) relatively high. But many others have both high exposure and low resilience (high vulnerability) and rank among some of the least well off countries in the world on human and overall levels of sustainable development. Without international support to mitigate the socio-economic impacts of decarbonization, these countries could see already low levels of development rolled back decades as we start to combat climate change.

In this paper, a total of 40 highly FF-dependent countries are identified, 31 of which are low- or middle-income countries. For the average country, FF generate 14.3 percent of GDP in rents annually, account for more than 60 percent of exports and likely more than one third of total government revenue. Under an ambitious global decarbonization scenario (net-zero by 2050) this group of countries is estimated to lose more than 60 percent, or (PV-adjusted) between $12-14 trillion, of oil rents alone, in the period 2023-2040 compared to a 'business as usual' (stated policies) scenario. This is a loss of rents equivalent in size to between 120 to 142 percent of the group's nominal GDP. Five-year cumulative impulse response functions estimated on a panel of emerging market and developing economy oil exporters suggest that lower oil prices have significant and persistent adverse impacts on growth, fiscal revenue and debt accumulation. More specifically, a ten percentage point decrease in (real) oil price inflation is associated with a 1.58 percent reduction in real GDP four periods after the shock, equivalent to an average annual growth rate of -0.31 percent; a decrease in annual government revenue as a percentage of GDP by between 0.6 and 0.7 pp; and an annual addition of about one half of a percentage point to government debt as a percentage of GDP.

Annex A – Data on fossil fuel dependence

Table A1: 40 most fossil fuel-dependent producer countries – indicators of dependency

COUNTRY	INCOME	OPEC	FOSSIL FUEL RENTS (% OF GDP), ANNUAL AVERAGE (2015-2019)[1]	FOSSIL FUEL RENTS (% OF TOTAL NON-RENEWABLE RESOURCE RENTS), ANNUAL AVERAGE (2015-2019)[1]	OIL RENTS (% OF FOSSIL FUEL RENTS), ANNUAL AVERAGE (2015-2019)[1]	FUEL EXPORTS (% OF TOTAL EXPORTS), ANNUAL AVERAGE (2015-2019)[2]	RESOURCE REVENUE (% OF GOVERNMENT REVENUE)[3]	DEPENDENCY INDEX[4]
Iraq	UMIC	1	37,2	100,0	99,5	98,0	92,1	95,0
Libya	UMIC	1	34,8	100,0	96,8	92,2	91,5	91,9
South Sudan	LIC		8,5	99,8	100,0	96,1	85,1	90,6
Turkmenistan	UMIC		17,6	100,0	37,6	89,8	..	89,8
Equatorial Guinea	UMIC	1	22,1	100,0	79,3	89,1	80,1	84,6
Brunei Darussalam	HIC		19,9	100,0	46,9	91,4	72,3	81,9
Kuwait	HIC	1	38,6	100,0	98,5	92,8	69,4	81,1
Oman	HIC		24,6	100,0	92,1	75,3	..	75,3
Azerbaijan	UMIC		21,0	99,4	86,0	90,6	58,5	74,5
Angola	LMIC	1	17,9	100,0	98,0	93,5	53,5	73,5
Saudi Arabia	HIC	1	24,4	99,8	97,4	73,6	68,7	71,1
Nigeria	LMIC	1	6,6	99,9	85,7	92,3	44,6	68,4
Algeria	LMIC	1	15,2	99,8	85,5	95,8	39,5	67,6
Timor-Leste	LMIC		57,4	100,0	28,9	69,5	61,9	65,7
Qatar	HIC		19,3	100,0	77,2	86,1	33,8	59,9
Chad	LIC		13,5	100,0	100,0	82,7	25,5	54,1
Congo, Republic of the	LMIC	1	29,2	100,0	96,4	52,3	53,2	52,8
Gabon	UMIC	1	14,9	99,7	98,8	68,1	35,8	52,0
Iran	LMIC	1	17,4	97,5	87,7	66,3	35,5	50,9
Venezuela	UMIC	1	11,7	99,0	97,2	86,7	14,5	50,6
Bahrain	HIC		4,0	100,0	54,3	49,7	..	49,7
Kazakhstan	UMIC		12,6	82,9	84,5	65,8	32,0	48,9
United Arab Emirates	HIC	1	14,6	100,0	95,5	50,3	47,4	48,9
Trinidad and Tobago	HIC		7,2	100,0	40,0	51,4	33,8	42,6
Yemen	LIC		2,9	100,0	95,0	47,6	36,5	42,0
Russian Federation	UMIC		10,5	94,0	70,0	53,0	23,5	38,2
Ecuador	UMIC		5,3	98,9	99,7	37,0	..	37,0
Norway	HIC		6,0	100,0	65,2	57,2	9,5	33,3
Colombia	UMIC		3,7	95,4	80,3	53,4	9,6	31,5
Mozambique	LIC		6,0	98,6	1,5	42,0	13,0	27,5
Bolivia	LMIC		3,0	76,1	53,3	34,1	18,4	26,3
Mongolia	LMIC		7,9	54,0	24,0	36,3	15,7	26,0
Cameroon	LMIC		2,8	98,7	88,6	36,6	14,9	25,7
Papua New Guinea	LMIC		7,2	76,0	30,4	44,2	7,0	25,6
Uzbekistan	LMIC		6,9	67,2	15,2	19,2	..	19,2
Sudan	LIC		2,4	71,7	100,0	23,8	13,3	18,5
Malaysia	UMIC		4,6	98,8	46,8	15,2	21,1	18,2
Egypt	LMIC		4,6	97,0	83,4	20,4	15,9	18,1
Ghana	LMIC		3,1	68,1	95,4	24,5	8,5	16,5
Suriname	UMIC		4,7	36,3	100,0	5,0	17,1	11,1
Median			11,1	99,8	85,9	61,5	33,8	50,2
Mean			14,3	92,7	75,3	61,2	38,6	50,9

Sources: Author based on data from World Development Indicators (WDI) from the World Bank, the Government Revenue Dataset (GRD) from UNU-WIDER, World Economic Outlook (WEO) from the IMF, Extractive Industries Transparency Initiative (EITI), oil production data from CEIC, and export data from the Observatory of Economic Complexity (OEC) which is based on the BACI dataset from CPII.

Notes:

[1.] Based on the available datapoints from 2015-2019 in the WDI database. Data for Venezuela is from 2014 and for South Sudan data is only 2015. Syria is not included as the lastest datapoint is from 2007.

[2.] Based on available datapoints in the WDI database for the series 'Fuel share (% of total merhandise exports)' which covers all SITC 3 categories of exports. For countries with all or many missing observations figures are instead based on OEC where fuel exports cover all 'mineral fuels, mineral oils and products of their distillation'. Countries that have been supplemented with BACI data are; Algeria, Bolivia, cameroon, Equatorial Guinea, Gabon, Papua New Guinea, Sudan, South Sudan, Suriame, Chad, Trinidad and Tobago, Venezuela, Yemen, Iraq, Saudi Arabia, Timor-Leste, and Turkmenistan.

[3.] Based on available datapoints in the GRD dataset. For Iran only years 2015 and 2016, and for Iraq, Malaysia and Timor-Leste only 2015. Note that the dataset does not allow for a differentiation between types of resource revenues. For Yemen, Venezuela and Libya the latest GRD datapoint is for 2012. These countries' resource revenue shares are instead estimated by scaling their oil production times global crude price in 2012 relative to their oil production and crude price in 2019 using CEIC data and using government revenue data from IMF WEO. For Mozambique and Colombia there is no recent GRD data, but EITI data for 2018 for Colombia and 2017 and 2018 for Mozambique.

[4.] Average of the fuel share of exports and fossil fuel share of revenue (latter as the resource revenue share of total revenue adjusted by the ratio of fossil fuel rents to total non-renwable rents). For countries with missing revenye estimates, the index is just the fule share.

Annex B – Local projection analysis

Estimation technique

Using a sample of oil-exporting EMDEs I estimate the cumulative impulse response functions (CIRFs) at projection horizon *h* for government revenue, expenditure, debt and real GDP from a shock to real oil price inflation using a local projections (LP) model framework developed by Jordà (2005) and using standard errors robust to heteroscedasticity, autocorrelation, and cross-sectional dependence. Results for each response variable is compared against results from the same model on a sample of oil-importing EMDEs. Specifically, for each horizon *h = 0, 1, 2, 3, 4* the panel-model specification is as in (1):

$$y_{i,t+h} - y_{i,t-1} = \alpha_{i,h} + \beta_h p_t + \Omega_{\boldsymbol{h}}(L) p_{t-1} + \Phi_{\boldsymbol{h}}(L)\boldsymbol{X_{i,t}} + \Theta_{\boldsymbol{h}}(L) y_{i,t-1} + \varepsilon_{i,t+h} \quad (1)$$

Where y is the response variable of interest for country i at time t, here real GDP, *gdp*, government revenue, *rev*, expenditure, *exp*, and debt, *debt*, and with *rev*, *exp*, and *debt* measured as percentage of GDP. Coefficients α_i are country fixed-effects. The main parameter of interest for each response variable is β_h which is the CIRF-coefficient at each horizon *h* for the impulse variable of interest, here global real oil price inflation, *p*. $\Omega_{\boldsymbol{h}}(L)$ and $\Theta_{\boldsymbol{h}}(L)$ are lag polynomials of order *l*, respectively on oil price inflation, *p*, and the response variable, *y*. In all specifications, lags of real GDP on the RHS enter in differences (growth rates), as GDP is clearly trending for most countries in the sample. *X* is a vector of control variables and is a lag polynomial vector of order *l* of loadings on *X*. All fiscal outcome variables (*rev*, *exp* and *debt*) and the GDP growth rate enter in all regressions and other control variables, *X*, include the domestic (CPI) inflation rate and the growth rate of global (real) industrial production, an often used proxy for global oil demand. Included are four lags for each variable.

Data

To create a sample of oil-exporting EMDEs I first include all energy exporters as identified in the June 2022 Global Economic Prospects Report (World Bank, 2022)[35] minus Guyana (who only started oil exports in recent years), plus Yemen and Uzbekistan all three of which are identified as oil exporters by the IMF[36], plus Turkmenistan, Malaysia, Venezuela and Sudan.[37] Oil-importers count all EMDEs not defined as an oil-exporter, but with exporters taken from World Bank (2022b) which uses a lower exports threshold to define exporters than in World Bank (2022a).[38] These definitions better ensure that the two samples reflect export and import dependence. Next, to obtain fairly balanced datasets all countries that do not have at least 20 observations on each variable are excluded.[39] This brings the total number of exporters in the oil-exporter sample to 30 and oil-importers to 74 (Table 1). The period used is 1991-2021 for both samples of annual data. Data for general government revenue, expenditure, GDP and consumer prices are from IMF WEO October 2022 (WEO 2022).[40] The oil price used is a simple average of the three major spot prices (Dated Brent, West Texas Intermediate and Dubai Fateh) as also reported in WEO (2022). The oil price is transformed to real terms using US (CPI) inflation. Global industrial production (constant US$) is from the World Bank's Global Economic Monitoring database.

[35] See Table 1.2.

[36] According to IMF regional outlooks (IMF, 2022a) and (IMF, 2022b).

[37] Sudan has been a net exporter for most of the sample period.

[38] In World Bank (2022a) commodity exporters are defined as countries where total commodities exports account for at least 30 percent of total exports, or any single commodity at least 20 percent. In World Bank (2022b) the threshold is at least five percent of exports.

[39] This excludes four oil-exporters from the sample (Iraq, Venezuela, South Sudan and Libya) and 15 oil-importers (Afghanistan, Argentina, Armenia, Lebanon, Lesotho, Marshall Islands, Mauritania, Nauru, Palau, Somalia, Tuvalu, West Bank and Gaza, Zimbabwe, Uruguay and Kosovo).

[40] Starting year is 1991 as this is the first observation for the global control variable 'global industrial production' from the World Bank.

Table B1: Countries in exporter and importer sample

EXPORTERS	IMPORTERS		
Algeria	Aruba	Honduras	St Vincent and the Grenadines
Angola	Bangladesh	Hungary	St. Kitts and Nevis
Azerbaijan	Belize	Jordan	Suriname
Bahrain	Benin	Kenya	Swaziland
Bolivia	Bhutan	Kiribati	Tajikistan
Cameroon	Bosnia and Herzegovina	Kyrgyzstan	Tanzania
Chad	Botswana	Laos	Thailand
Colombia	Burkina Faso	Macedonia	Tonga
Ecuador	Burundi	Madagascar	Turkey
Equatorial Guinea	Cambodia	Malawi	Uganda
Gabon	Cape Verde	Mali	Ukraine
Ghana	Central African Republic	Mauritius	Vanuatu
Indonesia	Chile	Micronesia, Fed. Sts.	Vietnam
Iran, Islamic Rep.	China	Moldova	Zambia
Kazakhstan	Comoros	Montenegro	
Kuwait	Congo	Morocco	
Malaysia	Costa Rica	Mozambique	
Myanmar	Dominica	Namibia	
Nigeria	Dominican Republic	Nepal	
Oman	El Salvador	Nicaragua	
Qatar	Eritrea	Pakistan	
Republic of the Congo	Ethiopia	Paraguay	
Russia	Gambia, The	Philippines	
Saudi Arabia	Georgia	Poland	
Sudan	Grenada	Romania	
Timor-Leste	Guatemala	Serbia	
Turkmenistan	Guinea	Sierra Leone	
United Arab Emirates	Guinea-Bissau	Solomon Islands	
Uzbekistan	Guyana	South Africa	
Yemen, Rep.	Haiti	Sri Lanka	

Results - GDP

For both exporters and importers, real GDP responds positively in the period of the shock, beyond which the cumulative response only remains statistically significant and increasing over time for exporters (Figure 8 in main text). More specifically, four periods after a ten pp positive shock to real oil price inflation, real GDP is estimated to be 1.58 percent higher – the equivalent to an average annual GDP growth rate of 0.31 percent. Alternatively, following a one standard deviation increase in oil price inflation (of 24.5 pp), real GDP would be higher by about 3.8 percent four periods after the shock – equivalent to an average annual growth rate of 0.76 percent. Assuming that oil price shocks have symmetric impacts, a ten pp negative oil price shock would, therefore, also be associated with a 1.58 percent decline in GDP four periods after the shock.

Past studies have also found a positive relationship between oil prices and GDP growth in oil exporters. As an example, a recent study from the World Bank also using LPs found that the impact of a ten pp increase in real oil price inflation was associated with a 0.2 pp increase in output growth over the subsequent two years (Baffes & Nagle, 2022). This is a relatively modest and short-lived impact compared to the GDP results from this analysis. The differences in results could have to do with differences in sample periods. Whereas the World Bank study uses a longer period (1970-2019) covering several commodity cycles, this study (to obtain a fairly balanced panel with respect to the included fiscal variables) uses a shorter period (1991-2019), mostly characterized by increasing and high oil prices (see Figure 6). It is likely that the large and persistent oil price boom in the 2000s and the first half of the 2010s had a larger impact on economic growth in oil exporters.

Not only is this study sample period dominated by positive oil price inflation but positive demand shocks where price and demand (proxied by industrial production) rise in tandem. Under global decarbonization the opposite is expected to unfold – a negative demand shock characterized by a fast and persistent fall in both quantity of oil demanded and price. In terms of trend and the level of oil prices, the chosen sample period could, therefore, resemble the main perception on how global decarbonization will affect the oil market albeit with opposite signs. This raises the question of whether oil price shocks have asymmetric impacts. Studying especially the impacts from negative demand shocks would be highly relevant for understanding the possible effects on oil exporters from global decarbonization. The data used in this analysis makes it difficult to study such possible asymmetries and types of shocks due to very few observations of negative demand shocks over the sample period. However, the former World Bank study found evidence that large price falls (as opposed to rises) have bigger and more lasting adverse impacts on GDP.

Results – revenue

Due to the generation of oil rents and the types of fiscal regimes adopted in most oil exporters, one would expect to find a positive link between oil prices and government revenue.[41] If a positive relationship exists between rev and p, this is an indication that revenue grows at a higher rate than GDP in response to a positive oil price shock. Several other considerations about revenue dynamics and price shocks are also worth considering. First, if one were to find that rev does not respond to an oil price shock or that the response is short-lived, this would not necessarily be evidence that oil revenue does not respond to oil price shocks. It could instead be a sign of a substitution effects, where governments in response to more (less) oil revenue collect less (more) non-resource revenue.

[41] The overall objective for the government of a resource-rich country should be to maximize the government take of resource rent without discouraging investors. Overall, there are three fiscal regimes used in resource-rich economies, although many countries have various combinations. One is a concession-based regime based on royalties and taxes. Another is a contractual regime based on service contracts and producer-sharing agreements, and the third is the state ownership regime. The latter is commonly used with respect to petroleum resources.

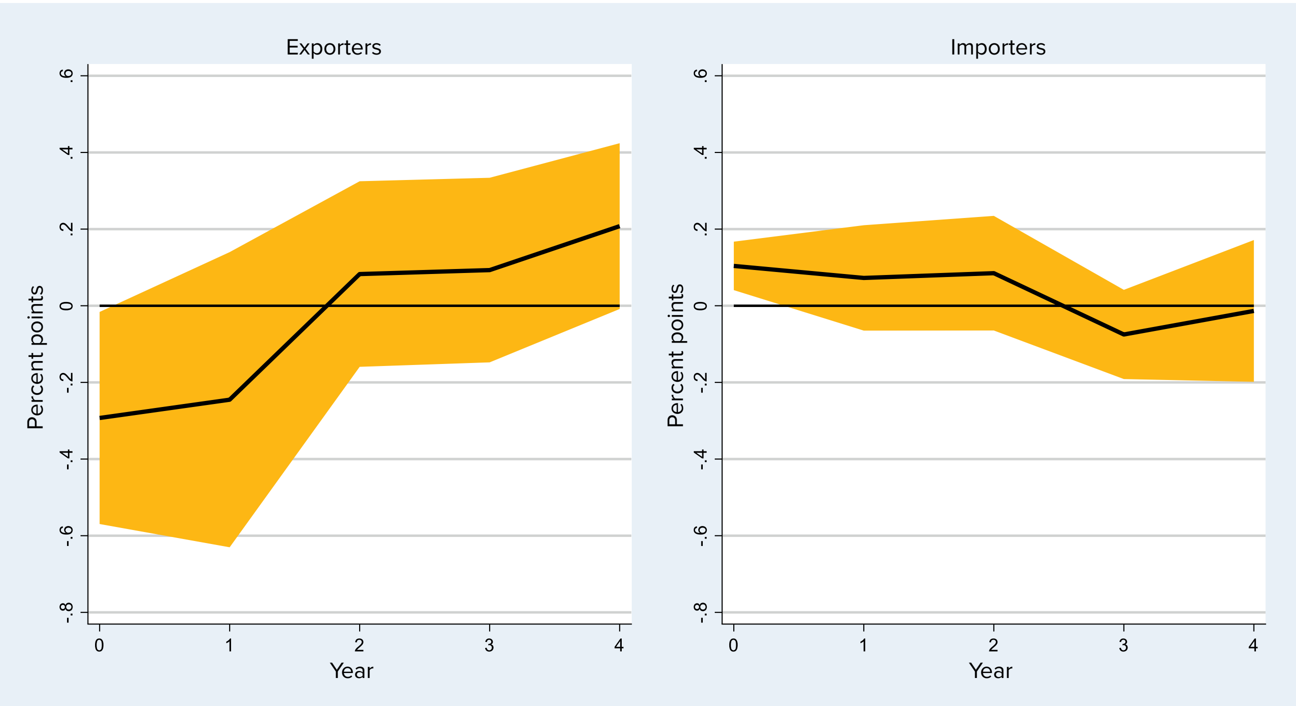
Results here suggest that for exporters the revenue ratio responds immediately, and the cumulative impact remains significant in both economic and statistical terms throughout the projection horizon (Figure 9 main text). More specifically, the CIRF-coefficient fluctuates between 0.6 and 0.8 pp for a 10 pp increase in oil price inflation – alternatively the revenue ratio improves by between 1.5 pp and 2 pp for a one standard deviation increase in oil price inflation. For importers a positive oil price shock is associated with a small negative impact on revenue, but the cumulative impact is not statistically significant (at the 95 percent confidence interval) four periods after the shock.

Results - expenditures

Some studies have found that fiscal policy is procyclical in developing economies, and especially pronounced in countries heavily dependent on selling natural resources (Frankel, 2011). One explanation given is that governments cannot resist the temptation or political pressure to increase spending when windfalls accrue. For instance, by increasing the public sector wage bill which can be hard to scale back when oil prices fall again (Medas & Zakharova, 2009). Other reasons can be less discretionary in nature as it is not uncommon for oil exporters to have in place substantial fuel subsidy programs (Balke, Plante, & Yücel, 2014).

Results of this analysis do not provide strong evidence in support of overall pro- or counter-cyclical spending behavior among exporters (Figure B1). If anything, results suggest a small initial countercyclical response, followed by an increasing spending pressure over time as the CIRF coefficient goes from negative to positive.

Figure B1: Expenditure response to a ten pp increase in (real) oil price inflation

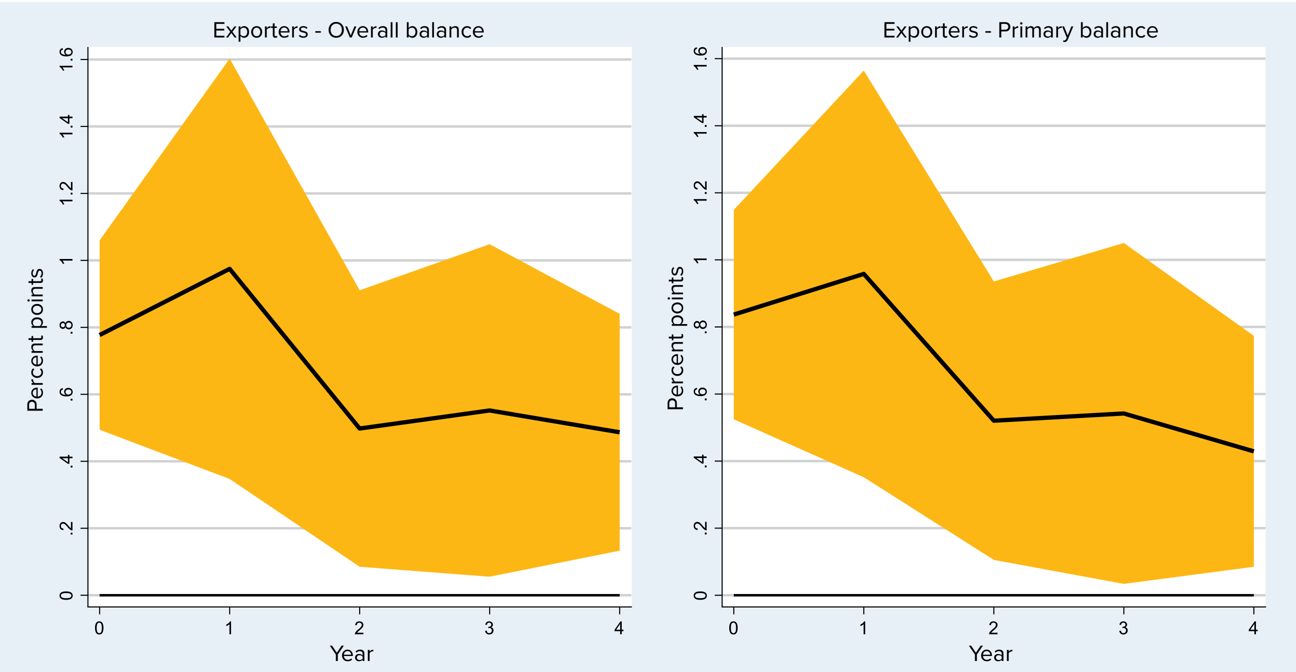


Source: UNDP. Note: Cumulative response of government expenditure (as a percentage of GDP) from a ten pp increase in the real oil price from a local projections model. The shaded area delineates the 95 percent confidence band.

Results - fiscal balances

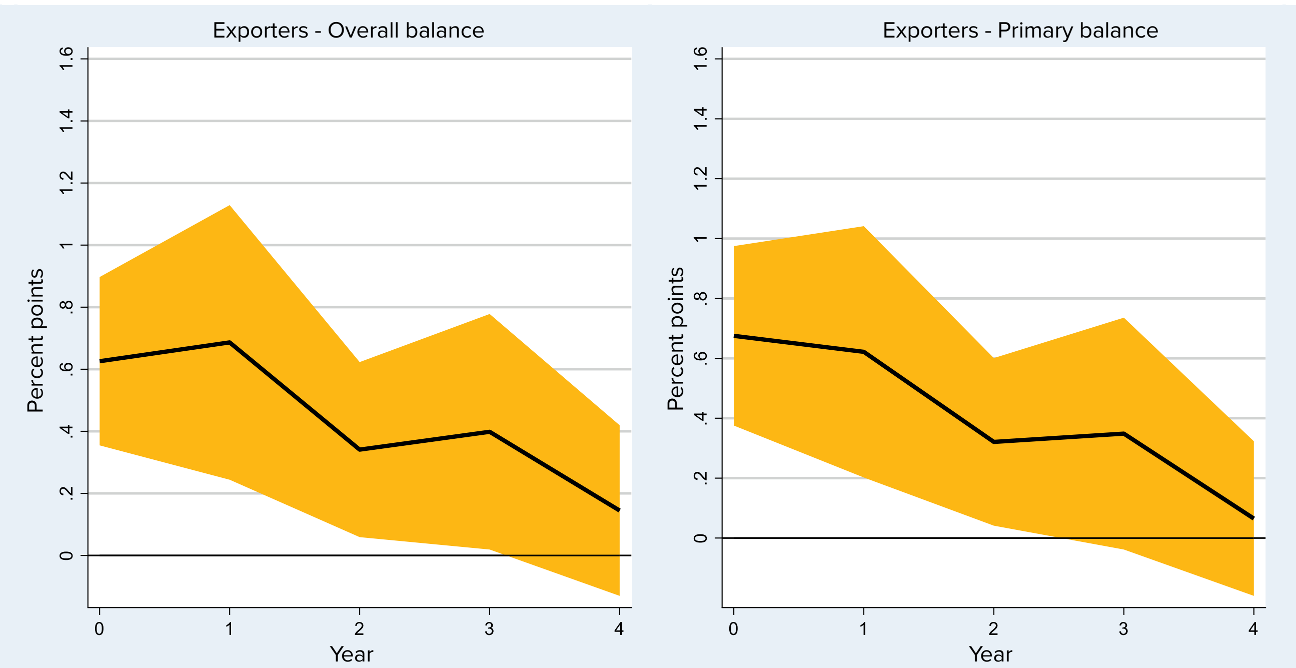
To take an alternative look at the fiscal response in exporters, rev and exp can be substituted in model (1) with either the overall or the primary fiscal balance. Results do, not surprisingly, confirm the revenue and expenditure results found above as both balances improve when oil prices increase, although it is worth noting that the cumulative improvement in both balances decline over time most likely because of changes to spending (Figure B2). This effect is even more pronounced in a sample that excludes the high-income exporters, as the cumulative spending response here becomes positive and significant four periods after the shock and there is no statistically significant improvement in fiscal balances beyond two or three periods after the shock (Figure B3).

Figure B2: Fiscal balance response to a ten pp increase in (real) oil price inflation – full sample



Source: UNDP. Note: Cumulative response of fiscal balance (as a percentage of GDP) from a ten pp increase in the real oil price from a local projection model. The shaded area delineates the 95 percent confidence band.

Figure B3: Fiscal balance response to a ten pp increase in (real) oil price inflation - excluding high income



Source: UNDP. Note: Cumulative response of fiscal balance (as a percentage of GDP) from a ten pp increase in the real oil price from a local projection model. The sample excludes high-income EMDEs. The shaded area delineates the 95 percent confidence band.

Results - debt

Finally, results suggest that positive oil price shocks strongly decrease the debt-to-GDP ratio in exporters but have no impact on the debt ratio for importers (Figure 10 in main text). For exporters, debt as a percentage of GDP is close to 2.5 pp lower four periods after a ten pp positive shock to oil price inflation – alternatively the debt ratio has fallen by about 6 pp four periods after a one standard deviation increase in oil price inflation.

References

Abdel-Latif, H., Rawlings, H., Reyes, I., & Zhang, Q. (2022, October). Managing Oil Price Uncertainty and the Energy Transition . October 2022 Regional Economic Outlook" Sub-Saharan Africa Analytical Note.

Addison, T., & Amir, L. (2022). Public Savings in Africa: Do Sovereign Wealth Funds Serve Development? Helsinki: UNU-WIDER.

Axadi, M., Northey, S., Ali, S., & Edraki, M. (2020). Transparency on Greenhouse Gas Emissions from Mining to Enable Climate Change Mitigation. Nature Geoscience, Issue 13, p. 100-104.

Baffes, J., & Nagle, P. (2022). Commodity Markets: Evolution, Challenges, and Policies. Washington DC: The World Bank Group.

Bainton, N., Kemp, D., Lèbre, E., Owen, J., & Marston, G. (2021). The Energy-Extractives Nexus and The Just Transition. Sustainbale Development, Volume 29, Issue 4 / p. 624-634.

Balke, N., Plante, M., & Yücel, M. (2014). Fuel Subsidies, the Oil Market and the World Economy. Federal Reserve Bank of Dallas, Research Department, Working Paper 1405.

Boer, L., Pescatori, A., & Stuermer, M. (2021). Energy Transition Minerals. IMF Working Paper.

CAT. (2022). Warming Projections Global Update - November 2022. Climate Action Tracker.

CTI. (2021a). The Sky's the Limit: Solar and Wind Energy Potential is 100 Times as Much as Global Energy Demand. The Carbon Tracker Initiative.

CTI. (2021b). Beyond Petrostates - The Burning Need to Cut Oil Dependence in the Energy Transition. The Carbon Tracker Initiative.

Frankel, J. (2011). How Can Commodity Exporters Make Fiscal and Monetary Policy Less Procyclical? HKS Faculty Research Working Paper Series RWP11-015, John F. Kennedy School of Government, Harvard University.

Frankel, J. (2012). The Natural Resource Curse: A Surey of Diagnosis and Some Prescriptions. Boston: Kennedy School of Government Working Paper Series RWP12-014, Harvard University.

GCP. (2022). The Global Carbon Budget 2022. The Global Carbon project.

IEA. (2021a). Net Zero by 2050 - A Roadmap for the Global Energy Sector. International Energy Agency.

IEA. (2021b). World Energy Outlook 2021. IEA.

IMF. (2012). Fiscal Regimes for Extractive Industries: Design and Implementation. The IMF.

IMF. (2019a). Guyana - 2019 Aticle IV Consultation.

IMF. (2019b). IMF Country Report No. 19/67 - Republic of Mozambique.

IMF. (2022a). Regional Economic Outlook Sub-Saharan Africa: A New Shock and Little Room toManeuver. Washington DC: IMF.

IMF. (2022b). Regional Economic Outlook Middle East and Central Asia: Mounting Challenges, Decisive Times. Washington DC: IMF.

IPCC. (2021). Climate Change 2021 - The Physical Science Basis. Intergovernmental Panel on Climate Change.

IPCC. (2023). Synthesis Report of the IPCC Sixth Assessment Report - Summary for Policymakers. IPCC.

Jordà, O. (2005). Estimation and Inference of Impulse Responses by Local Projections. American Economic Review.

Katayama, R., & Wadhwa, D. (2019). Half of The World's Poor Live in Just 5 Countries. World Bank Data Blog.

Medas, P., & Zakharova, D. (2009). A Primer on Fiscal Analysis in Oil-Producing Countries. IMF Working Paper, WP/09/56.

OECD. (2018). Policy Dialogue on Natural Resource-Based Development. Paris: OECD Development Centre.

Parker, D. (2021, November 5). Hope Floats for Mozambique LNG Project. Mining Weekly.

Rajan, R. (2019). A fair and simple way to tax carbon emissions . Financial Times.

Russell-Jones, R. (2021). The Global Carbon Incentive Fund as a Response to the Climate Crisis. Observer Research Foundation, Issue no. 488.

Rystad Energy. (2019). Rystad Energy Ranks the Cheapest Sources of Supply in The Oil Industry.

Stocker, M., Baffes, J., Some, Y., Vorisek, D., & Wheeler, C. (2018). The 2014-2016 Oil Price Collapse in Retrospect - Sources and Implications. Policy Research Working Paper 8419.

The Production Gap. (2020). The Production Gap - The Discrepancy Between Countries' Planned Fossil Fuel Production and Global Production Levles Consistent With Limiting Warming to 1.5°C or 2°C.

UNEP. (2021). Adaptation Gap Report 2021. The Gathering Storm - Adapting to Climate Change in a Post-Pandemic World. UNEP.

United Nations. (2015). Paris Agreement.

UNU-WIDER. (2021, August). GRD - Government Revenue Dataset. Retrieved from https://doi.org/10.35188/UNU-WIDER/GRD-2021

Welsby, D., Price, J., Pye, S., & Ekins, P. (2021). Unextractable Fossil Fuels in a 1.5 °C World. Nature.

World Bank. (2017). Economic, Fiscal and Social Challenges in the Early Phase of a Post Conflict Yemen. Yemen Policy Note 2. The World Bank Group.

World Bank. (2020a). Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. Washington DC: The World Bank Group.

World Bank. (2020b). Diversification and Cooperation in a Decorbonizing World - Climate Strategies for Fossil Fuel-Dependent Countries. The World Bank Group.

World Bank. (2021a). Causes and Consequences of Metal Price Shocks. Washington DC: The World Bank Group.

World Bank. (2021b). The Changing Wealth of Nations 2021 - Managing Assets for the Future. The World Bank Group.

World Bank. (2022, June). Global Economic Prospects. Washington DC: The World Bank Group.

United Nations Development Programme
1 UN Plaza, New York, NY 10075, USA